How Do Mathematical Manipulatives Enhance Student Learning
in a Seventh Grade Probability Unit?

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By
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This Master’s Research Project has been approved for the Department of Teacher Education

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# Table of Contents

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>1</td>
</tr>
<tr>
<td><strong>1. Introduction</strong></td>
<td>2</td>
</tr>
<tr>
<td>Research Questions</td>
<td>3</td>
</tr>
<tr>
<td>Definition of Terms</td>
<td>3</td>
</tr>
<tr>
<td>Limitations</td>
<td>4</td>
</tr>
<tr>
<td>Organization of Study</td>
<td>5</td>
</tr>
<tr>
<td><strong>2. Review of Literature</strong></td>
<td>6</td>
</tr>
<tr>
<td>Problem-Based Learning</td>
<td>6</td>
</tr>
<tr>
<td>Advantages of Problem-Based Learning</td>
<td>9</td>
</tr>
<tr>
<td>Limitations of Problem-Based Learning</td>
<td>10</td>
</tr>
<tr>
<td>Student Motivation</td>
<td>11</td>
</tr>
<tr>
<td>Human Development</td>
<td>13</td>
</tr>
<tr>
<td><strong>3. Methods</strong></td>
<td>17</td>
</tr>
<tr>
<td>Participants</td>
<td>17</td>
</tr>
<tr>
<td>Mathematical Manipulatives</td>
<td>18</td>
</tr>
<tr>
<td><strong>4. Findings</strong></td>
<td>26</td>
</tr>
<tr>
<td>Test Scores</td>
<td>27</td>
</tr>
</tbody>
</table>
Abstract

The purpose of this study was to determine whether mathematical manipulatives enhanced student learning in a seventh grade probability unit. A series of manipulative activities were used to represent simple events, tree diagrams, the Fundamental Counting Principle, theoretical and experimental probability, and independent and dependent events. Students’ knowledge was determined using a pre-test and post-test at the beginning and end of the unit. The findings suggest that while many of the students enjoyed problem-based learning and student-centered instruction, it did not necessarily increase student knowledge of probability.
CHAPTER ONE

INTRODUCTION

The purpose of this Master’s Research Project was to determine whether mathematical manipulative activities enhanced student learning during a seventh grade probability unit. Students were asked to participate in a variety of mathematical activities that involved manipulative activities to develop a deeper cognitive understanding of probability. The students in this seventh grade had no prior experience with problem-based or student-centered learning. Their prior learning consisted primarily of teacher-centered and textbook-driven lectures.

Another purpose of this Master’s Research Project was to investigate the impact and the implications of student-centered instruction and problem-based learning in a Middle Childhood mathematics classroom. Current research supports active and collaborative learning environments to structure and support student learning (Gallow & Grant, 2013). I used this opportunity to field-test and explore mathematical activities that I created and adapted to conform to this instructional approach. Research has also demonstrated the effective impact of action research on teacher’s classroom practice (Gallow & Grant, 2013).

Individually, students may benefit from this research by experiencing mathematics from a student-centered perspective, by having the opportunity to explore problem-based activities in the development of mathematical probability, and by developing their verbal or written communication skills. Students worked in a group setting in which they were required to collaborate to solve problems. All students were given a task to be completed before the end class. This allowed students to participate instead of one student completing all the work for the group.
Research Questions

The questions guiding this study were:

1. How do mathematical activities involving probability manipulatives enhance student learning in a middle school mathematics class?

2. How do problem-based learning and student-centered learning affect test scores in a middle school mathematics classroom?

Definition of terms

The following defines how each term was used in my classroom or in the way students in my school typically understood a term or acronym.

Complementary Events – The probability of an event happening and not happening is complementary. The sum of the probabilities of complementary events is 1.

Compound Event – An event consisting of two or more simple events.

Dependent Event – One of two or more events in which the outcome of one event affects the outcome of the other event(s).

Experimental Probability – An estimated probability based on relative frequency of positive outcomes occurring during an experiment.

Fair Game – A game in which players of equal skill have an equal chance of winning.

Fundamental Counting Principal – Uses multiplication of the number of ways each event in an experiment can occur to find the number of possible outcomes in a sample space.

Independent Event – One of two or more events in which the outcome of one event does not affect the outcome of the other event(s).

Probability – The chance that some event will happen. It is the ratio of the number of ways a certain event can occur to the number of possible outcomes.
Problem-based Learning – A constructivist pedagogical approach to learning in which students work together to find solutions to a complex problem.

Outcome – One possible outcome of a probability event.

Random – Outcomes occur at random if each outcome is equally likely to occur.

Sample Space – The set of all possible outcomes of a probability experiment.

Simple Event – One outcome or a collection of outcomes.

Student-centered Learning – Refers to learning opportunities that are relevant to the students, the goals of which are at least partly determined by the students themselves.

Theoretical Probability – The ratio of the number of ways an event can occur to the number of possible outcomes.

Tree Diagrams – A diagram used to show the total number of possible outcomes in a probability experiment.

Limitations

Limiting factors that played an important role in this study are:

1. I was only given a time period of two weeks to complete the activities involving manipulatives with the students. This time frame limited the amount of time I could spend on each topic in the unit because of the amount of information I still needed to cover prior the Ohio Achievement Assessment.

2. The pre and post-tests were standardized tests designed by an online program used by the math teachers at Rosewood Middle School to help prepare students for the Ohio Achievement Assessment. Unfortunately, I had no control over the type of problems on the test.
3. After the pre and post-test were completed, I noticed that many of the students were missing the problems on independent and dependent events. After closer inspection, it was discovered that there was a glitch in the computer system and the program was marking problems wrong that were in fact correct.

4. Student attendance also made it difficult to gather all the information I needed to complete my study. Some students miss several days at a time, making it very difficult to catch them up on all the material they missed when they were absent.

   Organization of study

   This chapter described the purpose of this study and its expected outcomes. It also discussed how students might benefit from participating.

   Chapter Two consists of a review of the literature. Chapter Three will present the methodology used in this Master’s Research Project. Chapter Four will discuss the results and findings of my research while Chapter Five will present the conclusion and implications.
CHAPTER TWO

REVIEW OF LITERATURE

Problem-based learning

The purpose of this literature review is to provide findings based on research that supports Problem-Based Learning (PBL) in a mathematics classroom and how it affects student achievement. Many educators have a hard time incorporating activities into their lessons and allowing students to use prior knowledge to solve a problem. One of the primary features of PBL is that it is student centered. “Student-centered” refers to learning opportunities that are relevant to students, the goals of which are at least partly determined by the students themselves (Gallow & Grant, 2013). Students involved in PBL tend to have more positive attitudes towards the course and perform better on tests (Gallow & Grant, 2013).

Teaching content through skills is one of the primary distinguishing features of PBL (Gallow & Grant, 2013). Students are able to learn more thoroughly as they try to solve problems using multiple paths. Problems used during problem-based learning pertain to real-world problems related to the concepts being studied. Because there are multiple ways to solve these problems, students are able to provide an answer based on critical thinking and reasoning. PBL, by allowing students to demonstrate for themselves their capabilities, can increase students’ motivation to tackle problems (Gallow & Grant, 2013).

A teacher’s role during problem-based learning can be very difficult. Many teachers believe that instruction during class needs to incorporate lecturing and taking notes, but PBL is the exact opposite. The most common instructor role is to question the students about their learning process by asking “meta-cognitive questions: “How do you know that?” What
assumptions might you be making?” (Gallow & Grant, 2013). Questions like these are used to teach students to reflect upon their answers and critique their own learning process. Because teachers are encouraged to help student reflect on their thought process, PBL is also considered process-centered instead of product centered. Teachers should also provide certain kinds of experiences in which students are able to work as young mathematicians and researchers (Busadeea, Laosinchai, Panijpan, Pathom, & Ruenwongsa, 2010). As a result, implementation of problem-based learning requires a change from traditional methods of instruction in which the teacher acts as the “expert” to a role of facilitator or metacognitive coach (Ferreira & Trudel, 2012).

The teacher’s role as a facilitator during PBL is extremely important. As a facilitator the teacher guides the students through (a) what questions to ask during problem definition; (b) how to locate information related to the problem; (c) how to analyze and synthesize the information; and (d) how to sort potential solutions to the problem (Ferreira & Trudel, 2012).

During PBL, students are able to work in groups and use prior knowledge to solve problems, as well as, -knowledge from others. Students should have ample opportunities to utilize the inquiry cycle in carrying out their own mathematical investigations when learning mathematics (Geban, Sungur, & Tekkaya, 2006). When students work together in groups, they have to share their information and solving strategy with each other and they must be sensitive to other student’s feelings. By placing students in groups, they are not only learning to work collaboratively with one another, but they are also learning how to use each other as a helpful resource.

A study by Sungur, Tekkaya, and Geban, PBL provided evidence to support the claim that student-centered classrooms - in which students work on open-ended tasks cooperatively by
identifying knowledge, deficiencies, generating appropriate learning issues, assessing different resources, and monitoring understanding - lead to the development of lifelong learning skills (Geban et al, 2006). By using a problem-based learning approach in the curriculum, teachers are giving students the opportunity to think logically and develop a deeper cognitive understanding of concepts that they will use later in life.

Unlike traditional instruction in which students are lectured on a topic before they have the opportunity to apply what they have learned, in PBL students learn the concepts and principles related to the topic through the process of solving the problem. This approach mirrors how problems are solved in the real world and requires a shift from teacher-centered to student-centered pedagogy, as learning focuses on understanding and application of knowledge (Ferreira & Trudel, 2012).

To begin a PBL approach in any classroom, one must consider the characteristics of problem-based learning. The following is a list of characteristics that should be considered when deciding whether problem-based learning is the correct approach to classroom instruction:

- The learning process must be started with a problem; especially a problem that is evidently critical/still unsolved must be used.
- Content and practices must include situations which attract students’ attention.
- The teacher must merely be a guide in the classroom.
- Students must be given time necessary to think or gather information and to set their strategies in problem solving, and their creative thoughts must be encouraged.
- The difficulty of the subject matter to be studied must not be at such a high level as to discourage students.
A comfortable, relaxing, and safe learning environment must be established in order to develop students’ skills in thinking and problem-solving by themselves (Akinoglu & Tandogan, 2007).

The characteristics that describe a well-rounded problem-based learning scenario are as follows:

- Problems must be chosen from among the problems which are the most fitting to the real world.
- Problems must be open-ended.
- It must arouse curiosity.
- It must focus on only one issue.
- It must teach good and ethical behaviors rather than negative events and behaviors.
- It must help students to reflect on freely and express themselves.
- By making suitable personifications, students must be given the opportunity to treat the problem as if it were their problem and to be willing to solve it (Akinoglu & Tandogan, 2007).

Advantages

Both advantages and limitations of problem-based learning that can emerge while using this method in a classroom scenario. Advantages of problem-based learning include, but are not limited to:

- Classes are student-centered instead of being teacher-centered.
- It develops self-control in students. It teaches making prospective plans, facing realities and expressing emotions.
- It enables students to see events multi-dimensionally and with a deeper perspective.
- It develops students’ problem-solving skills.
- It encourages students to learn new materials and concepts when solving problems.
- It develops students’ sociability levels and communication skills by enabling them to study and work in a team.
- It develops students’ high level thinking/critical thinking and scientific thinking skills.
- It unites theory and practice. It allows students both to merge prior and new knowledge and to develop their judging skills in a specific discipline environment.
- It motivates learning for both teachers and students.
- Students acquire the skills of time management, focusing, data collection, report preparation, and evaluation.
- It paves the way for lifelong learning (Akinoglu & Tandogan, 2007).

Limitations

Limitations of problem-based learning include:

- It can be difficult for teachers to change their teaching styles.
- It can take more time for students to solve problematic situations when these situations are first presented in the class.
- Groups or individuals may finish their works earlier or later.
- Problem-based learning requires rich material and research.
- It may be difficult to similarly implement problem-based learning model in all classes. It is ineffective to use this strategy with students who do not fully understand the value or scope of the problems.
- It is quite difficult to assess learning (Akinoglu & Tandogan, 2007).
Researchers examining the impact of PBL on student outcomes have found that when well implemented, problem-based learning can lead to greater conceptual understanding and problem-solving skills (Ferreira & Trudel, 2012). Three major complaints from employers about college graduates are that they have poor written and verbal skills, are unable to problem-solve, and have difficulty working collaboratively with other professionals. PBL can address all three areas (Gallow & Grant, 2013). Students who have participated in problem-based learning report that PBL has helped them become independent learners and has given them sense of personal growth, increased subject matter knowledge, and greater enjoyment of learning (Ferreira & Trudel, 2012). At the end of the studies carried out by students through a problem-based learning model, Akinoglu and Tandogan (2007) found that cooperation with each other and social development were influenced positively and that positive change occurred in their social skills in such areas making collaborative decisions together and developing team spirit.

Student motivation

A critical component of middle grades students' success is motivation. It is often in the middle grades when males and females tend to lose interest in mathematics in great part to motivational factors that include a feeling that the subject is hard, and effort versus reward, that is, motivational reward, does not merit the effort (Association for Middle Level Education, 2013). Each student has his or her own innate individual level of motivation. Students also have their own special and particular way of understanding or interpreting their personal motivational drive. Furthermore, students' individual motivation is rooted deeply and influenced by earlier life experiences—both positive and negative (Association for Middle Level Education, 2013).
Setting high expectations plays a very important role in motivating students. Young adolescents look to teachers, peers, and parents for guidance and motivation. Therefore, teachers must look for developmentally appropriate teaching strategies and pedagogy that increases student motivation and recognize the importance of setting high expectations to help increase it (Association for Middle Level Education, 2013).

Motivating students can be one of the hardest tasks for any teacher to accomplish in any classroom. Every student is motivated by something different and it becomes the teacher’s job to keep lessons and activities interesting. Depending on the age of the students, the teacher must find a way to keep students engaged in the lesson so they not only learn, but also remember the material later in life.

It’s not impossible to motivate others besides oneself. With sufficient determination a teacher can often make his or her students do things by using rewards and punishments. But you can’t make them do those things well—“You can command writing, but you can’t command good writing” (Kohn, 2011). According to Kohn, teachers need to stop using coercion to entice students to learn material or concepts. Instead, teachers need to try to motivate students by other methods such as problem-based learning and student-centered learning. What a teacher can do—all a teacher can do—is work with students to create a classroom culture, a climate, a curriculum that will nourish and sustain the fundamental inclinations that everyone starts out with: to make sense of oneself and the world, to become increasingly competent at tasks that are regarded as consequential, to connect with (and express oneself to) other people.

According to Kohn (2011), there are seven ways to kill students’ motivation. They are:

1. Quantify their assignments
2. Make them write reports
3. Isolate them
4. Focus on skills
5. Offer them incentives
6. Prepare them for tests
7. Restrict their choices.

These factors play an important role in student motivation. Allowing students to have a choice in their assignments, provides them the opportunity to learn by their own standards. They are more likely to remember concepts that they found interesting.

Human development

More than any other psychological perspective, the psychodynamic approach to human behavior is embedded in popular culture, particularly in people's way of talking and thinking about their problems and everyday actions (Tavris & Wade, 2001). According to Freud, personality is made up of three major systems: the id, the ego, and the superego. Although each system has its own function and elements, human behavior is nearly always a result of the interaction among all three (Tavris & Wade, 2001). The id, which is present at birth, is the reservoir of unconscious psychological energies and the motives to avoid pain and obtain pleasure. The ego, the second system to emerge is a referee between the needs of instinct and the demands of society. The superego, the last system of the personality to develop, represents morality, the rules of parents and society, and the power of authority (Tavris & Wade, 2001). Freud believed that personality development is completed by the age five or six.
Erik Erikson, another psychoanalyst, argued that every individual passes through eight stages of human development throughout life. Erikson’s two stages of human development that pertain to this research are stages four and five, competence versus inferiority and ‘identity versus role confusion’.

Stage four, ‘competence versus inferiority’, is the crisis for school-age students, who are learning to make things, use tools, and acquire skills for adult life. Children who fail these lessons of mastery and competence risk feeling inadequate and inferior. (Tavris & Wade, 2001). Middle school students are constantly learning new things and looking to educators and peers for guidance. This is a very important stage in their lives because they are learning the necessities that will help them evolve into young adolescents.

Stage five, ‘identity versus confusion’, occurs during adolescence when teenagers must decide what they are going to be and what they hope to make of their lives (Tavris & Wade, 2001). The term identity crisis was used by Erikson to describe the emotional ups and downs a teenager encounters during this period of his or her life. Those who resolve this crisis will come out of this stage with a strong personal identity, ready to (Association for Middle Level Education, 2013) plan for the future. Those who do not will wink into confusion, unable to make decisions (Tavris & Wade, 2001).

Erikson’s work was important because he showed that development is never finished; it is an ongoing process, and the unconscious crisis or issues of one stage may be reawakened during another (Tavris & Wade, 2001).

According to the Association for Middle Level Education (AMLE), early adolescence is a period of human growth and development that occurs between childhood and adolescence. During this remarkable stage of the life cycle, young adolescents (10- to
15-year-olds) experience rapid and significant developmental change (Association for Middle Level Education, 2013). Physical development encompasses bodily changes including growth, improved gross and fine motor skills, and biological maturity. During early adolescence, the body undergoes more development than at any other time, except the first two years of life (Association for Middle Level Education, 2013). Puberty also occurs during this stage of life causing an increase of hormones in the body. These hormones cause noticeable changes in the body that may make adolescents feel uncomfortable about their physical development and appearance.

Intellectual development refers to the increased ability of people to understand and reason. In young adolescents, intellectual development is not as visible as physical development, but it is just as intense (Association for Middle Level Education, 2013). Young adolescents tend to be interested in a wide variety of topics and display interests in learning from new experiences. Young adolescents, as learners, build upon their individual experiences and prior knowledge to make sense of the world around them (Association for Middle Level Education, 2013).

Another change that young adolescents encounter during this stage of life is moral and ethical development. Young adolescents start to view moral issues in shades of grey rather than strictly in black and white. They start to consider complex moral and ethical questions, yet are unprepared to cope with them (Association for Middle Level Education, 2013). Teachers need to recognize and capitalize on the relationship between young adolescents' intellectual development and their moral reasoning. They need to plan instructional experiences that foster higher order thinking skills and higher levels of moral reasoning (Association for Middle Level Education, 2013).
During early adolescence, emotional and psychological development is characterized by the quest for independence and identity formation. It is a time when young adolescents seek their own sense of individuality and uniqueness (Association for Middle Level Education, 2013). They are searching for an adult identity as well as adult acceptance, while striving to maintain peer approval. Young adolescents have a tendency to be moody, restless, and may exhibit erratic and inconsistent behavior including anxiety, bravado, and fluctuations between superiority and inferiority (Association for Middle Level Education, 2013).

The last characteristic that young adolescents endure is social development. Social development refers to a person's capacity for more mature interactions with individuals and groups. Young adolescents have a strong need to belong to a group—with peer approval becoming more important as adult approval decreases in importance (Association for Middle Level Education, 2013). They tend to test limits of behavior set by adults and usually try to challenge adult authority. Social maturity often lags behind physical and intellectual development. Consequently, young adolescents may overreact to social situations, ridicule others, and feel embarrassment. Young adolescents are also socially vulnerable due to influences of media and negative interactions with adults (Association for Middle Level Education, 2013).
CHAPTER THREE

METHODS

I began my research when my seventh grade mathematics class started chapter 9 on probability. I chose to use this chapter for my research because there are many manipulatives and activities that can be used to teach students probability. During my research, I used problem-based learning to help students better understand probability. Many of the activities I chose were *Math By All Means: Probability Grades 3-4* by Marilyn Burns (1995). Other activities and manipulatives were found on the internet and some were changed to better cater to my seventh graders.

Participants

At Rosewood Middle School, students have block scheduling for math and language arts. Because I had my students for ninety minutes, I had more time for my students to participate in each activity. Students from my block one and my block three were the students I chose to participate in my study. These students were in a basic seventh grade math class and moved through each chapter at the same pace. Test scores and averages from each class were very similar and both classes contained nineteen students. Block one received regular lessons and note given on the SmartBoard. Block three participated in problem-based learning using activities and manipulatives to enhance student learning. The students participated in an activity for every lesson in chapter 9. There were five lessons in chapter 9. The last lesson was broken down into two separate lessons because of the content. Therefore, students will be participated in six different activities.
Before I began chapter 9, I had the students take a short ten question pre-test as an introduction to the chapter. I used this pre-test to measure their prior knowledge about probability. The students were also asked to take a diagnostic test, which was required by the school district, before beginning any chapter in the book. These results were used to record student growth throughout the chapter.

Manipulative activities

Lesson 9-1 was the first lesson in chapter 9. This lesson teaches the students how to find the probability of simple events. By definition, a simple event is an outcome or a collection of outcomes (Burns, 1995). For example, rolling a dice is a simple event and the dice landing on a particular number is probability. Probability is the chance that any event will occur. The ratio that the students learned to use for finding probability compares the number of favorable outcomes to the number of possible outcomes. The students use an equation to solve probability of simple events.

The first manipulative was to teach the students probability using simple events, which correlates with lesson 9-1. I divided the students in to six groups each containing three students. The students were given a packet of worksheet that they were required to turn in at the end of the period. They were then given three brown paper bags that contained twelve tiles each, a styrofoam cup, six yellow and red counter, and a red and yellow colored pencil.

The first worksheet was for the game Shake and Spill. The students were given a worksheet were they were asked to show their work. The worksheet contained a chart with six boxes and within each box were six circles. The circles represented the number of counters in each cup. During this game, the students used the styrofoam cup, the yellow and red counters,
and the two colored pencils. The student put the six counters into the cup and shook them up. They then dumped the counters on their desks and counted how many red and yellow counters were laying face-up. The students used the red and yellow colored pencils to fill in the circles on their worksheet. These circles were used to represent how many counters of each color were lying on the desk. The students repeated these steps until they had done a total of six trials.

After the students had finished filling out their worksheet, I made a chart on the board to represent each situation that could occur: 6 reds, 5 red and 1 yellow, 4 reds and 2 yellows, 3 red and 3 yellow, 2 reds and 4 yellows, 1 red and 5 yellows, and 6 yellows. I had each student report their findings on the board. I asked them to use tally marks to represent the each event that occurred during their trials. The students soon realized that the most common outcome was 3 reds and 3 yellows. I had the students discuss why this happened with the members of their group and then share their responses with the rest of the class. The students were able to see that because they were using six counters, a 50% chance would be represented by 3 red counters and 3 yellows counters. Therefore, they had a 50% chance to choose either a red or yellow counter.

The next activity was called Tiles in Three Bags. The students used the brown paper bags containing 12 tiles in this experiment. Each bag contained 12 red blue and yellow tiles, but different amounts of each color. On the board, I wrote how many tiles of each color the bags contained. Bag A had six red, three blue, and three yellow tiles, Bag B had two red, eight blue, and two yellow tiles, and Bag C had one red, two blue, and nine yellow tiles. It was the student’s responsibility to figure out which bag they were using. Students were given a table to record all the information. Each student had to reach in to the bag and pull out a tile, record the color of the tile in the table, and then return the tile to the bag. They were asked to repeat this process thirty-six times and after the last time, they had to predict which bag they had and come up with
a hypothesis for their prediction. All of the students were able to correctly guess which bag they had and what color tiles the bag contained.

The next lesson was on tree diagrams and the Fundamental Counting Principle. Tree diagrams are used to represent sample space and fair game. Students learned how to draw tree diagrams to represent all the possible outcomes that could happen during a probability experiment. The Fundamental Counting Principle can also be used to find the number of possible outcomes in a sample space by using multiplication instead of tree diagrams.

During this activity, I asked the students to make a life-size model of a tree diagram expressing the possible outcomes of four different types of bread, three different types of lunch meat, four different types of cheese, and two different condiments. The students were divided into four groups and given all the materials they needed to complete the activity. I used construction paper to make the bread, lunch meat, cheese and condiments. The students use the construction paper cut outs to create their tree diagram. They were asked to glue everything onto the paper in the order that would represent the number of outcomes possible, also known as the sample space. Students were also asked to write down the amount of possible incomes on their construction paper.

The next lesson in chapter 9 was on theoretical and experimental probability. I wanted to spend more time on this concept because I thought that the students would find it difficult. I decided that I would teach the students the concept one day and use manipulatives the following day to help my students in block three better understand the concept. When teaching this lesson, I gave a note sheet to each student so they could take notes off the Smartboard. I had the students look up the definitions for theoretical and experimental probability. I then asked the students to explain what they thought each definition meant in their own words. The students
agreed that theoretical probability was what was supposed to happen and experimental probability was what actually happened during a probability experiment.

The following day, students in block one worked on theoretical and experimental probability worksheets and they were given the opportunity to ask as many questions as they wanted. They were also given an assignment in class for homework and given the remainder of the period to work on it.

The students in block three were asked to participate in three different manipulatives that would help them better understand theoretical and experimental probability. I had the student work individually during the first two activities to ensure that everyone was grasping the concept before I broke them into groups for the final activity. I also wanted each student to know how to solve both theoretical and experimental probability before the group work to keep all students involved, instead of just one student doing all the work.

The first manipulative used to expand knowledge on theoretical and experimental probability was rolling a die. I gave each student a worksheet that was labeled “Reality Check” and a die. Students were asked to roll each die 100 times and keep track of how many times they rolled a four with a tally mark. According to what the students know about probability and calculating percentages, they were able to figure out that the probability of rolling a 4 on a single die was 1 out of 6, which converted to a 17% chance to roll a four. After each student finished rolling the die 100 times, I had each of them record what their experimental probability was of rolling a four and then convert it to a percent. The students were very anxious to see whose probability was closest to the actual percentage. After everyone had finished the first trail, I asked them to do two more trials, but this time rolling a six and then a one. The students really seemed to enjoy this activity.
The next activity required the students to perform an experiment using M&M’s to prove experimental and theoretical probability. Each student was given a separate bag of M&M’s, either peanut butter, peanut, or plain chocolate, and asked to work individually. The first step in the experiment was to predict how many of each color of M&M’s there were without opening the bag. After the student predicted the colors, they were asked to perform ten different trials pulling an M&M from the bag, recording the color, and replacing the candy back into the bag. After each student completed all ten trials, they were asked again to predict how many of each color was in the bag. Because the students executed the trials, they were able to make better predictions as to what colors were actually in the bag. The students were then asked to dump the contents of their M&M bag on to their desk and record what was actually inside each bag.

After emptying the M&M’s onto their desks, the students were to write the theoretical probability for each color candy and then the experimental probability of each color. The activity sheet required the students to explain the difference between their predictions and actual results. I decided to have the students make a table or chart to record their results.

Table 1.

<table>
<thead>
<tr>
<th>Color</th>
<th>Prediction</th>
<th>Actual</th>
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<td>Brown</td>
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</table>
After the students had recorded their results in the chart, they were asked to make a double bar graph to denote the difference between their predictions and actual results. After the students had finished this activity, they were allowed to eat the M&M’s.

Another manipulative that I used to enhance learning for experimental and theoretical probability was a simulation on the Smartboard using a spinner containing red, orange, green, and blue sections. The students were given a worksheet on which they could record their data. I asked a student from the classroom to go the board and spin the spinner fifteen times. All of the other students were to keep track of each spin and the color where the spinner landed. After all fifteen trials, the students had to answer the questions on the worksheet about experimental and theoretical probability.

The next simulation involved using a six digit die on the SmartBoard. One student was asked to come to the front of the class and roll the virtual die forty-two times. The other students in the class had to keep track of how many times the dice landed on each digit using tally marks. Once all forty-two rolls were complete, the students answered questions about experimental and theoretical probability using a die.

The last lesson in chapter 9 was on independent and dependent events. An independent event is an event where the outcome of one event does not affect the outcome of another event. In other words, two separate events are happening and they do not affect each other. A dependent event is an event where the outcome of one event does affect the outcome of another event. Students have most difficulty understanding dependent events because the first event is changing the second event in some way. I knew students would have trouble realizing the difference between independent and dependent events so I chose an activity that would keep them interested and would be easy for them to understand.
Students were divided into groups for three or four students. The students were given a worksheet that contained questions about independent and dependent events that they would be required to answer throughout the activity. The students were given a brown paper bag containing eight cherry, eight strawberry, eight apple, and eight banana Laffy Taffy candies. Students were to answer questions about independent events such as:

- What is the probability of choosing a banana Laffy Taffy?
- What is the probability of choosing a banana and then a cherry Laffy Taffy?
- What is the probability of not choosing an apple, and then choosing a strawberry?

Students were asked to remove taffy from the bag and not replace them to find the probability of a dependent event. Questions included:

- What is the probability of choosing a cherry taffy?
- What is the probability of choosing a strawberry and then choosing a banana if there is no replacement?
- What is the probability of choosing an apple taffy?

After the student finished this phase of the activity, they were told to divide the taffy up evenly between all of the members of the group. They were given the rest of the period to clean up and begin their homework assignment.

The post-test was given to the students the day before the chapter 9 test because I did not want them to feel pressured to finish everything before the end of the period. I used the same assessment for both the pre- and post-test so I could visualize how much knowledge the students gained during the chapter. The students were given the chapter 9 diagnostic test and had the entire period to complete the test. The diagnostic tests are standardized, so the students had to fill in a bubble sheet and scan it themselves. A tops report is printed that shows students their results.
and what questions they missed. It also shows them what answer they chose in contrast to the right answer.
CHAPTER FOUR
FINDINGS

The activities that were described in chapter three were all used to help the students gain a better understanding of probability and how it can be used outside the classroom. Each manipulative represented another section of the probability unit and I used these activities to measure students’ knowledge during the chapter instead of giving quizzes every other day. I noticed that the students enjoyed this aspect of learning much more than homework and quizzes.

The first manipulative activity that the students participated in during my research was on simple events. This activity included Shake and Spill and Tiles in Three Bags. Simple events are the building blocks to probability and it was very important that every student understood this concept before the class moved forward to tree diagrams and The Fundamental Counting Principle. All of the students seemed to grasp the concept of simple events and I decided that students were ready to move on to the next lesson.

I combined tree diagrams and The Fundamental Counting Principle into one lesson because once the students understood tree diagrams The Fundamental Counting Principle was rather self-explanatory. The students really enjoyed the activity for tree diagrams because it was a hands-on lesson and required them to get up and move around the classroom instead of just sitting at their desks for 90 minutes. Once I realized how much the students appreciated this lesson, I tried to incorporate similar activities into my daily lessons. I also found that this type of lesson was also more enjoyable for me as well. It was very gratifying to observe my students enjoy math class as much I enjoyed teaching them.

The next manipulative I used was to represent theoretical and experimental probability. I knew going into this lesson that it might be a difficult concept for students so I wanted to make
sure I used my time wisely. I spent extra time on this lesson and had the students participate in
two different activities. By the end of these activities, the students were able to give me the
definitions of theoretical and experimental in their own words and explain to other members in
the class how to solve these types of problems.

The lesson that I found the students had the most difficulty with was independent and
dependent events. This lesson was more complex than any other lesson because it involved
thinking logically about what was happening and whether the denominator or numerator was
going to change during the problem. When this concept was first introduced, I prepared several
example problems on the note sheet. I also spent almost the entire 90-minute class period
working with individual students and on the board. I found that students seemed to struggle the
most with dependent events. Dependent events depend on each other and it took several class
periods for students to understand that detail.

After the manipulative activities for independent and dependent events the students began
to understand this concept better. For example, I overheard the students in block three, who
participated in student-centered and problem-based activities, talking about how much they were
learning in math class. They were also telling their friends, who were not in the same class, about
how much fun they were having. This was a complete change from the beginning of the year and
it was interesting to see change in the students when they actually enjoyed the lessons.

Test scores

All data was entered into a Microsoft Excel spreadsheet to calculate the mean, median,
mode and range of pre and post-test score of the block one and block three. Both sets of data
were then compared to determine whether problem-based learning made a significant difference
in student test scores.
The pre and post-test were scored by a scantron machine and the results were then recorded into the grade book. Students were able to get immediate feedback from the scantron machine. The students were asked to turn in their tests so they could be reviewed and then recorded. Each class had 19 students; block one had 11 males and 8 females and block three had 10 males and 9 females. Gender did not have an impact on the results of my research.

Table 1. Total scores

<table>
<thead>
<tr>
<th></th>
<th>Block 1</th>
<th></th>
<th>Block 3</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
<td></td>
<td>Pre-test</td>
</tr>
<tr>
<td>Mandy</td>
<td>9</td>
<td>10</td>
<td>Cody</td>
<td>16</td>
</tr>
<tr>
<td>Hanna</td>
<td>9</td>
<td>23</td>
<td>Cory</td>
<td>8</td>
</tr>
<tr>
<td>Drew</td>
<td>16</td>
<td>28</td>
<td>Peyton</td>
<td>17</td>
</tr>
<tr>
<td>Isaac</td>
<td>9</td>
<td>14</td>
<td>Dominick</td>
<td>14</td>
</tr>
<tr>
<td>Henry</td>
<td>15</td>
<td>15</td>
<td>Joe</td>
<td>14</td>
</tr>
<tr>
<td>Jase</td>
<td>15</td>
<td>13</td>
<td>Kenzie</td>
<td>17</td>
</tr>
<tr>
<td>Trevor</td>
<td>8</td>
<td>11</td>
<td>Chelsea</td>
<td>15</td>
</tr>
<tr>
<td>Jimmy</td>
<td>10</td>
<td>25</td>
<td>Heather</td>
<td>22</td>
</tr>
<tr>
<td>Chris</td>
<td>11</td>
<td>18</td>
<td>Nikki</td>
<td>18</td>
</tr>
<tr>
<td>Kayla</td>
<td>9</td>
<td>10</td>
<td>Steven</td>
<td>15</td>
</tr>
<tr>
<td>Trenton</td>
<td>14</td>
<td>14</td>
<td>Jake</td>
<td>10</td>
</tr>
<tr>
<td>Ashley</td>
<td>16</td>
<td>22</td>
<td>Brandon</td>
<td>15</td>
</tr>
<tr>
<td>Justin</td>
<td>16</td>
<td>27</td>
<td>Brian</td>
<td>9</td>
</tr>
<tr>
<td>Elijah</td>
<td>15</td>
<td>16</td>
<td>Devon</td>
<td>14</td>
</tr>
<tr>
<td>Bailey</td>
<td>11</td>
<td>13</td>
<td>Nathan</td>
<td>6</td>
</tr>
<tr>
<td>Kendra</td>
<td>15</td>
<td>10</td>
<td>Liz</td>
<td>12</td>
</tr>
<tr>
<td>Wyatt</td>
<td>20</td>
<td>26</td>
<td>Morgan</td>
<td>10</td>
</tr>
<tr>
<td>Brad</td>
<td>19</td>
<td>17</td>
<td>Josh</td>
<td>15</td>
</tr>
<tr>
<td>Jessica</td>
<td>10</td>
<td>18</td>
<td>Auja</td>
<td>13</td>
</tr>
</tbody>
</table>

Block one included students in my first and second period class as well as in my homeroom. This class received student-centered and textbook-driven lessons every day. Class started at 7:50 a.m. and ended at 9:25 a.m. This class was also my intervention class. It included three students who had an Individualized Education Plan (IEP) and three students who had a 504 plan. Mr. Fisher, a pseudonym, who was our seventh grade intervention specialist, attended this class every day and worked individually with students who had an IEP or a 504 plan.
Block one was not chosen to be the experiment group for several reasons. Before I began my research, I did a trial run with both blocks to see which class reacted better to group work. Unfortunately, several students did not react as well as I had hoped. One student refused to work in his assigned group and started causing a scene making the other students feel very uncomfortable. Another student requested that he be given bookwork because he “didn’t like” the other students in his group. This became very frustrating and I began to wonder whether block one would be able to serve as the experiment group. Another reason this block was not chosen as the experiment group was because of the 504 plans that required two students an extended amount of time on all assignments. Because all the manipulative activities needed to be finished during class, students were only given 90 minutes to complete assignments. This became a problem when adhering to the guidelines of each individual 504 plan.

Trenton was one student who had great potential, but did not attend school regularly. He would miss two or three days a week and it was difficult to keep him up to date with all the assignments he missed when he was absent. Usually by the time I got Trenton caught up with all of his work, it was time to take a chapter test and began a new chapter. Trenton always received mediocre grades and he was pleased with those grades. I expected him to perform better than he did on the post-test because he thought probability was interesting.

Justin was another student who I thought had great potential. He hardly ever missed school and always turned his assignments in on time. I feel that Justin would have benefitted from participating in the manipulative activities that were used in block three for several reasons. He was a very hands-on learner. He loved to do problems on the board and participate in review games for chapter tests.
Isaac and Maddy were two of my students that often found themselves in trouble for one thing or another. Maddy was expelled the year before for bringing a knife to school and threatening another student. Trouble seemed to follow her everywhere she went and usually she found herself in the principal’s office. Maddy also gave my cooperating teacher an attitude every time she spoke to her, but for one reason or another, I never had an issue with her. Isaac missed several weeks of school when he tried to take his own life. He was being bullied because of the way he chose to dress and the color of his hair. Isaac became a very sensitive subject for all the teachers in the seventh grade wing.

Bailey and Kendra would often work together on assignments outside of the classroom. I believe they would have been perfect candidates for problem-based learning. Both struggled with certain concepts in math such as the distance and midpoints formulas, but probability never seemed to be difficult for either one of them. I expected both of these girls to perform better on the post-test because they always asked questions during the lessons and would come in for extra help when needed.

Elijah and Henry competed against each other on everything. From the field to their grades, they were constantly battling to see who was better. They would also race to see who could finish the test the fastest. This became an ongoing problem throughout the year because the boys were not performing to their full potential. At one point, my cooperating teacher had a meeting with Elijah’s mother and informed her of the situation involving Elijah and Henry. After Elijah’s mother spoke to him, the situation got somewhat better and he began taking class more seriously.

Chris, Trevor, and Hanna were the students who had an IEP and received extra help from Mr. Fisher. These students were also given tests that included accommodations. I do believe that
the significant increase in grades for these three students was due to the modified version of the test. Hanna’s scores had the most dramatic increase out of these students. Depending on the day, Hanna would either love math class or hate math class. Hanna hated coming to school because she was bullied by some of her other peers. Trevor’s IEP was mainly for language arts because he had 1st grade reading level. This made taking tests for him difficult because he could not read most of the problems. Chris, who had a math level of a 2nd grader, struggled immensely in math. Throughout the year, I felt that Chris was not in his least restrictive environment because he was constantly falling behind on every lesson.

Kayla, Brad, and Jase had a 504 plan. All three of these students had to be removed from the class setting to complete any assessment given during class. Mr. Fisher would take these students, along with the three students with IEPs, to his classroom and administer the test. Because of students with reading difficulties, Mr. Fisher would read the assessment to all the students in the classroom. There was no significant increase or decrease in Kayla, Brad, or Jase’s test scores.

The two students who had the most significant increase in tests scores were Drew and Jimmy. Throughout the year, these students received the highest scores on most of the assignments. Drew loved math and was always willing to work out problems on the board. When Jimmy applied himself, his grades improved. These two students would have also benefitted from problem-based learning and student-centered instruction.

Block three was my eighth and ninth period class and the block that received problem-based learning and student-centered instruction. This class was 12:50 to 2:25 and none of the students in the class had an IEP or a 504 plan. None of these students were pulled out of class for assessments and they did not receive extra help from an intervention specialist.
Josh, Morgan, Liz, Nathan, and Auja all transferred to Rosewood in January 2013. They struggled to find where they belonged among the other seventh grade students in terms of social groups. Auja moved from Portland, Oregon to Ohio and encountered a huge difference in culture than what she was used to in Oregon. She would get frustrated easily with the lesson because her old school was much further along in the curriculum than my class. Morgan, Nathan, and Josh transferred from neighboring counties and schools whose curriculum corresponded with what we were learning at that time. Liz moved to the school because her uncle, who was a seventh grade teacher, gained custody of her for the rest of the school year. These three students all responded positively to problem-based learning and their grades improved from the pre-test to the post-test.

Brian, Brandon, and Jake responded very well to problem-based learning. During the lessons, like Kenzie and Chelsea, the boys were able to relate the manipulative activities to the lessons they learned the day before in class. They were able to recognize which concept we were experimenting with and use their problem solving skills to finish each activity correctly. After the unit was finished, these three boys would ask about other activities that could be incorporated into the lessons.

The two students who had the most significant increase in grades were Chelsea and Kenzie. These two also scored the highest in the class. Both of these girls were very attentive and class and eager to learn. I believe that one of the main reasons these girls did so much better on the post-test was because of the use of manipulative activities. They realized that the manipulative activities were all connected to lessons that were being taught in class at the same time. They were able to use definitions and keywords to figure out the outcome of each manipulative.
The only students whose scores decreased from pre-test to post-test were Devon and Steve. Devon typically failed to pay attention, often talked to his peers, spent time drawing on his note sheet or day dreaming. Furthermore his home life appeared to a large impact on his academic performance as he often mentioned that his mother was a single parent who not around much nor able to help him with his school work. Steven’s grade dropped by three points from the pre-test to the post-test. He was the only student whose seat assignment had to be moved throughout the year. He resisted my instruction. While I thought he disagreed with my teaching methods, I soon realized that many of his friends were in the same class and he was trying to show off.

Heather was one student who I thought would respond very well to problem-based learning. She was very artistic and enjoyed working collaboratively with other students. She was also great with tutoring other students on difficult concepts. One of the reasons her grade may have been lower on the post-test than the pre-test was because she missed several days of school during the probability unit making it very difficult for her to catch up on everything she had missed.

The remaining 7 students in block three had an increase in post-test scores. The increase ranged from 1 point to 6 points. Some students responded better to problem-based learning and student-centered instruction than others. My cooperating teacher used teacher-centered instruction as her only method of teaching. She never allowed the students in any of her classes to participate in group work or in class activities. This made the transition to problem-based learning and student-centered instruction more challenging for me. This method was completely different from what the students were used to and it required them to use prior knowledge to
solve real-life problems. After a few days, the students began to adapt and grow from this type of instruction.

Because of the increase in grades, I would speculate that problem-based learning and student-centered instruction helped the students’ gain better understanding of concepts on probability. Because every student in this class was so different, it was hard to determine whether each student benefitted from problem-based learning and student-centered instruction. I would have liked to spend more time on the unit and introduce new manipulative to the students, but I was only given a two week time frame to complete the lessons in the probability unit. The manipulative activities used during this unit helped many of the students remember important information, but not all of the students.

Using Microsoft Excel, I calculated the mean, median, mode, range, and standard deviation of the pre and post-tests for both blocks. The test was worth 30 points and each student was given 90 minutes to complete the entire exam. The results from each of these tests are presented in Table 2.

Table 2. Descriptive statistics.

<table>
<thead>
<tr>
<th></th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Block 1</td>
<td>Block 3</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>13</td>
<td>13.7</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td><strong>Mode</strong></td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td><strong>Standard Deviation</strong></td>
<td>3.7</td>
<td>3.8</td>
</tr>
</tbody>
</table>

The mean represents the average of all the test scores that were recorded. Block 1 was the control group whereas block 3 was the experimental group. When comparing the post-test scores from block one and three, both blocks’ scores showed nearly similar levels of
improvement. The mean for block 1 increased by 4.4 points whereas the mean from block three increased by 4.1. Block that received student-centered and problem-based learning. The difference in the pre-test and post-test mean narrowed from .7 to .4, suggesting greater improvement in block 1 than in block 3.

The median represents the mid-point value between the lower and upper 50% of all scores. The median in pre-test was the same in block 1 and block 3. In block 1 the median shifted in a positive direction from 14 to 16, while the median in block 3 shifted from 14 to 18. This data indicates that students in block 3 performed better than those in block 1.

The mode represents the score that occurs most frequently in the data set. The pre-test mode in block one was 9, while the pre-test mode in block three 15. This pattern repeated itself in the post-test with a mode 10 in block 1 and a mode of 20 in block three. Whereas the mode in block 1 improved by 6 points, the mode in block three improved by 10 points, suggesting a greater positive effect due to a problem-based approach to learning.

The range is the difference between the lowest and highest scores. The range in both blocks increased from the pre-test to the post-test. Whereas the range in block one increased from 12 to 18, in block three it also increased from 16 to 19. While the range in block one in increased by 6, in block three it increased by 3, suggesting a somewhat greater central tendency around the mean. Because block one was my control group, they did not receive problem-based lesson and this had no effect on my results for the experiment group. Nonetheless the increase in the range in both blocks indicates greater outliers and that differences in student performance increased rather than decreased.

Block one was an intervention class that include three students with an IEP and three students with a 504 plan. These students were allotted more time on all assignments and were
removed from the regular classroom to take any tests. I also think that grades were lower in block because of the student who had either a 504 plan or an IEP.

The standard deviation represents how much variation exists from the mean or average of the data set. The standard deviation was nearly similar on the pre-test in both blocks. Consistent with the data on the range, while the standard deviation increased in block one as well as block three, in block one increased by 2.4 from 3.7 to 6.1, in block three it increased by 1.1 from 3.8 to post-test 4.9.

Reactions

The students in block three had never experienced a student-centered learning or problem-based learning approach to learning. The only method of instruction they knew was teacher-centered. I spent many hours prior observing the students in both blocks sit through lectures and work on assignments. I decided that my Master’s Research Project would offer an avenue for introducing problem-based and allow students to think outside the box.

This chapter has offered several reasons above why block one was my control group instead of my experimental group. Several students in block one proved to resist cooperation in the classroom and chose to or were unable not follow directions. Their classroom demeanor did not appear to be conducive group work or the manipulative activities. The following are some typical quotes from students in block one:

- “Miss Antonik, I do not want to work with the other kids in my group. I don’t like them.”
- “This is stupid; I don’t want to do this. Can’t I just work out of my book?”
- “Why do we even have to do this? I’m not learning anything anyways.”
- “I don’t want to go over the homework today. It takes too much time. I’d rather work on our assignment for the rest of the period.”
The first activity the students in block three participated in appeared to work well. I divided them into groups and for the first time I observed them enjoying math class. As they cooperated during the manipulative activities, I noted that the students were gaining a deeper understanding of probability concepts.

On several occasions the students in block three stopped me in the hallway to ask questions about what they were going to be doing in class that day. In fact, the enthusiasm displayed by the students in block three was such that students in block one began to ask me questions about the manipulative activities. Some typical enthusiastic comments by students in block three were:

- “Miss Antonik, what are we doing in class today? Are we going to get to eat candy again?”
- “This is so much more fun than just doing homework all the time”
- “Miss Antonik, when you have your own classroom, your students are going to love you!”
- “Don’t you remember? We did an activity on that. Remember the M&Ms. That was experimental and theoretical probability. And then we got to eat them!”
- “I remember this because we did the experiment with the dice. We had to roll is 100 times and see how many times we rolled a 4.”
- “Math is one of my favorite subjects because we have so much fun”
- “Miss Antonik, are we going to be doing more fun activities like this? I really like drawing the life size tree diagrams. Would it be ok if I took this home and showed my parents?”
These quotes provide evidence that the students appreciated and enjoyed the manipulative activities used during the probability unit. Although the manipulative activities may not have had a positive impact on test scores, I believe that the change in instruction did have a positive impact on the way these students felt about mathematics.
CHAPTER FIVE

CONCLUSIONS AND IMPLICATIONS

Implications

Every student who attends a public school in the state of Ohio is required to take the Ohio Achievement Assessment (OAA) at the end of the school year. Educators are also mandated to teach a set of standards that are used to prepare students to take the OAA. The standards used for this Master’s Research Project were the Ohio Academic Content Standards. Teachers are to create a curriculum around these standards and are required to cover all of the standards before the OAA. Teachers must think of ways to help students remember concepts from the entire school year that will be on the test. This test is given during the month of April giving teachers eight months to cover all the necessary material.

One way that has been known to help students better remember information is by using problem-based learning. During problem-based learning students are given a problem and asked to work in a group to solve the problem. The classroom switches from teacher-centered to a student-centered classroom allowing the teacher to be more involved with hands on tasks rather than lecturing the entire class period.

I used my research project to test the theory that problem-based learning helps students retain information more thoroughly because it allows them to have hands on experience with concepts. I chose to perform my research during a probability unit in my seventh grade classroom. Unfortunately, because teachers are required to cover a set of standards before students take the OAA, I was only given two weeks to complete the chapter and my research. I felt that this was not enough time to complete the amount of work required for this unit and allow extra time for group work and problem-based learning activities. This time included
complete lessons and activities on simple events, tree diagrams, The Fundamental Counting Principle, complementary events, compound events, independent and dependent events, and theoretical and experimental probability. I would have liked to spend more time working with my students on experimental and theoretical probability and independent and dependent events.

A pre-test and post-test were given at the beginning and end of the chapter to test prior and post knowledge of each one of the students. Unfortunately, both pre and post tests were designed by a program used at Rosewood Middle School called Accelerated Math. This program was used to make pre and post tests for every chapter. The tests were scored by a scantron machine and the results were reported to the principal at the end of every chapter. The students were able to see their scores immediately and I then recorded them in the grade book.

The problem that I encountered when looking over the tests was that the Accelerated Math program was placing problems on the test that the students had not learned and would not be covered until the following year. Students were having difficulty with these problems because they had not been taught how to solve them yet and I was unable to help them because it was a test.

Another problem that I became aware of after the students had taken the pre and post-tests was that the program was actually marking problems incorrect that were correct. The students seemed to be missing a large amount of the independent and dependent event problems. After taking a closer look at the tests, I discovered that there was a glitch in the computer system and that was why many of the students were missing these problems.

The final implication that I believe had an impact on the results of my Master’s Research Project was student attendance. Many of the students who were in my classes would miss several days at a time making it difficult to catch students up on work they missed. Attendance also
became an issue when administering the pre and post-test. Students were given three days to complete all make-up work that they missed when they were absent and if they had not completed all make-up work within those three days, scores resulted in a zero. Fortunately, the pre and post-test results were reported to the principal so every student was able to take both tests.

Suggestions for future studies

Future studies might involve including manipulative activities in the intervention class instead of in the regular class. Another option would be to include manipulative activities in both classes which would allow for an analysis of whether class composition and prior knowledge is a contributing factor to differing levels of progress.

Future studies could also include an in-depth analysis of a control group that received teacher-centered direct instruction which would provide a basis for a comparative analysis. Such a comparative analysis could also focus more on individual students through in-depth assessments, surveys and interviews.

Furthermore, future studies could examine the extent to which the number and kind of manipulative activities impact learning outcomes. This should include continuous assessment of mastery of concepts.

Finally, future research should be the outcome of original assessments developed by the researcher rather than consist of publishing company programs such as the Accelerated Math program that was used to create all chapter tests at Rosewood Middle School.

Conclusion

When I conducted my research in these two middle school classrooms, I was hoping that the students who received student-centered instruction and problem-based learning would gain
greater knowledge of probability. I was also hoping that the test scores from this class would prove that problem-based learning and student-centered instruction helps students retain more information. Unfortunately, these were not the results that I got when I analyzed my data.

Although the test scores from block three did improve, I do not believe that it was due to the manipulative activities. There was no significant increase in the mean, median, mode, range, and standard deviation that would suggest that the manipulative activities had an impact on student learning. These were not the results that I anticipated because the students had never experienced problem-based learning before the start of this unit. I expected the students to thrive and learn so much more through this method of teaching.

The findings in this Master’s Research Project suggest that when my students enjoyed learning, I enjoyed teaching more. After looking at the results from my research, I realized that the students also learned more because I was able to work with them individually. When the students worked together in groups, they were able to use the other students in the group as resources and learn from each other.

After taking the time to prepare each activity and implementing them into my class, I know that this is the way I want my classroom to be. I want students to enjoy coming to my class and have fun, but still learn the standards needed to pass any standardized test at the end of the year. Incorporating activities and manipulatives into each class can take much more time than lecturing, but from my experience, I know that students retain information better.

I do believe that problem-based learning had a positive impact on student learning in this probability unit. I felt that students were able to take the information learned during the lesson and apply it to the manipulatives helping create a better understanding of the topic. I also believe that the students enjoyed the lessons and this made them eager to learn new and exciting
concepts. Students were also able to relate information from the classroom to events outside the classroom.

Prior to my Master’s Research Project, my students were never introduced to any type of problem-based learning. Their instruction was strictly teacher-centered and they were never permitted to work in groups or use manipulatives to enhance learning. I believe that the manipulatives used during my research sparked student interest because it was something new and exciting to them. These activities were used to show the students that mathematics does not always have to be memorization and homework.
References


