Inquiry-Based Teaching Strategies in Middle School Math and Science
Motivate Students to Learn and Achieve

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Chair: Stan Schmidt, PhD
Abstract

While considering the difficulties that American educators have getting their students to perform competitively with global schools in math and science, the task of helping students achieve better has many facets and can be daunting and overwhelming. This research project will focus on the assessment of one factor in that large task: motivating students to learn math and science. Motivation comes from different places in different kids, but it is assured that engagement is the key, and my study will focus on inquiry-based education as the motivator. The students participating are 8th graders from Leslie Middle School in Salem, Oregon, to whom I taught a two-week unit on probability and its uses. The data collected includes data available (records, modifications, grades, etc.), attitude surveys, focus group discussions and reflections, classroom observations, and pretest/posttest scores. These data were analyzed using content and ethnographic analysis to determine if inquiry-based learning is a key to motivation to all learners.
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CHAPTER ONE: INTRODUCTION TO THE PROBLEM

Introduction

The following document describes an action research project that studied the effects of an inquiry-based math and science teaching unit on the motivation that students have to learn. Much of the research that is discussed leads me to understand that motivated students are high-performing students. They are eager to learn and take pride in their progress and achievement. This project allowed me to study carefully the effect in my own classroom.

Summary of Instructional Problem

There is a real concern in the United States about student achievement in middle level mathematics and science education. The problem can be—and is—blamed on several different events: NCLB mandates (including standardized tests), inability of teachers to teach other than “to the test,” and the lack of education and experience of science faculty (Kilpatrick & Swafford, 2002). The most common and current strategies and methods of teaching science have been turning students off to the excitement and wonder of math and science at an early age (American Association for the Advancement of Science, 1990; Patrick & Yoon, 2004; Pyle, 2008; Windschitl & Thompson, 2006).

Symptoms of this problem are seen throughout the ages as students advance from elementary to high school. First, students at elementary levels are driven to ask fewer and fewer questions—to become less and less curious—as time goes by; those same students, by age 12, have been well trained to stop asking questions and to go along with what the curricula state and the tests ask (AAAS, 1990; Donovan & Bransford, 2005).
Second, too many math and science teachers state that they have no time to concern themselves with students’ curiosities or making science exciting; they barely have enough time to get them ready for state-mandated tests. Teachers are hard-pressed to prepare science labs, investigations, experiments, or other curiosity- and inquiry-driven lessons, since they are so worried about driving the facts into their lessons (Pyle, 2008; Windschitl & Thompson, 2006).

Finally, the comparison of U.S. students with global counterparts is troubling to educators and policymakers who believe we are handicapping our next generation in an increasingly global and highly competitive economy. Since the 1990s, American 8th grade students have consistently underperformed on international assessments against 16 other nations in science and 23 nations in math (out of a total 30 industrial and technological nations) (AAAS, 1990; Kilpatrick & Swafford, 2002).

Middle school students—especially minority students—who listen to lectures, read textbooks, learn vocabulary, and watch videos are being taught that math and science are bodies of knowledge that authorities in their fields have collected and confirmed. They learn quickly that the fields are difficult to understand and read. They have been taught that their questions are moot, even unappreciated, since the work has already been done. These students have been taught that math and science are static and developed for them to learn, not to practice and not to question (AAAS, 1990).

Current state

As my mentor pointed out recently, inquiry is something everyone seems to be talking about, but not many teachers are practicing. It’s just too easy to resort back to the old, traditional ways of lecturing, assigning reading from the textbook, and testing (personal communication,
Many teachers will point to their individual teaching methods and strategies proudly to proclaim that they are doing things differently and effectively, and many of them are right. Science and math teachers are working in a system where they have to find the best ways to teach, often without support or training from the districts or universities from where they expect such support.

The focused problem that I wanted to address during the project is the continuing lack of motivation and achievement among subgroups (ELLs, minorities, special needs students, etc.) in math and science, as compared to higher performing subgroups. Also, while these subgroups are making gains in the Salem-Keizer School District, their scores still lag significantly behind those of the “mainstream.” I recognize this as a multifaceted problem, and believe that one way to achieve a narrowing of that gap is to discontinue the traditional models of science and math education (which have been shown by a growing body of research to be ineffective) in favor of an inquiry-based intervention.

**Desired state**

The intervention that I studied during this action research project is the use of inquiry in an integrated math and science unit. The desired state is finding a strategy, method, or system that would—to the best of its ability—be inclusive, engaging, and successful to all students of all backgrounds and abilities. So far, inquiry learning seems to have the most promising mechanisms in place to make that happen.

It would be ideal to see classrooms where students are active learners, taking responsibility and initiative for their learning. Unfortunately, traditional behaviorist and many cognitivist models of teaching do not make room for active learning. Inquiry learning is a
constructivist model: students ask questions, form hypotheses, investigate problems, conclude from research and evidence, and communicate their findings to their peers. While not all lessons can be taught this way, inquiry learning is the most promising strategy for all students to learn skills and concepts, especially in mathematics and science.

Research Questions

My focused research questions are as follows:

1. When math and science material is learned through inquiry-based teaching methods, is there a significant increase in student understanding? This will be measured using a paired $t$–test.

2. How do students feel about their learning when inquiry-based teaching strategies are used in their math and science classroom? This will be discussed and measured using Likert-scale data, observations, and student reflections.

CHAPTER 3: METHODOLOGY

Introduction

The methods and instruments used to collect data are those that are common to action research. I have read in many sources that too many different sources of data can be overwhelming and can lead to frustration. Keeping this in mind, I also wished to have several different methods of data collection to use in order to triangulate and confirm the data that I collected. The methods and instruments I chose appear to fit the action-research project I chose well and I listed them in this section, headed by type and briefly described.
Participants

Table 1

General Demographic Information of Learners. Total number of students: 56.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Data Collected</th>
<th>Resources Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>44 students are 13 years old (69%)</td>
<td>Electronic attendance database</td>
</tr>
<tr>
<td></td>
<td>12 students are 14 years old (19%)</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>30 students are male (61%)</td>
<td>Electronic attendance database</td>
</tr>
<tr>
<td></td>
<td>26 students are female (39%)</td>
<td></td>
</tr>
<tr>
<td>Cultural/ethnic background</td>
<td>53% of students are Caucasian (non-Hispanic)</td>
<td>Electronic attendance database</td>
</tr>
<tr>
<td></td>
<td>30% of students are Hispanic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8% of students are African-American</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5% of students are Asian/Pacific Islander</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3% of students are Native American</td>
<td></td>
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<tr>
<td></td>
<td>4 students are multiethnic (6%)</td>
<td></td>
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<tr>
<td>Special needs</td>
<td>8 students have IEPs/special needs (13%)</td>
<td>Student data folders</td>
</tr>
<tr>
<td></td>
<td>10 students are talented and gifted (TAG) (15%)</td>
<td></td>
</tr>
<tr>
<td>Language</td>
<td>11 students are English Language Learners (17%)</td>
<td>Student data folders</td>
</tr>
</tbody>
</table>

Description of Research Instruments

Readily available data

Data in this category will include ethnographic, cultural, and demographic data; student grades; attendance records; and student journals and reflections. One more large measure of the efficacy of the intervention was comparing the first round of standardized testing with the second round. Those data are also readily available.

Quantitative Data

This data will be collected from a pretest and posttest that contain different items that will test the same skills. All three class periods will receive the same tests.
Qualitative Data

Survey. One of the most important data that I can collect for this action research is student attitude. Using this method of data collection, I got snapshots of the attitudes of the entire group of students at different points in the action research period. One of my main questions is whether inquiry-based intervention will motivate students to learn, and attitude is a major indicator of motivation.

Observations. Observing students at work in a classroom where the intervention is being studied is an important method of data collection. My observations were kept in a journal, where I recorded field notes of student interactions, questions, resolutions, and understandings. This is the area where my bias may be the strongest affecter, so I also kept track of my own feelings, reflections, and thoughts.

Focus and reflection group. Finally, I collected qualitative data through partially-structured interviews with a total of 9 students (three students selected from each class period). The questions asked were open-ended and student-led (in other words, I allowed the student responses to lead me to my next questions and developed new questions to lead me into a deeper understanding). I was generally looking for feedback related to attitude and motivation, and reflection based on gender and ethnicity.

Research Design and Procedure

Before beginning the learning unit and collecting data, I believed it was ethical and beneficial to make students and parents aware that I was performing the action research project in their classes, and that I would be collecting data as we moved through the unit.
The unit to be observed built upon skills previously learned about the use of probability and statistics. Prior to the unit of instruction, I had students participate in a brief, one-period re-introduction to basic probability concepts. This included old examples using marbles, dice, playing cards, and even socks in a drawer. I used this period as the “activating prior knowledge” step of my unit.

The next day, I administered a pretest to all level 3 students, which included the skills that would be learned over the next two weeks (the test items are found in Appendix F). A posttest was administered after the completion of the unit, using the same skills and concepts—and fundamentally the same questions, although with the numbers and scenarios slightly changed. A pretest-posttest system collected quantitative data related to learning the material.

Many practice scenarios were introduced, which gave students the practice and guidance needed to ask questions about variable relationships, collect data in tables and graphs, and create experiments of their own to determine theoretical and experimental probabilities.

Finally, a student project was assigned in which students chose a relationship to study, asked questions about that relationship, formed hypotheses about the questions, collected the data to answer those questions, and derived results and conclusions.

The most important parts of the procedure were the ongoing observations I made during class time. Using an inquiry intervention in my lessons means allowing students to work cooperatively and to ask questions. While I was leading them with questions related to the objectives and modeling of certain procedures, the work they did independently was my focus while observing. I listened to their conversations, trying to find their use of trade and academic
language while working through their investigations. Finished work was an indication of how well they were learning the concepts being presented and how well they were developing the skills that inquiry-based education requires. These observations are what I, the observer, journaled about regularly.

At the beginning of my needs analysis, I gave my students a questionnaire, regarding their attitudes toward their math and science education in middle school. I repeated that questionnaire (with some alterations) with my students after the research project to look for changes in their attitudes or motivations about learning math and science.

I believe this procedure allowed me a wide array of qualitative data—as well as some important quantitative data—which is also deep enough to understand the effects of the intervention, and come to solid conclusions about the results of the intervention and how it effects the motivation to learn in all students.

Data Analysis

The data analysis that I did for this action research project provided me with several pieces of information that lead me to answers to my research questions.

*Readily-available data*

This data helped me make categorize data according to ethnicities and gender and make comparisons of motivation and attitude based on those identifications, which I believe is important in determining how inquiry affects *all* students. By listing my participants, along with their demographic and ethnographic data, I had a template set up that shows gender, ethnicity, and subgroup classification (ELL, SPED, etc.) in order to see how equitably my intervention affects all students.
Quantitative data

This analysis was performed using a simple “one-group pretest-posttest” study and inferential statistics for analysis. The pretest was given before the instructional unit and recorded; the posttest (which will measure the same skills) was given after the unit and recorded in interval scores from 1 to 100. Using a dependent sample t-test was the best method to analyze the test scores, where the dependent variable of the three tested groups will be the gain scores, and the independent variable will be the instructional intervention. I used Microsoft Excel to organize and code this data for further analysis.

Students completed a questionnaire after the intervention, related to motivation to learn math and science using Likert-style prompts and responses. The prompts and responses were designed to help me determine how students felt about the subjects and how motivated they were to learn in those subject areas. This data was analyzed using categorical analysis, where data was coded, classified, and checked for patterns. The data collection is designed to link ethnicity, grade, and gender (nominal data) to several items that determined and ranked attitude towards math and science education (ordinal data, where a 1 through 5 scale is used for student agreeability to each item). The mode of the response sample set will be found to determine overall student agreeability of high engagement and motivation.

Classroom observations

As I taught, and as I watched and recorded my students at work, I took field notes and kept a journal and recordings of observations and informal assessments that I saw in the classroom. Analyzing this data meant I will first categorized it (e.g. group work, independent
practice, hands-on activities, etc.) and added notes regarding student behavior, thought processes, and problem-solving methods that I observed from my students. Classroom observations allowed me the in-depth qualitative data that helps me make valid conclusions about what’s really happening in the field. As objectively as possible, I used what I wrote to determine if students were engaged, motivated, and showing understanding of the concepts being learned.

Focus and reflection group

Focus group conversations were recorded and transcribed and analyzed for content, so that I could make determinations about what the intervention was doing for this small group of students. Note-based analysis compiled a useable transcript of important quotes and ideas. The data were summarized, coded by similar ideas and themes, and discussions from the first week were compared to the second week to look for differences in attitude and motivation. I interpreted and added this to the above data sources to help build a deeper conclusion about what students were feeling and how they were responding to the intervention. This required my constant checking for reliability and validity of the questions themselves and the interviews as a whole.

CHAPTER 4: DATA ANALYSIS AND RESULTS

Using the text, *Educational Research*, by L.R. Gay and Peter Airasian (2003), as a guide, I will discuss the analysis process by type of data collected and how I analyzed each type. By organizing and interpreting this data, I am able to conclude a strategy to present to other professionals in the field.
Generally, the main categories within each group of data seek to show characteristics of overall motivation and achievement growth in the grade level.

Quantitative Data

This analysis was performed using a simple “one-group pretest-posttest” study and inferential statistics for analysis. The pretest was given before the instructional unit and recorded; the posttest (which measured the same skills) was given after the unit and recorded in interval scores from 1 to 100. Using a dependent sample \( t \)-test is the best method to analyze the test scores, where the dependent variable of the tested group will be the gain scores, and the independent variable will be the instructional intervention. I used Microsoft Excel and eInstruction’s Classroom Performance System to organize and code this data for further analysis.

The results for the pretest-posttest data collection are shown in the following table.

Table 2

<table>
<thead>
<tr>
<th>Test score gains from pretest to posttest</th>
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<tr>
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</table>
| \( \begin{array}{llllll}
| Pretest & Posttest & Gain & t & p \\
| M & SD & M & SD & & \\
| Level 3 students (n = 57) & 72.12 & 23.27 & 76.07 & 18.20 & 3.95 & 8.16 & 0.583 \\
| \end{array} \) |
|                                          |

The \( p \) value in the above table shows that there is no reason to believe that the intervention resulted in a real change in test scores outside of chance. There is no statistically significant gain between the pretest and posttest scores for this particular intervention.

Student Opinion Survey

Students completed a survey after the intervention, related to motivation to learn math and science, using Likert-style prompts and responses. The prompts and responses are designed to help me determine how students felt about the subjects and how motivated they were to learn
in those subject areas. This data was analyzed using categorical analysis, where data was coded, classified, and checked for patterns. The data collection is designed to determine and rank attitude towards math and science education (ordinal data, where a 1 through 5 scale is used for student agreeability to each item). The data was analyzed by noting the mode of the answers and explaining what that means to me, the researcher.

Table 3
Likert data for student attitude and motivation survey

<table>
<thead>
<tr>
<th>Question number</th>
<th>Strongly agree (1)</th>
<th>Agree (2)</th>
<th>Not sure (3)</th>
<th>Disagree (4)</th>
<th>Strongly disagree (5)</th>
<th>Mode</th>
<th>Invalid</th>
</tr>
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<tbody>
<tr>
<td>5</td>
<td>21 37</td>
<td>14 25</td>
<td>8 14</td>
<td>3 5</td>
<td>6 11 1</td>
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<td>6</td>
<td>11 19</td>
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<td>31 54</td>
<td>12 21</td>
<td>2 4</td>
<td>9 1</td>
<td>3 5 1</td>
<td></td>
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</tr>
</tbody>
</table>

Notes:
1. Questions 1 through 4 were items for collecting demographic/ethnographic data.
2. \( N = 57 \)
3. Invalid column represents number of responses on the pad that did not correspond to a valid response.
As seen in the table, the most frequent responses were 1s and 2s (strongly agree and agree, respectively), which corresponded to the responses that show high engagement and/or high motivation to learn and engage. The modes of these data suggest that students had a good attitude about the lessons and were engaged in the daily activities and learning exercises that were planned and executed for the two-week unit.

Qualitative Data

Classroom observations

Qualitative data were collected during observations of three separate lessons, which covered different objectives from the unit. The following discussion will examine results under the heading of each lesson’s title. In addition, data that was coded by type of instructional strategies employed and the motivation levels observed during each lesson will be discussed.

Independent events lab

The objective for this lesson was, “students will use prior knowledge and an investigation of probability to understand the concept of independent events and how those events affect outcomes.” The general goal is to calculate a theoretical probability (the hypothesis) and find an experimental probability to test the hypothesis.

The lesson followed a general scientific method of investigation (which is prescribed by several inquiry models) and involved cooperative learning strategies and student questioning. Since students have been in increasingly inquiry-based science classes in middle school, I expected them to be familiar with the scientific process of investigation and discovery. I found that the majority of students were only minimally aware of that process and most did not know how or when to start the lab. This fact led to a period of reteaching the scientific method.
The reteaching period was taught using teacher lecture and demonstration, class discussion, and the aid of a computer slideshow. Students were not enthusiastic about relearning the method, and some students offered the comments that they “hated” this stuff. It was difficult to maintain student interest during the reteaching, since students had already had a bad history with this material and found it too boring, too rigid, and just another thing they had to learn in science.

The actual lab came next, which employed teacher modeling, a hands-on activity, small-group work, and cooperative learning. We had already talked in-depth about independent probability events and had played a dice game and listed examples of those events. Together, each class came up with a question to investigate about independent events. As the teacher, I modeled some metacognitive processes to show students how to think through the problem, consider the materials I was given, and understand the situation before me. Students were then encouraged to talk to group members to come up with a question regarding the problem to be investigated.

From that point on, students were given a template to follow as they conducted their investigation, which involved pulling colored blocks from a bag and counting how many times each color presented. Prior to the experiment, students chose the color of which they wanted to find the probability of pulling—what we called the “favorable” outcome. Most students were aware on their own that in order to maintain independent status, each block pulled had to be replaced in the bag. Those students who were unsure were coached by other students; I did not need to offer that advice. During this phase of the investigation, there was 100% engagement, where all students participated and had a place in their groups.
The analysis portion of the investigation—where students looked at their counts and calculated the experimental probability of pulling their selected colors—was also a period of high engagement. Students drew on prior knowledge and knew exactly what to do to calculate the results. Again, those students who were unsure were eagerly coached by their peers and all students came to acceptable conclusions.

The template then offered guiding questions to help students write a conclusion about the experimental probability’s relationship to the theoretical probability. This is where students began to lose interest and motivation. I circulated and asked leading questions, as well as questions related to motivation. One student told me that she was having trouble starting because she didn’t “like writing” and wasn’t “sure how to begin.” Throughout the year, I have tried to instill in my students that coming up with the “right” answer is meaningless if you can’t tell other people what it means or how it affects them. Scientific conclusions are meant to justify the answers we get, and 8th grade students seem to have a difficult time motivating themselves to justify or explain answers.

Finally, in the last fifteen minutes of the period, I presented a list of 5 practice questions, which were problem-based and required calculations similar to the ones used in the lab. Interestingly, this reignited the students and I was back to a short period of 100% engagement. Students were eager to show that they knew what they were doing and that they, again, could find the “right” answers. Students who finished early would quickly offer assistance to the students who were struggling; students who were struggling were made happy by the idea that, with the help of their classmates, they finally “got it.”
The wrap-up phase of this lesson (which I had very little time for) led to another shift in engagement and motivation. The difficulty with our current 45-minute-per-period schedule is that it is nearly impossible to fit a meaningful learning experience into such a short time. Consequently, I estimated that I had the attention of perhaps 30% of the class during our wrap-up discussion as the others began readying themselves to leave at the sound of the bell. Although I do try to refocus, I have the understanding that students are ready to finish and I cannot punish them for feeling rushed and eager to switch gears for the next class.

*Dependent events lab*

After a day of practice and review of the independent events skills that we had investigated, I planned to engage my students in a lesson to illustrate dependent events. This lesson would show the differences between dependent and independent events and would familiarize students with the sometimes difficult task of keeping track of the changes that occur in a dependent scenario. The objective was that students could use that understanding to make predictions and decisions based on changing probabilities.

A quick Internet search reacquainted me with an old, favorite game show: *Card Sharks*. Looking back, the game was somewhat dull (and my students had never heard of it), but the entire game is based on the dependent events of probability when using a deck of standard playing cards.

The introduction phase of this lesson was a period of high engagement and motivation in my students. A few students offered phrases such as, “We get to play a card game? Cool!” Oddly, I had two students groan and ask if they could just do a worksheet; others told them to be quiet and enjoy the fact that we were doing something fun. I explained the rules of the game,
which is a basic high-low prediction game with wagers of points. Fifteen cards are placed face down and turned over one at a time. After each card is turned, players figure the dependent probability of the next being higher or lower and place a bet of up to 5 points. Students were made aware that since each turned card is out of play, the probability changes with each card.

The first round of the game was played with me as the “dealer.” I also played along, modeling the use of the probability ratio as it applied to the game. Students were excited by the competitive nature of the game, but they were somewhat resistant to performing the calculations for each turn. I noticed that the cooperative learning strategy did not apply here as it had with the lab, since students were much more interested in winning (beating their teammates at the game) than they were in assisting each other with the work.

After the initial round (where I was the dealer), small groups were encouraged to play together, with one student dealing and the other 4 or 5 playing as contestants. The same trend occurred, where students who were comfortable with the calculations were excited to bet and win, and those who were not comfortable with the math were much less engaged and not motivated to learn how to play and win.

My thoughts and reflections during the activity were confirmed by the conversation we had during the wrap-up phase of the lesson, where engaged students said they really found the probability helpful to their decision-making process, especially when the ratio was converted into a percentage. Students who were not engaged stated that they either went along with their teammates’ decisions or chose not to engage at all.
Create your own game

The unit project was a two-week-long assignment, where students could work in pairs or individually to create an original carnival or casino game that was based on probability. Students were given an instruction sheet, a write-up template, and the rubric (see Appendix C).

The introduction phase of the project involved my reading the instructions and clarifying and answering student questions. All students were highly engaged and motivated to do well on this project from the very beginning. Even my typically lower-performing students were excited to get started!

The working phase of the lesson included three in-class “work days,” where I provided students with several materials and plenty of time to work as a group designing, testing, and calculating probabilities for the game. Work days went very well; students were on-task, hardworking, and highly engaged. They spoke to each other with academic language and pertinent vocabulary. They helped each other with difficult concepts and calculations, and they tested their games tirelessly to look for and fix any problems.

The last phase was the Carnival, or class game day. The event turned into a fun day, where students brought in snacks and went around playing (or testing) games that other groups had designed. The only problem with the Carnival seemed to be that the period was too short; students really wished they could have stayed there for another hour.

Patterns and Themes

The most obvious finding for me was the difference in motivation and engagement between the Card Sharks lesson and the Carnival project. Students are highly engaged when they are involved in cooperative—instead of competitive—activities. This surprised me a bit,
since I’ve been under the assumption, from reading several articles and books, that middle-level students are highly driven by individualistic motivators and that getting them excited about competition is a way to engage all students. My classroom experiences and observations oppose that idea. In fact, it seemed that the competition of Card Sharks caused a good portion of my students to lose motivation and to give up.

One recurring theme in all three lessons was the increase in motivation to perform when students felt prepared to meet the challenge asked of them, be it the understanding of the task ahead or knowledge of the skills and concepts ahead of time. In my literature review, I discussed how Dr. Kirschner believed that inquiry and constructivist education could not lead to student success (2006). My study suggests that this depends on how well the facilitator (teacher) prepares students for the upcoming tasks and how confident students are about their abilities in advance of the lesson.

Finally, it is apparent from all three lessons that when students feel empowered to make decisions, ask questions, and direct their own learning (in addition to being prepared), they become highly motivated to take control of their progress and to make sense of the work they do.

Unfortunately, the one part of the lessons that was difficult to keep students motivated during was the end—the summary or the wrap-up phase. Students seem ready to be finished at the end of the period and it’s difficult to keep them on task or to start a new part when the anticipation of the end of the period is distracting them. I believe that if I, the teacher, spent more time at the beginning of the year training students that I expect bell-to-bell effort, this effect could be minimized.
Focus and Reflection Group

Seven students accepted my invitation to participate in focus group discussions and a final written reflection regarding the entire unit and how they felt during instruction and interaction with peers. Most questions dealt with these individuals’ personal reflections on their own engagement and motivation during the unit, with a few questions asking them about observations they noticed around them. Note-based analysis compiled a useable transcript of important quotes and ideas. The data were summarized, coded by similar ideas and themes, and which I interpreted and added to the above data sources to help build a deeper conclusion about what students are feeling and how they were responding to the intervention.

Discussions and reflections unanimously revealed that students were excited about being in math, because the “unit was fun” and students were allowed to use their own creativity and come up with their own problems to solve.

All students agreed that performing investigations like the independent events lab was beneficial to them, relative to learning how to compare experimental and theoretical probabilities from a textbook or a worksheet. Students really liked being able to compare and investigate with their own eyes and hands, instead of using prepared data. When asked what their least favorite part of the lab experience was, one student offered, “the writing,” and three other students agreed.

I spent some time with students also discussing the outcomes and reflections of the unit project, where students designed, tested, and administered a carnival-type game that was to be based on independent or dependent probability events. Again, students unanimously said that it was a lot of fun. About half of the group believed that it really helped them learn new things
about probability (especially calculating and testing the theoretical probability), while the other half suggested that the project didn’t teach them anything that they didn’t already know.

Another common theme that arose from these discussions was the importance of cooperative learning. Some students insisted that they work alone before the project, yet their reflections suggested that they wished they had had a partner during the design and execution phases. One young man suggested that the groups should be assigned by the teacher, and that the teacher should give everyone a job, since his group was made up of friends and no one really wanted to take charge or get anything done.

Another common theme was time. All students agreed that the seven school days I gave them to work on the project was sufficient, but most believed that the test and investigation period (the “game day”) was much too short. I agree with their assessment and find it difficult to schedule events like this in advance, since I am a mobile teacher (I do not have a permanent classroom) and our class periods are only 45 minutes long.

A final theme that came out in the discussion was the students’ ability to recognize and solve problems as they arose. A young man told me that he had a “great number of problems, but figured them out after a little bit of thought.” He said that he and his team put a lot of thought in how to make the game “fun and fair.” Overall the game was a “great success,” according to him. All students agreed that they enjoyed the level of independence they were granted to find the solutions to their own problems.
Data Analysis Summary

Rationale

The chosen qualitative data analysis methods are meaningful to the study because I wanted to find out what motivates students to learn and perform well in math and science, and if inquiry-based education can be considered a “motivating strategy.”

Classroom observation analysis is categorical in order to visualize how students learn in the field and the analysis is important to develop a baseline understanding of how the intervention is affecting the whole group, as well as the individuals within.

The survey analysis is appropriate since the Likert scale data was not seeking ratios or intervals, but simply ranking (and naming, in the case of demographic data matching). This data can be easily and effectively shown on a graphic to show the trend among the students after the intervention.

The focus group content analysis is appropriate since it took carefully coding and organizing to find useable data that is both valid and reliable. This data provides an in-depth look at the effect of the intervention on individual sample students, but also has a high bias potential. Careful content and categorical analysis lessens this potential.

The rationale for using the quantitative data analysis for the pretest-posttest system was to find the effects of motivation on learning and understanding within one group that is receiving the intervention lesson. The idea was to measure gains in student scores before and after the instructional unit and to compare means of interval scoring. The computer programs assisted me in this analysis to reduce my error.
Interpretation of Data

It is noted that the quantitative data collected and analyzed in this study did not statistically support the expected outcome of student achievement.

The qualitative data, however, does show that inquiry is a motivating strategy because the data triangulated and showed support for that idea. The following is a recapitulation of the three data sources that brought forth those findings:

The questionnaire shows a significant number of positive answers. In other words, after analyzing the responses that students gave, I saw a high number of responses that showed that students are enjoying the subject and are engaged.

The focus group gave me sufficient dialogue to support the idea that students feel more motivated and have a better attitude about the subjects.

My classroom observations gave me sufficient reason to believe that students are engaged (meaning they are participating, using academic language, know the objectives and goals of the lesson, etc.).

The interpretation of the collected data did not treat each source separately (at least not for very long). The idea was to collect data from several sources, as described, and use them to triangulate results into a conclusion that was cohesive and representative of the population that I teach. The final conclusion is that inquiry-based instruction showed a solid and well-supported increase in intrinsic motivation in middle school students; student achievement, however, needs to be further studied to determine statistically meaningful results.
CHAPTER 5: LIMITATIONS AND IMPLICATIONS

Based on the results discussed above, I will discuss the implications and limitations that this study presents to the field of middle-level math and science education. I use both math and science because the unit studied was to determine how inquiry-based education affects student motivation in an integrated classroom, where math and science methods, concepts, and skills are taught together and used interchangeable. However, I do believe that the implications and limitations apply to those math and science courses that are taught separately.

Triangulation of the data was briefly discussed and demonstrated in the previous chapter. I will further show how the data triangulates here to present the implications and limitations below.

Implications of the Research

The most important implication that stems from this action research project is the idea that students who are motivated are also students who want to learn. The survey data collected after the intervention included responses to the prompt, “I felt happy about going to class for the past two weeks.” Responses to this prompt were overwhelmingly positive and this appears to be an important piece of data in knowing that students are motivated to learn. If students dread going to math and science class, then they are not ready to learn and achieve.

Inquiry-based education, as discussed numerous times in this document, constructs an active-learning environment and students become central players in their own learning. The literature review and my own observations show that students who are participant in their learning are highly expected to take ownership and responsibility for the outcomes of their efforts. When students are given this expectation and opportunity, they begin to increase their
intrinsic motivation. The prompts and responses to the survey support this conclusion as students responded favorably to prompts that suggest high engagement, meaningful interaction with the material, and motivation to succeed.

Just as important, the qualitative data collected and analyzed during the classroom observations showed a consistent pattern of high engagement among students. The use of inquiry-based teaching strategies leaves no room for students to be bored or inattentive, since the learning and doing of the lesson is put into students’ hands (and minds). In contrast to traditional teaching models, where students are passive learners, inquiry gives the students the “job” of being active participants. As noted in the literature review, students are expected to perform the roles and duties of scientists, conducting investigations, analyzing data, and formulating conclusions.

Finally, the motivation that was observed in the analyses was most decidedly intrinsic in nature. Of course, I did offer encouragement and praise along the way as needed, but students seemed much more motivated to see favorable results or to see their work completed successfully and meaningfully. I did not offer tangible awards at any point during this unit and, as far as my data shows, I did not need to.

Overall, the data triangulates into a common theme that suggests that if motivation is what we seek, then inquiry-based education is a very good strategy to use. To recap, students who are active participants in their learning and who are owners of their success, then they are intrinsically motivated to succeed and to achieve. These are students who are motivated and engaged in their learning, and these are the students who want to achieve. It takes the guidance and aid of a well-trained facilitator and a cohesive curriculum to make that possible.
Limitations

This study brought up a limitation that is suggestive of the importance of a complete, cohesive, and well-rounded curriculum. As noted in the results, the pretest-posttest system did not yield the expected or desired results that would have indicative of an intervention that led to student achievement. While high motivation was readily observed, the scores on the tests were not statistically indicative of concept and skill proficiency.

Perhaps time was an issue, or perhaps planning should have allowed more independent practice and skills development, but in any case students did not show statistically significant growth. In light of this, I would suggest that further study or research be done in the achievement and growth areas of this study to determine what additions or changes should be advanced in order to measure and find that growth. Most of the literature I read showed a strong case for the success of inquiry-based programs in student proficiency, but my action research project did not.

Finally, a major limitation of this research is in teacher training. The literature suggests that teachers are traditionally not trained to teach inquiry and many teachers have never or seldom seen it in action. Without fluent and meaningful teacher training, inquiry-based education seems to be a far-off goal. I even believe that I could have used additional training before pursuing this project, as it may have allowed me the foresight to see missing components that could have led to an increase in proficiency.

Inquiry is the way that scientists do their jobs. Therefore, it should be the way that science students do their learning. Scientists are highly trained after years of education and practice to conduct their investigations in a meaningful, literate, cohesive, and authoritative
manner. Teachers who are offered the same training can pass it on to their students, who can then become the “little scientists” we want them to be, which also motivates them. Finding answers to their own curiosities is what sets motivation and learning in motion. The results of my action research project show me that allowing and encouraging students to be curious and to seek their own meaning and answers in a problem leads to engagement, motivation, and a deeper understanding of how complex ideas work in the real world.
REFERENCES


APPENDIX A

Quantitative Data Tables

<table>
<thead>
<tr>
<th>Test Score Gains from Pretest to Posttest</th>
<th>Pretest</th>
<th>Posttest</th>
<th>Gain</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>Level 3 students (n = 57)</td>
<td>72.12</td>
<td>23.27</td>
<td>76.07</td>
<td>18.20</td>
<td>3.95</td>
</tr>
</tbody>
</table>

The $p$ value in the above table shows that there is no reason to believe that the intervention resulted in a real change in test scores outside of chance. There is no statistically significant gain between the pretest and posttest scores for this particular intervention.
Likert data for student attitude and motivation survey

| Question number | Strongly agree (1) | Agree (2) | Not sure (3) | Disagree (4) | Strongly disagree (5) | Count | % | Count | % | Count | % | Count | % | Count | % | Mode | Invalid |
|-----------------|-------------------|-----------|-------------|-------------|----------------------|-------|---|-------|---|-------|---|-------|---|------|---|-------|
| 5               | 21                | 37        | 14          | 25          | 8                    | 14    | 3 | 5     | 3 | 6     | 11 | 1     | 1 |
| 6               | 11                | 19        | 15          | 26          | 15                   | 26    | 5 | 9     | 3 | 7     | 12 | 3     | 4 |
| 7               | 15                | 26        | 19          | 33          | 13                   | 23    | 7 | 1     | 3 | 5     | 2  | 2     |   |
| 8               | 19                | 33        | 18          | 32          | 11                   | 19    | 3 | 5     | 6 | 11    | 1  | 1     |   |
| 9               | 10                | 18        | 21          | 37          | 15                   | 26    | 4 | 7     | 6 | 11    | 2  | 1     |   |
| 10              | 26                | 46        | 15          | 26          | 8                    | 14    | 2 | 4     | 5 | 9     | 1  | 1     |   |
| 11              | 11                | 19        | 14          | 25          | 20                   | 35    | 5 | 9     | 7 | 12    | 3  | 3     |   |
| 12              | 33                | 58        | 10          | 18          | 2                    | 4     | 6 | 1     | 4 | 7     | 1  | 2     |   |
| 13              | 19                | 33        | 14          | 25          | 16                   | 28    | 4 | 7     | 4 | 7     | 1  | 1     |   |
| 14              | 28                | 49        | 13          | 23          | 6                    | 11    | 6 | 1     | 3 | 5     | 1  | 1     |   |
| 15              | 23                | 40        | 17          | 30          | 11                   | 19    | 3 | 5     | 3 | 5     | 1  | 1     |   |
| 16              | 14                | 25        | 22          | 39          | 12                   | 21    | 8 | 1     | 1 | 2     | 2  | 2     |   |
| 17              | 22                | 39        | 27          | 47          | 2                    | 4     | 4 | 7     | 1 | 2     | 2  | 1     |   |
| 18              | 29                | 51        | 14          | 25          | 7                    | 12    | 7 | 1     | 4 | 7     | 1  | 1     |   |
| 19              | 17                | 30        | 24          | 42          | 7                    | 12    | 2 | 4     | 3 | 5     | 2  | 2     |   |
| 20              | 31                | 54        | 12          | 21          | 2                    | 4     | 9 | 1     | 3 | 5     | 1  | 6     |   |

Notes: 1. Questions 1 through 4 were items for collecting demographic/ethnographic data.
2. N = 57
3. Invalid column represents number of responses on the pad that did not correspond to a valid response.
# APPENDIX B

## Unit Plan for Instructional Intervention

<table>
<thead>
<tr>
<th>First and Last Name</th>
<th>Kris Nielsen</th>
</tr>
</thead>
<tbody>
<tr>
<td>School District</td>
<td>Salem-Keizer Public Schools</td>
</tr>
<tr>
<td>School Name</td>
<td>Leslie Middle School</td>
</tr>
<tr>
<td>School City, State</td>
<td>Salem, Oregon</td>
</tr>
</tbody>
</table>

**Unit Title**

Probability

**Unit Summary**

Using theory and experiments, students will explore probability in statistics and science.

**Subject Area**

Integrated Math and Science

**Grade Level**

8

**Approximate Time Needed**

10 days

**Targeted Content Standards and Benchmarks**

**Student Objectives/Learning Outcomes**

Students will:

- Properly communicate what probability is and how it is determined in various contexts.
- Perform experiments and activities that rely on probability for meaningful outcomes.
- Calculate probability from various examples and scenarios.

**Curriculum-Framing Questions**

<table>
<thead>
<tr>
<th>Essential Question Unit Questions</th>
<th>What is probability? How is it useful in understanding the world?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>What is a sample space? What is the difference between independent and dependent probability events?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Content Questions</th>
<th>Lesson 1: What is the difference between theoretical and experimental probability? How can I relate them in an experiment?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lesson 2: How does probability change when dependent events are used?</td>
</tr>
<tr>
<td></td>
<td>Lesson 3: How can I use probability to create a fair and fun game?</td>
</tr>
</tbody>
</table>

**Assessment Timeline**
### Before project work begins

| Pretest | Exercises to assess prior knowledge |

### Students work on projects and complete tasks

| Independent events lab | Dependent events lab Create your own game project |

### After project work is completed

| Posttest | Reflections |

### Assessment Summary

**Lesson 1:** Independent Events – students complete lab report, which is graded on a rubric.

**Lesson 2:** Dependent Events – students participate in Card Sharks game, while keeping running record of changes in sample set and student score. Peers check for completeness and correctness and teacher records grade.

**Lesson 3:** Create Your Own Game – Students are assessed on design, teamwork, write-up, and participation based on a rubric.

### Prerequisite Skills

Students have prior skills and knowledge in fractions, ratios, percents, and basic knowledge of odds and probabilities.

### Instructional Procedures

See lesson plans.

### Accommodations for Differentiated Instruction

| Resource Student | Special needs students are served well with support from high-performing peers and small groups. Clear expectations and rubric support are beneficial. |

| Non-Native English Speaker | English language learners need to know the goals of the lesson, the expectations for the final product, the use of simple language, and the help of small grouping. Examples of finished products may be helpful. |

| Gifted Student | The activities in this unit are well-prepared for the gifted student to explore independent learning and further study. Complex ideas may be discussed with gifted students to ensure that they do not become overwhelmed. |
Lesson Plans

Lesson One: Independent Events Lab (used with PowerPoint presentation as a guide)

Objectives and Goals:

- Students will understand the difference between theoretical and experimental probability
- Students will be able to calculate and compare the two and make conclusions about predictions

Anticipatory Set (5 minutes):

- Suggest an example experiment (I used the sock drawer with replacement).
- Help students make sense of how the sample set does not change.

Direct Instruction (10 minutes):

- Introduce students to the multiplication rule of multiple events and offer examples
- Guide students through a review of the general scientific process of investigation

Guided Practice (15 – 20 minutes):

- For this lab, guide students through the experimental process using the slides, having them complete each step after you discuss it
- Students will perform the experiment step independently

Closure (5 – 10 minutes):

- Discuss conclusions with whole class, allowing each group to report findings
- Encourage each group to make a statement regarding the relationship between experimental and theoretical probability

Independent Practice (10 minutes):

- The remaining slides after the experiment contain practice problems
- Teacher should discuss each problem after allowing independent student performance

Required Materials and Equipment:

- Paper bags (1 per group), colored blocks or marbles, PowerPoint guide

Assessment and Follow-Up:
Lab reports that students or groups complete can be graded against a rubric for completeness and understanding.

Independent practice can be assessed informally and followed up with a formal quiz.

Lesson Two: Dependent Events Game

Objectives and Goals:
- Students will understand what dependent probability events are and how they affect the sample space.
- Students will be comfortable making predictions and decisions based on dependent probability events and possible outcomes.

Anticipatory Set (5 minutes):
- This game is based on the old 1970s game show, Card Sharks!
- This is a fun way to investigate how dependent events determine probability.

Direct Instruction (10 minutes):
- Review the concepts of sample sets, multiplication rule, and the sock drawer.
- Introduce the idea of the sock drawer without replacement.
- Demonstrate the game for students.

Guided Practice (20 – 25 minutes):
- Play the game with students.
  - Lay 15 cards face down and flip over the first card.
  - Explain that the odds of the next card being higher or lower depend on the face-up card being out of play and the sample set being reduced by one.
  - Continue to flip cards and calculate the new odds, using them to predict what the next card will be (higher or lower) and make decisions about what to wager.

Closure (5 – 10 minutes):
- Discuss with students what some of the major differences are between independent and dependent events.
- Encourage to come up with additional examples of where they may see both types of events in the real world.

Independent Practice:
- Homework may be assigned for more practice with dependent events.
- Have students play the game in small groups, rotating who gets to be the dealer.

Required Materials and Equipment:
- Deck of standard playing cards; students will keep track of odds and score on paper.
- Overhead camera and projector.

Assessment and Follow-Up:
- Student papers can be collected and assessed.
This game was fun any time that a class has extra time to kill
Use understanding to solve new problems where dependent events are used

Lesson Three (Unit Project): Create Your Own Game/Class Carnival

Objectives and Goals:
- Students will use probability skills and concepts to design an original game based on odds of winning and the concept of “fairness”
- Students will play other games and determine the odds and fairness
- Students will reflect on their work and learning

Anticipatory Set (5 minutes):
- Discuss the success of casinos and carnival games
- Let students know that they will design their own game to present and run for their peers
- Announce that this will result in a Carnival Day, where we will all play each others’ games

Direct Instruction (10 minutes):
- Distribute instructions and rubrics to students and discuss with them the steps to follow
- Answer questions about the project and make suggestions as needed
- Make sure students understand this is an original game (they cannot “design” blackjack)

Guided and Independent Practice (5 – 7 days):
- While some work may be done at home, I find it necessary to allow students several days of in-class work periods
- Help students understand how to calculate probabilities and make changes if needed
- Help students “test” their theoretical probabilities (i.e. play their games!)

Closure (1 – 2 days):
- Game day is a chance to see how probability affects the odds of winning and certain outcomes
- After game day, a one page reflection paper allows students the opportunity to think qualitatively about their work and the experience as it pertains to the real world

Required Materials and Equipment:
- Provide materials as needed/available (e.g. playing cards, dice, coloring materials, etc)
- Student handouts

Assessment and Follow-Up:
- Informal assessment is ongoing and important
- Student write-ups will be collected
- The entire project is graded on a rubric (see Appendix D)
APPENDIX D

Instructions and Materials for Unit Project

The Write-up for the Game Project (1 per Group on Separate Paper)

1. Introduction - Provide an overview of your game
   ✓ What type of game is it?
   ✓ Where would you play this type of game?
   ✓ Does it cost anything to play?
   ✓ Are there prizes if you win?

2. Game Description – What do you need to play the game?
   ✓ List all materials needed to play (dice, spinner, darts, ball, etc.)
   ✓ Draw picture of your game board, if necessary, on a separate paper

3. Instructions - Step-by-Step instructions for how to play the game.

4. Probability Analysis
   ✓ Show the mathematical calculations for the theoretical probability of winning the game.
   ✓ Does the game rely on independent or dependent events? Explain.

5. Each student must write a 1-page reflection on another sheet of paper (1 Per PERSON)
   ✓ What were your overall feelings about this project?
   ✓ Did this project help you understand the probability any better?
   ✓ How did your group work together?
   ✓ What have you learned about “Fair Games”?
   ✓ What is your opinion about Las Vegas and the gaming industry?
   ✓ Do you think it’s fair to have establishments designed for people to lose money?
   ✓ What is your opinion on the lottery? Would you advise your grandmother to play?
Performance Assessment: Design Your Own Game Instructions

In this assignment, you will be designing your own game in pairs or groups. The game should be the type of game that you would play at a carnival, amusement park or casino. It cannot be a game that already exists; your group must create a unique game. You must be able to explain the probability of your game, so don’t make it too complicated!

Final Products:

1. **Game** – Include all game boards, playing pieces, cards, balls, etc. for your game.
2. **Instructions** - You must create a set of typed instructions to clearly explain your game. They must be easy to follow so that anyone can pick them up, read them and begin playing your game.
3. **Write-Up** – See next page.
4. **Advertisement** - Each group will create a poster ad for their game. Be creative!

Grading

See rubric.

**The Write-Up**

6. Introduction - Provide an overview of your game. *(1 Per Group)*
   ✓ What type of game is it?
   ✓ Where would you play this type of game?
   ✓ How much does it cost to play?
   ✓ What are the prizes if you win?

7. Instructions - Step-by-Step instructions for how to play the game. *(1 Per Group)*

8. Game Description – What do you need to play the game? *(1 Per Group)*
   ✓ List all materials needed to play (dice, spinner, darts, ball, etc.)
   ✓ Draw picture of your game board, if necessary

9. Probability Analysis *(1 Per Group)*
   ✓ Show the mathematical calculations for the theoretical probability of winning the game.
   ✓ Does the game rely on independent or dependent events?
# Problem Solving: Probability & Statistics - Design a Game Rubric

**Student Name:** ________________________________________

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Game</strong></td>
<td>Students create a fully functioning game that students can play. They bring all of the game materials to class.</td>
<td>Students create a game that students can play. There may be slight over-sights, but overall the game can be played.</td>
<td>Students create a game, but it cannot be played in class.</td>
<td>Students have an idea for a game.</td>
</tr>
<tr>
<td><strong>Instructions</strong></td>
<td>Instructions are clear and easy to follow. The game can be played by others without referring to the game creators for help.</td>
<td>Instructions are somewhat clear and easy to follow. The game can be played by others with minimal interaction with creators of the game.</td>
<td>Group has written instructions but they are unclear and a verbal description of the game is necessary.</td>
<td>Instructions are incomplete.</td>
</tr>
<tr>
<td><strong>Group Write-Up</strong></td>
<td>Group has comprehensive write-up including: introduction, instructions, game description and probability analysis. The write-up has been thoughtfully prepared and provides insight into the actions of the group.</td>
<td>Group has write-up including: introduction, instructions, game description and probability analysis. The write-up provides some insight into the actions of the group.</td>
<td>Group has an incomplete write-up including some of the following: introduction, instructions, game description and probability analysis.</td>
<td>An attempt at a write-up is made.</td>
</tr>
<tr>
<td><strong>Probability Analysis</strong></td>
<td>Group provides accurate analysis of the math behind their game. The idea of a fair game is clearly explained in terms of their project and an alternative for making their game fair is presented.</td>
<td>Group provides somewhat accurate analysis of the math behind their game. The idea of a fair game is explained in terms of their project. An attempt at providing an alternative for making their game fair is presented.</td>
<td>Group provides some analysis of the math behind their game. The idea of fair game is mentioned.</td>
<td>Group attempts some sort of analysis of their probability.</td>
</tr>
<tr>
<td><strong>Individual Reflection</strong></td>
<td>Reflection clearly explains students thought process during the project. The relevance of the project is clearly described.</td>
<td>Reflection attempts to explain students thought process during the project. The relevance of the project is described.</td>
<td>Reflection attempts to explain students thought process during the project.</td>
<td>Some attempt at a reflection is made.</td>
</tr>
<tr>
<td>Ad Poster</td>
<td>Group created an attractive, persuasive, and colorful poster that invites others to play their game.</td>
<td>Group created a poster that invites others to play their game.</td>
<td>Group attempted a relevant poster.</td>
<td>Group provides some type of poster.</td>
</tr>
<tr>
<td>-----------</td>
<td>--------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------</td>
<td>---------------------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>In Class Game Day Participation</td>
<td>Individual participated in Game Day with a good attitude.</td>
<td>Individual participated in Game Day.</td>
<td>Individual somewhat participated in Game Day.</td>
<td></td>
</tr>
<tr>
<td>Neatness and Organization</td>
<td>The work is presented in a neat, clear, organized fashion that is easy to read.</td>
<td>The work is presented in a neat and organized fashion that is usually easy to read.</td>
<td>The work is presented in an organized fashion but may be hard to read at times.</td>
<td>The work appears sloppy and unorganized. It is hard to know what information goes together.</td>
</tr>
</tbody>
</table>
APPENDIX E

Student Survey Prompts

The following are the questions that were used in the questionnaire. The response choices followed an ordinal, ranking Likert scale, as follows:

5 – Strongly agree
4 – Agree
3 – Not sure/sometimes
2 – Disagree
1 – Strongly disagree

Questions 1 through 4 were for the purposes of collecting demographic data, and are not included in the Likert study. The response data for this survey is found in Appendix A.

5. I have done well in my math and science classes over the years.

6. I enjoyed the unit on probability.

7. I am good at learning new things when the teacher is demonstrating and talking about them.

8. I think that using manipulatives (dice, cards, spinners) really helped me understand the concepts.

9. I understand more about probability now than I did before the unit.

10. I felt good about the game I created for the project.

11. I think that creating my own game was a good way for me to see how probability affects outcomes in everyday events.
12. I would rather do lab work than book work.

13. Genetics was an interesting way to learn probability.

14. Using probability was a useful way to understand genetics and heredity.

15. I felt happy about going to class for the past two weeks.

16. I felt like I really wanted to understand what we were learning about in class.

17. I asked questions about probability (to myself or to the class) and was able to find the answers by myself or with my group during investigations, labs, or discussions.

18. I felt engaged in the discussions and activities we had during the probability unit.

19. If I have a question about probability, I’m pretty sure I could figure out the answer.

20. I am proud of the work I did during the probability unit.
APPENDIX F

Pretest/Posttest Questions

The following is the list of the questions that were found on the pretest and posttest data collection instrument. The same questions were asked for both tests and the order was changed. Data for this instrument is found in Appendix A.

1. A game involves spinning this spinner. What is the probability of the pointer landing on Y?

   A 1/8
   B 3/8
   C 5/8
   D 1/2

2. You roll a standard number cube. Find $P(\text{number greater than 4})$.

   A 1/3
   B 2/3
   C 1/2
   D 3/5

3. A bag contains 3 red marbles, 2 white marbles, and 5 blue marbles. You pick a marble without looking. Find the probability of drawing a white marble.

   A 1/2
   B 3/10
   C 4/5
   D 1/5

4. A standard number cube with the numbers 1 through 6 is rolled. Find the probability of rolling a number greater than 2.

   A 1/3
   B 1/6
   C 1/2
   D 2/3


   A 7/12
   B 5/12
   C 12/5
   D 1/3
6. Find P(red)
   A 1/4
   B 1/8
   C 1/2
   D 4/8

7. Find P(red or blue)
   A 3/4
   B 1/2
   C 1/8
   D 3/8

8. A coin is tossed and a standard number cube is rolled. What is the probability that the coin shows tails and the number cube shows an odd number?
   A 1/4
   B 2
   C 1/6
   D 1/8

9. Suppose the probability that it rains in the next two days is 1/4 for tomorrow and 1/3 for the day after tomorrow. What is P(rain tomorrow, then rain the day after tomorrow)?
   A 1/12
   B 2/7
   C 1/6
   D 7/12

10. A drawer contains 2 red socks, 6 white socks, and 10 blue socks. Without looking, you draw out a sock and then draw out a second sock without returning the first sock. Find P(white, then white).
    A 5/51
    B 1/3
    C 1/27
    D 1/9

11. If the spinner is spun twice, what is the probability that the spinner will stop on a consonant then a vowel?
    A 2/9
    B 1
    C 7/9
    D 3/4

12. A fair coin will be flipped 3 times. What is the probability that the coin will land on tails exactly once?
    A 1/8
    B 1/3
    C 3/8
    D 5/8
13. In a Punnett Square, the lower-case letter stand for _______________ .

A heterozygous  
B dominant  
C homozygous  
D recessive

14. A yellow pea plant (Yy) and a green pea plant (yy) could be expected to produce ______________ out of 4 green offspring.

A 1  
B 2  
C 3  
D 4

15. G = white flowers  
g = pink flowers

A 0  
B 1  
C 3/4  
D 1/4

16. What’s percentage of offspring of Gg and Gg will have red flowers?

A 0%  
B 25%  
C 50%  
D 100%

17. What percentage of the shape is shaded in?

A 50%  
B 33%  
C 44%  
D 40%
APPENDIX G

Informed Consent Form

INFORMED CONSENT FORM
Western Governors University

Master of Arts in Science Education
Action Research Project
Researcher: Kris L. Nielsen

Introduction
You are invited to participate in a research project being conducted by a researcher from Western Governors University. Mr. Kris L. Nielsen is conducting research to determine the effect of inquiry-based instruction on the motivation of middle school students to learn math and science.

Description of the project:
This project is a study to determine the effect of inquiry-based instruction on the motivation of all students in learning complex mathematical and scientific concepts and skills. Inquiry is a strategy that relies heavily on student engagement, curiosity, cooperative learning, and performance assessment. This study will also determine the effects of inquiry on unit test scores.

● The Connected Math curriculum will be used in conjunction with scientific investigations and other inquiry-based activities.

● The research will be conducted during normal class time and in regular classrooms. The research period will be approximately two school weeks (May 4 – May 14).

● All students are expected to participate fully in all routine classroom activities.

● All participants will be required to participation in the curricular activities and answer two in-class surveys that will help the researcher determine motivation to learn the subjects. A few students will be asked to participate in audio taped interviews.

Benefits and risks of the study:
Since the study will take place during normal classroom instruction, using research-based instruction techniques, there is absolutely no foreseen risk to students from the study.

Benefits are important and include: being engaged and learning new concepts in math and science, feeling motivated about their achievements and abilities, and feeling that they are contributing to a body of research that will lead to better quality education in math and science. Students will also receive standards-based instruction that will teach them skills that are useful now and in the future.

Confidentiality:
Privacy protection is very important. All data collected during this study will be aggregated and coded, meaning that confidentiality will be maintained at all times. Student records will be seen by only the researcher. All participants will be anonymous in the results of the study.
Voluntary participation and withdrawal:
Participants are expected to participate in any regular classroom instruction but may choose to voluntarily participate or withdraw from audio taping and interviews. Generally, since surveys are used to inform instruction or measure pre-post gains, these are considered part of regular classroom instruction.

Participation in audio-taped interviews and focus groups is fully voluntary and students may refuse to participate in or withdraw from those activities at any time without penalty.

Questions, rights, and complaints:
All questions and complaints are always welcome. You may reach Mr. Nielsen at klnielsen74@gmail.com or by leaving a message at (503) 580-0038.

All participants and legal guardians have the right to copies of the findings and results of the study.

Consent statement: By signing below, you certify that you have read this document; that you understand the purpose of the research, the benefits and risks, the confidentiality statement, and your rights; and that you agree to participate in the study.

________________________  _______________________
Signature of Participant    Signature of Legal Guardian

________________________  _______________________
Typed/printed Name         Typed/printed Name

________________________
Date

Principal, Leslie Middle School

Thanks so much for your assistance in this important study!

Kris L. Nielsen
Klnielsen74@gmail.com
(503) 580-0038
## APPENDIX H

### Demographic Table

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Data Collected</th>
<th>Resources Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>44 students are 13 years old (69%)</td>
<td>Electronic attendance database</td>
</tr>
<tr>
<td></td>
<td>12 students are 14 years old (19%)</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>30 students are male (61%)</td>
<td>Electronic attendance database</td>
</tr>
<tr>
<td></td>
<td>26 students are female (39%)</td>
<td></td>
</tr>
<tr>
<td>Cultural/ethnic background</td>
<td>53% of students are Caucasian (non-Hispanic)</td>
<td>Electronic attendance database</td>
</tr>
<tr>
<td></td>
<td>30% of students are Hispanic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8% of students are African-American</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5% of students are Asian/Pacific Islander</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3% of students are Native American</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 students are multiethnic (6%)</td>
<td></td>
</tr>
<tr>
<td>Special needs</td>
<td>8 students have IEPs/special needs (13%)</td>
<td>Student data folders</td>
</tr>
<tr>
<td></td>
<td>10 students are talented and gifted (TAG) (15%)</td>
<td></td>
</tr>
<tr>
<td>Language</td>
<td>11 students are English Language Learners (17%)</td>
<td>Student data folders</td>
</tr>
</tbody>
</table>