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"I SAW STATISTICS OVER THE WEEKEND!": WHAT CAN HAPPEN WHEN STUDENTS ARE TAUGHT TO CONNECT CLASSROOM LEARNING WITH THE OUTSIDE WORLD

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ABSTRACT

This qualitative study investigated the experiences of incorporating real world examples into an Honors-level high school statistics classroom. Twenty one students in grades eleven and twelve participated in the study conducted in an urban high school containing approximately 3000 students in the northeastern United States.. Methods of gathering data included teacher observation, student surveys, informal and formal student interviews, and student work. Methods of analysis included coding, construction of theme statements, and review of student work. The students were presented with statistical concepts through real world examples, which included collecting data in and outside of class and using examples of statistics meaningful to the participants. Findings suggest that using real world examples is an essential part of student engagement and achievement in a secondary school statistics classroom. Furthermore, students are likely to become more eager to learn even challenging concepts when statistics are related to their own lives. All participants involved in the study reported a preference for real world examples to those typically provided by the textbook publisher.

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To my 8th period Statistics class: Thank you for all your hard work and your enthusiasm towards statistics. Your class was a great encouragement to me as I learned how to become a better Stats teacher.

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To my husband: Thank you for your love and encouragement.

To God: Thank you for providing all that I need.

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RESEARCHER STANCE

I never remember my high school math classes connecting to the real world. I sat through four years of math classes, but I don't remember anything about the numbers and variables that went beyond solving an equation. Although I enjoyed Algebra I, II, and even Calculus, there was never a valid reason that I could find for solving the equation or finding the area under the curve or finding the volume of the cube. All those tasks seemed slightly meaningless. The only reason I could see for completing each problem was to get an "A," graduate, and go to college. I never questioned why the material didn't connect to the real world but simply assumed that all math classes were not connected to anything meaningful.

In college, I was enrolled in more seemingly meaningless math classes. Abstract Algebra was just one of many. For the first time I took a statistics class, which focused heavily on probability. It was the same as my high school math classes: memorize the procedures and formulas just to get an "A" on the exam and complete the class. To me, probability and statistics had no connection to the real world but rather was just a bunch of formulas and long terms like *sample space* and *geometric and binomial probability*. All I knew was that I was about to graduate and become a math teacher. I completed the class without a thought as to how it related to the real world or what was actually important about what I had learned.

I finally did graduate and become a math teacher, and those meaningless math classes must have been worth something because now I was qualified to teach them. So I continued to teach the same classes I had taken in high school with the same meaningless approach. This time, though, my students questioned me:

"Why are we learning this?"

"When am I ever going to use these equations in my life?"

"Is there any point to learning this?"

I didn't have answers to their questions. I didn't know why you were to learn Algebra 1; when I learned it I never asked "why". Suddenly, my students were asking questions that made sense but didn't have ready-made answers. I told them that I didn't know, all the while feeling a void.

One day, the head of our math department announced that there was a need to create an Honors Statistics class for the following year and that course would eventually evolve into an AP class. All teachers interested were to make that known and our department head would pick the most qualified teacher. Immediately, a few of the teachers started making comments:

"Statistics? I hated that class in college."

"I did so badly. I barely passed the class."

"Statistics was so difficult and boring.".

Yeah, it wasn't fun, but it wasn't any different than any other math class I had taken- the same old learn the procedure and formula, pass the test, move on to the next math class. Here I am, thinking, *this could be a great*

opportunity for me as a second year teacher, but will I get chosen to teach it? Surely, there will be more experienced teachers vying for the position. But as it turns out, most felt the same way about statistics as those teachers who made the comments at our department meeting- boring and difficult, and, in fact, I got the position.

Hence, my journey began. I planned the curriculum just like most other math classes. The teacher's manual suggested a few activities that connected concepts to students' lives. This was a foreign idea to me, and I neglected to take advantage of most of those activities. In reality, I was just planning lessons the "safe" way and never really considered trying these activities that seemed so out of place in a "math class." Real world connections were not appropriate, it seemed to me at the time, in a math class; they clearly fit better in history or English classes.

There was, however, one real world activity that I took advantage of. My students were assigned a midterm project in which they had to use what we learned in class to collect data and analyze something in our high school or community. Suddenly, I was receiving comments such as:

"Wow, finally a math class where we actually do something useful."

"This is the first time I actually see why we are leaning this."

This was exciting! It was exciting not only for me, but for my students. For once, they could see connections between their math class and their world. They could see why they were learning the concepts presented in class. My students were more interested in statistics because they could see the

importance of *summary statistics, standard deviation, measures of center, random numbers,* and *observational studies.*

Seeing that my students got exciting over real world connections was great. Could this continue? What would happen if I taught like this all year? Would the students see the connections to the real world? Would I be able to make connections? Would my future students get as excited over real world connections as this last group did? Could I connect the topics to the real world? What does the research say about this? Wanting to explore connections to the real world came at an ideal time, as I was preparing to conduct action research in my classroom.

I hope to encourage my students to see the connection between what they're learning in the classroom and what is occurring in the outside world. I hope to inspire them to look for the connections and continue learning outside of class. I hope also that through this study other teachers will be able to see the importance of connecting math to the real world.

LITERATURE REVIEW

Introduction

School needs to have a greater purpose than testing isolated skills devoid of an authentic context. Making connections to the real world through school curriculum is important and through these connections, students gain more meaning from school. Often, students view their mathematical studies as separate from what goes on in their everyday life with no applicability to their future careers (Brooks & Brooks, 1993). They can compartmentalize school and see no connection between their school and out of school lives. Through this literature review, current practices in the teaching of concepts and skills will be described, the need for change will be articulated, and best practices for teaching, and specifically, teaching statistics will be expanded upon. These best practices for teaching are based upon constructivist learning theory and support authentic instruction. As cited in this literature review, through these practices, students can make the connections to the real world that are important and likely to make school more meaningful. As students make meaningful connections, they are more likely to become more engaged in the curriculum and demonstrate greater achievement (Newmann, et al, 1995, Blank, 1997, Akey, 2006). Hopefully, they will also be more prepared for the unpredictable world they will encounter outside of school.

Current Practices

What makes traditional teaching methods ineffective?

Historically, mathematics teachers have taught students to imitate or mimic procedures as opposed to developing understanding of mathematical concepts for themselves (Jackson, 1986). Traditionally, teachers have given students formulas, techniques, and steps to calculate an answer without necessarily teaching students to understand and apply the concepts supporting the use of those steps. Many experts in the field have recognized the existence of learning without understanding since as far back as the 1930's (NCTM, 2000). Steen (1990) noted that traditional methods of forming curricula have given students the impression that their learning does not relate to their other experiences in or outside of school. Newmann (1992) describes a study of 9th grade literature in which less than a third of what teachers asked of students was built upon students' input and concluded that schools do not set high expectations for students to use their minds. Likewise, Ellis (2001) recognized that students were able to solve fewer real-world problems upon completion of an Algebra I class than they had been upon entering that class. He states that, "unfortunately, many teachers of algebra…provide instruction that constricts rather than expands student thinking" (p. 62).

Why the need for change?

The National Council of Teachers of Mathematics (2000) emphasized that, "There is no question that the effectiveness of mathematics education in

the United States…can be improved substantially" (p. 5). They assert that there is substantial evidence that students are not gaining the knowledge in mathematics that they need. NCTM suggests that this is due to the fact that students are not engaged or are not committed to learning. The following are reasons why teaching methods need to be changed:

Results from NAEP- The National Assessment of Educational Progress is the "only nationally representative and continuing assessment of what America's students know and can do in various subject areas (National, Overview, under NAEP: A Common Yardstick). The NAEP assesses students at the age of 9, 13, and 17. When comparing 17 year olds taking the assessment in 2004 to those taking it in 1973 or 1999, no significant difference was found between average scores (Perie & Moran, 2005). Although there were gains for 9 and 13 year-olds between these years, 17 year olds were not found to have any improvements in over a 30 year period.

Changing World- The traditional methods of teaching have been questioned in the past and the National Council of Teachers of Mathematics has played a major role in supporting higher quality teaching practices. One good reason for change is that we live in a changing world (NCTM 2000). In this changing world, the importance of mathematics is increasing and the decisions we make daily rely on our understanding of mathematics. NCTM believes that mathematical understanding can give our students opportunities in their futures that those without complex mathematical understanding may not have. Because of our changing world, we need a change in teaching

practices. NCTM promotes learning with understanding and recognizes that this has not always been a common practice in the past.

Preparation for the future- Blank and Hardwell (1997) believe that we cannot justify keeping the same high school model that lacks concrete understanding and connections to the real world.

> In a time in which our graduates will face increasing global competition in the rapidly changing workplace, a time when they will change careers many times, [they] will be faced with the most critical social and environmental decisions in human history, and a time in which they will live in a technological world we can only imagine. (p. 1)

They realize that if we want to prepare our students for the adult world, we need to model our teaching in response to this real world.

Global competition- Blank and Hardwell (1997) also mention global competition as an important topic when considering education's importance. The Trends in International Mathematics and Science Study (TIMSS) tests students' knowledge of mathematics and science in various countries around the world (National, 2004). According to the 2003 TIMSS report, United States fourth graders were outperformed in mathematics by eleven out of twenty-four other countries that participated in the TIMSS study. Also, United States eighth graders were outperformed by nine out of thirty-four participating countries. About seven percent of United States students reached the advanced benchmark compared to about one-third or more in Singapore, Chinese Taipei, Korea, and Hong Kong (Mullis, Martin, Gonzalez,

& Chrostowski, 2004). In these countries, about sixty percent or more of students reached the high benchmark compared to thirty-five percent of students in the United States.

The results reported in the 2003 TIMSS report demonstrate the need for improvement in mathematics education. The purpose of TIMSS is to assist countries to improve student learning and classroom teaching by evaluating current trends in mathematics and science instruction and knowledge (Mullis, 2004). Since many countries are outperforming the United States, the need for reform to improve student learning is evident

Student engagement and achievement- Students need to be engaged in the classroom (Newmann, 1992, Akey, 2006). Unfortunately, the absence of meaning in student work produces little student engagement (Newmann, 1995). Student engagement is defined as the amount of time an individual student participates and is intrinsically interested in school (Newmann, 1992). Engagement includes behaviors that students demonstrate such as persistence and effort and attitudes that might be present such as pride in success and enthusiasm. Engaged students show curiosity in what they are learning and a desire to dig deeper into the subject at hand.

"The merit of any technique, whether conventional or innovative, must be judged on its capacity to improve the intellectual quality of student performance" (Newmann, Secada, & Wehlage, 1995, p. 3). Change is important if students are achieving more as a result. Merely engaging students in classroom activities is not a means to an end, but instead, students

need to have high expectations and greater achievement.

One way Newmann, et al. (1995) define authentic academic achievement is through students constructing their own knowledge, which leads students to a deeper understanding of the material. Merely reproducing knowledge does not call for evaluation or synthesis of information, which are indicators of a more in depth understanding of concepts.

It is important that students stay engaged in the classroom, and it is student disengagement that Newmann (1992) considers the biggest issue in need of attention. Researchers have found that engaged students learn and retain more of what they are learning in the classroom. A direct link has been made between engagement and student achievement in math. Research suggests that when students are engaged, they are more successful in standardized tests (Akey, 2006). Newmann (1992) suggests that the focus of instruction be on engagement because academic achievement will increase through students engaging in the curriculum.

Lamborn, Brown, Mounts, and Steinberg (1992) studied the link between engagement and achievement in nine high schools. The results of surveys administered to the students reveal an association between student engagement and achievement. The survey asked students about their engagement in English, math, social studies, and science by rating their effort, concentration and attention in those classes. The researchers found that students who had higher levels of engagement also had higher grades and spent more time on homework than students who were less engaged. The

researchers assert that consistently, students who are engaged achieve more than students who are less engaged.

Best Practices: Methods to keep students engaged

Constructivism

What is constructivism?

As opposed to requiring students to mimic information given by a teacher, constructivist teaching causes students to internalize and alter or rethink new information (Brooks & Brooks, 1993). Jean Piaget, considered by many to be the father of Constructivism, describes his theory in which people encounter the world and are able to construct their own knowledge and understanding about that world. Therefore, learning is unique to each individual learner because no two learners can experience and construct exactly the same understanding. In a constructivist classroom, students are active in their own learning (Brooks & Brooks, 1993). Students share the responsibility for their own learning, rather than the sole responsibility resting on the teacher.

When students enter the classroom, they have prior knowledge that can be used to construct new knowledge (Brooks & Brooks, 1993). Teachers are not starting from a blank slate, but building on knowledge that students already have to learn more about a certain concept or topic. Students also use the experiences they have had in the real world, evaluate new experiences, and make their own conclusions. Teachers are encouraged to engage students in

activities that build upon their prior knowledge. Having students use past knowledge to construct new knowledge is central to the constructivist theory.

How is constructivism implemented in the classroom?

Constructivism encourages students to ask questions pertaining to their own learning (Brooks & Brooks, 1993). When students ask questions, they are able to take initiative, giving them a sense of ownership over their own learning. Students are to be active participants in their learning, usually in small groups.

While constructivism is largely student centered, teachers also play a crucial role in students' learning. Teachers are encouraged to create environments in which they provide opportunities for their students to think and explore and, in turn, learn how to acquire a deeper understanding of the concepts they encounter (Brooks & Brooks, 1993). "Deep understanding occurs when the presence of new information prompts the emergence of enhancement of cognitive structures that enable us to rethink our prior ideas" (p. 15).

Teachers are also to determine students' prior knowledge and clear up misconceptions associated with that knowledge (Brooks & Brooks, 1993). Lamon (2003) reminds teachers that students do not come into the classroom with ideas that are "fully baked." Therefore, teachers need to play the role of refiner, revising the prior knowledge that students have, and carefully building upon that knowledge.

Research supporting constructivism in statistics teaching

Tsao (2006) examined the effect of constructivist-based teaching methods on students' attitudes towards statistics in an introductory statistics class at the undergraduate collegiate level. Class sessions were one-and-one-half hours long and instruction took place over a 16-week period of time, for a total of 90 hours of class time. The goal of this statistics class was "to teach students to think critically, using fundamental concepts of statistics" (p. 60). Tsao implemented constructivist-based learning techniques in which students were learning in small groups in a variety of learning activities including demonstrations or hands-on experiments that involved data analysis, sampling and experimental design. Tsao's goal was to see if the differences between students' attitudes towards statistics in constructive learning environments at the beginning and the end of the class would be statistically significant.

To measure students' attitudes towards statistics, Tsao administered the Survey of Attitudes Toward Statistics (SATS) at the start and close of the course's 16 weeks. This survey asked 36 questions about student attitudes towards statistics, plus questions pertaining to math in general. The students answered each question on a scale from 1 to 7, with 1 representing "strongly disagree" and 7 representing "strongly agree." The students voluntarily filled out the survey and were told that their answers would not affect their grade, using a fictitious name to ensure anonymity.

At the conclusion of the course, after both pre and post surveys were

collected, Tsao tabulated the results using a t-test to compare the average scores before and after applying what he termed constructivist methods in class. He reported that students had more positive attitudes about statistics at the end of the course and that these results were statistically significant, meaning that the techniques applied in class could be attributed to the increase in attitudes towards statistics. Tsao also states: "Constructivist-based learning approach provides students with the opportunity to apply theory to real-life situations and bring concepts and theories to life, thereby enhancing student learning" (p. 62).

Dietz (1993) also conducted research using Constructivist-based techniques in an introductory statistics classroom at the collegiate level. Dietz describes activities introducing sampling techniques implemented in four 50-minute classes.

Dietz introduced the concept of sampling during the first class. She chose not to give students the information they needed in the form of a lecture but rather recognized that her students were not blank slates and already possessed prior knowledge that they could build upon. The students were asked to come up with their own ways to select a representative sample from a given population. She found that the answers students gave led to their own definitions of statistical terms such as *sample, population, representative, statistic,* and *parameter*. On the third day, Dietz asked her students to discuss sampling schemes and biases based on a reading assignment and then discuss other schemes and biases they might encounter. Again, students used prior

knowledge to analyze the reading assignment and brainstorm schemes and biases. On the fourth day, when introducing the topic of random numbers, Dietz asked her students to come up with their own random numbers. She revealed the flaws in their random numbers, and through this activity was able to demonstrate how difficult it is to act randomly.

Overall, Dietz (1993) saw many successes when implementing constructivist-based teaching techniques. One important success was that her students became more independent thinkers. Students commented that they were able to understand the material because they had to think on their own, and the material was more interesting. She concluded that:

> Most students…seemed surprised and delighted to learn that when they 'created their own' sampling methods, they actually discovered for themselves the 'proven methods.' When students are actively involved in their own learning, they gain confidence in their own abilities and intuition. Knowledge that students have constructed for themselves is understood better and remembered longer than procedures memorized from a textbook. (p. 108)

Authentic Instruction

What is Authentic Instruction?

Blank (1997) has described Authentic instruction as what a teacher will present to a class that involves the "real world" and causes them to gain deeper understandings or new insights on the concept. Authentic instruction involves presenting students with tasks that they might encounter outside the

academic world. When they leave the classroom, what they are learning in the classroom should still be useful. Authentic instruction causes students to have more in depth understandings of the concepts presented in the classroom and the ability to see their uses outside the classroom. Authentic instruction differs from Constructivism, but both encourage students to construct their own individual understanding of the material.

Newmann and Wehlage (1993) articulate five standards of authentic instruction. They found that creating these standards was necessary in the authentic assessment movement. They aimed to counteract two hindrances that they believe make traditional teaching methods inauthentic. The first is that students complete work that does not lend them the opportunity to use their minds well, and the second is that the work they complete has no inherent meaning or worth to the students beyond attaining success in school. Newmann and Wehlage hope that teachers can use these standards to create work for their students that causes them to use their minds well and has meaning beyond school. These five standards are:

Higher-order thinking. This occurs when students are given information and are able to take it, manipulate it, and develop new meaning from it. This standard resembles the constructivist model in which students are constructing their own meaning from given information. There is a level of uncertainty when it comes to this higher-order thinking because the student's individual learning outcomes are not predictable.

Depth of knowledge. Students should have such a deep knowledge of a topic that they are able to "make clear distinctions, develop arguments, solve problems, construct explanations, and otherwise work with relatively complex understandings" (p. 3).

Connectedness to the world beyond the classroom. Activities that address real-world pubic problems or allow students to use their own personal experiences to apply their knowledge can be deemed authentic.

Substantive conversation. Students are able to interact about a given topic by applying ideas and raising questions. A discussion is formed between students and teacher and ideas are shared within the classroom.

Social support for student achievement. All students are given high expectations and a mutual respect for all members of the classroom is formed.

These five standards are a valuable resource for teachers in reflecting upon their teaching and examining their current teaching practices. Although not all instruction can be authentic, Newmann and Wehlage encourage teachers to focus on how their teaching can move towards more authentic methods. These five standards can help this shift toward authentic instruction.

How is Authentic Instruction implemented?

Cornell (1999) asserts that, "Effective math instruction can be enhanced by increasing real-world applications…to ensure continuous learning" (p. 255). Frakes and Klien (2000) concur, suggesting that teachers connect events in their students' lives to their learning of mathematical concepts. Newmann, et al. (1992) describe authentic work as tasks that

students do that are worthy of their time. It is work that students complete that makes them feel connected to in a real way and is also fun and engaging. Lovett and Greenhouse (2000) describe tasks that cause students to see statistics in a more authentic manner. These techniques are described in detail on the pages that follow.

Research supporting Authentic Instruction

Newmann, Marks, and Gamoran (1995) recognized that classrooms have been moving to more authentic pedagogy and sought to research the use of authentic instruction within 24 schools, including eight elementary, middle, and high schools. The researchers selected three mathematics and three social studies classes from each school and observed them four times throughout the year, reporting data from 504 observed lessons. Each teacher was asked to share two examples of assessments that showed the students' understanding of the subject and at least one example of student work connected to the assessment task.

By studying these 24 schools, the researchers were able to document the relationships between authentic instruction and academic performance. Three criteria were used to define authentic academic achievement: construction of knowledge, disciplined inquiry, and value beyond school. Each sample given by the teacher of student work was given a performance score according to these criteria.

At the conclusion of the study, three main findings were documented. First, the researchers found that the amount of authentic instruction observed

in the classrooms was far below the levels they had expected. Second, they found that authentic instruction and improved academic performance were associated. Third, they found that authentic instruction could be delivered equitably, and its effect on academic achievement was fairly equitable among gender, race, ethnicity or socioeconomic status. Overall, the researchers concluded that "if the implementation of student-centered, or constructivist practices were guided by explicit standards for authentic intellectual quality, this study indicates that student performance would benefit" (Newmann, et al., 1995, p. 30).

What are some potential problems with implementing Authentic Instruction?

Blank (1997) explains that there can be difficulty developing an authentic curriculum with a preexisting curriculum, textbooks, and standards. Newmann (1992) suggests that more time be taken on the design of new curricula. There is also a fear that spending class time on authentic learning can take away time preparing for standardized tests, but the concepts needed for these tests can be learned in the authentic classroom (Blank, 1997).

Another concern is that students will not be properly prepared for standardized or basic skills tests (Newmann, et al., 1995). It is important to understand that authentic instruction is not meant to replace all types of "inauthentic" work in school. There are times when skills need to be taught through memorization. Although not all concepts can be taught authentically, there are many concepts that can be. Despite the concerns, the research suggests that when students learn these concepts through authentic methods,

they outperformed their peers in more traditional classroom settings (Knapp, Shields, & Turnbull, 1992).

Using Constructivism and Authentic Instruction in a Statistics classroom

Scaglione (1997) recognizes that "the mathematics of the large majority of workplaces includes basic math operations, measurement systems, probability, statistics, percentages, rations, fractions, decimals, and graphical data" (p. 10). The concepts used in statistics can be applied to many aspects of life and students' future jobs. Therefore, statistics needs to be real from the very beginning. Velleman and Moore (1996) suggest that students use real data to learn new concepts and reinforce already learned concept in relation to statistics.

Bock, Velleman, and DeVeaux (2006) titled their book *Stats: Modeling the World,* and recognize that statistics should not be just what students encounter in a textbook, because statistics really do model the world that we live in. The authors state in their introduction that, in the real world, students will not be given problems that are accompanied with a chapter that tells them exactly what to do to find a solution. Therefore, at the end of each chapter they include problems that model something that students might encounter in the real world. Tsao (2006) found that students entered statistics with negative attitudes but when authentic learning occurred, students left with more improved attitudes about statistics.

Lovett and Greenhouse (2000) explain that students are prone to use their prior knowledge of statistical terms when they enter a statistics

classroom. They suggest that teachers build upon this past knowledge by clarifying what students already know about the concept. Building upon prior knowledge can be important when it comes to a topic like probability, and teachers can use this to clarify misconceptions students might have about the topic. Once misconceptions are cleared up, the prior knowledge can be used to benefit student leaning of new knowledge.

There are many methods to presenting statistical material in a more authentic manner. Lovett and Greenhouse (2000) describe the use of statistical software to aid students in seeing datasets in a real way and answer questions about these datasets. Most statistical software available contains many datasets that contain real-world data. They also mention projects in which students are asked to collect their own data from the real world.

Conclusion

Overall, students need to engage in a high quality mathematics education. For years, theorists and researchers have seen the importance of an authentic learning experience for students. This importance is captured by Dewey (1916) in a chapter he titles "Waste in Education" in his book *School and Society*:

> From the standpoint of the child, the great waste in school comes from his inability to utilize the experience he gets outside . . . while on the other hand, he is unable to apply in daily life what he is learning in school. That is the isolation of the school--its isolation from life. (p. 89)

It is important that students see connections from school to daily life (Newmann, et al, 1995, Blank, 1997). When these connections are made, as described in this Literature Review, students exhibit more engaging behavior, which in turn causes higher achievement. When students use prior knowledge to construct new knowledge, they are more engaged and feel more involved in the learning process. Students need to see the value that school has in life outside of the school walls. Therefore, changes must be made in classrooms and the education system as a whole.

METHODOLOGY

Setting

This teacher action research study takes place in an urban high school of approximately 3,000 students in the northeastern United States. This school is ethnically and economically diverse with 3% Asian, 12% Hispanic, 18% Black, and 67% White students, and 18% of all students are eligible for free or reduced lunch. Advanced Placement, Honors, College Preparatory and Basic/Applied classes are offered. I gathered data within my own Honors Statistics classroom and, on occasion, within an adjacent computer lab. The classroom consists of 27 student desks placed in three rows of paired desks. Each student was paired with a partner except for a lone student, who joined a nearby pair to form a group of three when necessary.

Participants

This particular Honors Statistics class consisted of 20 twelfth grade students and one eleventh grade student. While the school has a diverse ethnic population, this class enrolled only white students of varied ability levels. One student came from Honors Algebra 2; twelve students came from CP Pre-Calculus; one student came from Honors Calculus; four students came from Honors Pre-Calculus; one student came from Algebra 3/Trig and two students came from CP Algebra 2. Honors Statistics is an elective course not required to satisfy graduation requirements. Hence, students enrolled have

opted to take an additional mathematics course and therefore may feel differently about mathematics that the school population as a whole.

Procedures

First, I submitted an application to the Human Subjects Internal Review Board (HSIRB) (see Appendix A). After receiving approval from HSIRB I was able to ask my building principal for approval (see Appendix B). Next, after receiving approval to proceed from my principal, I talked with my students about the study and handed out parent consent forms (see Appendix C). I discussed with them what my study would entail and answered any questions they had about the study. I received 21 signed consent forms, one from each student in the class. All agreed to be research participants.

To start the study, I needed to know their initial thoughts and attitudes about statistics. I administered a survey to gather this data titled "Statistics Survey" (see Appendix D). I also administered this survey at the conclusion of the study in order to see what attitudes had changed. Six and twelve weeks into the study I administered a survey about participant thoughts on the class and the connection to the real world (see Appendix E). At the conclusion of the study, I listed some real world examples that were presented in class and asked students to comment on them (see Appendix F and G).

My intention throughout the study was to connect the concepts learned in class with the outside world by helping students to collect their own data about the class, the school, and the larger community. Students also collected data by weighing pennies and looking at M&M distributions. Throughout the

study, I attempted to present statistical concepts in the context of students' personal lives. The concepts encountered through the course of this study were the same concepts taught in previous years, without subtracting any content from the curriculum. The only change was the use of real world examples in the place of pre-existing book examples, consisting of numbers that had little or no meaning to my students.

Data Sources

Among the data sources that I used to document the happenings in my classroom and my students' progress throughout the study were observation and field logs, surveys, interviews, and student work and test data. These methods align with Wolcott's (2009) concept of triangulation, a method of gathering and comparing data from different sources.

Observations and Field Logs

Throughout the study, observation was a vital part of understanding my students' learning and attitudes. I observed what my students did and said in the classroom as they worked individually, in groups, and as they interacted with me. As I taught I kept a small piece of paper near and was able to jot down quick notes of the students' interactions. This enabled me to record students' actions and comments, all of which Holly, Arhar, and Kasten (2005) recommend. I maintained a log of such interactions whenever any facet of the real-world curriculum was implemented. Keeping a field log ensured that over time I was documenting a fairly accurate picture of what happened in the classroom and was useful later for reflection and analysis. It was important

that I kept a fairly accurate picture by using my notes throughout class to write in the field log later that day or the next. There were, of course, thoughts that came to mind as I wrote in my field log. These observer comments I kept in my field log and distinguished my thoughts by placing them in brackets. This allowed me to later know the difference between what actually happened in my classroom and what I was thinking pertaining to the situation. This process is recommended by Bogdan and Biklen (2002).

Surveys and Interviews

I distributed several surveys to my students in order to understand their thoughts and progress throughout the study. These surveys allowed me to analyze their attitudes and their ability to connect what we were learning with the outside world. Through the surveys I was able to gain valuable insight as to whether they were seeing real world connections and if how well they understood new curricular concepts. I was also able to interview a few students about their attitudes towards statistics and their general thoughts on the concepts taught. Interviewing allowed me to probe deeper into their thoughts. I used questions from the survey that I thought needed more clarification. I also used the answers I received from the surveys to craft deeper questions and allowed my students to give open and honest answers. Because I left the questions opened ended my students were able to give me feedback about their experiences throughout the class. This semi-structured method is recommended by Hendricks (2009).

Student Work and Test Data

Hendricks (2009) suggests collecting student work and analyzing it as part of the research process. By looking at assignments students had completed I gained better insight relating to their understanding of the concepts being taught. Also, test data was a good way to monitor student achievement and to ascertain what concepts needed further exploration. I was also able to see if teaching the concepts using real world examples was associated with a better understanding of the concepts.

TRUSTWORTHINESS

There were several steps that I took to ensure that my research was ethical and trustworthy. The following section explores the steps I took to ensure a trustworthy teacher action research study:

Consent Forms

I began the research study by gaining consent from the college's Human Subject's Internal Review Board (HSIRB). HSIRB approved my formal proposal, which ensured that my study was not placing student at risk (See Appendix A). Next, I gained permission from my building principal (See Appendix B). I then described the study to my students and distributed participant consent forms (See Appendix C), informing students and parents of the study studying more detail. Holly, Arhar, and Kasten (2005) recommend discussing the study with students before implementing. The ensuing discussion with my students about the study provided an important opportunity for me to answer my students' questions, which provided an important first step.

Reflective Memos and Field Logs

Reflecting on my teaching practices helped me to refine and analyze lessons and evaluate the effectiveness of the activities. Throughout the study, reflection on my current and future teaching practices was key to moving ahead and planning lessons that would benefit my students. Reflective memos helped me to understand my view of the students and their learning and helped me make decisions on the best teaching practices. This also helped me

to understand and deflate any biases that I might have. I was also able to keep a field log of events in the classroom that related to my study (Ely, 1991; MacLean & Mohr, 1999; Hendricks, 2009). The field log contained students' actions and comments during the class period written in the log soon after it had happened. This log allowed me to assess what had happened at a later time.

Anonymity

To keep my students' work anonymous, each student was assigned a pseudonym, as suggested by Holly, Arhar, and Kasten (2005). I made sure that their names, our school name, and the names of staff members remained confidential. No names were kept on student work, but rather were immediately replaced with pseudonyms.

Safeguarding Data

All collected data was safeguarded, which allowed me to maintain each student's anonymity. Students were not able to access my personal computer, where I typed my reflections and logs. Student artifacts were kept in a locked cabinet at school when I was not using them to reflect or collect data. At the end of my research study, original work was returned to students, and my field log was destroyed.

Multiple Perspectives

Throughout the data collection process, a teacher research support group consisting of myself and two other degree candidates met once a week to discuss the progress of our respective studies and offered each other

suggestions and encouragement. It was essential to gather feedback from other professionals. MacLean & Mohr (1999) recommend meeting as a group to gain further insight and advice pertaining to my study. We were able to read each others field logs, surveys, and plans for future activities and receive feedback and at times much needed constructive criticism and support.

Preconceived Notions

There were, of course, biases that I had to define, sort through, and reflect upon before I could implement my research study (MacLean & Mohr, 1999). The first that I had to come to terms with is the idea my students would automatically be more motivated when classroom activities clearly relate to them. Since I studied an Honors class, it is easy to assume that all students will be motivated and interested in the activities. Although it was my hope that the activities would create enthusiasm and interest, I realized this was not always the case. I had to be prepared and learned to adjust lessons appropriately.

Along the same lines as motivation, I also had to realize that my students were not always able to see the real world connection and appreciate that connection. Although I saw the links between the content material and real world experiences, some students were not always able to see the association. This was a surprise to me and it caused me to rethink some activities and focus more on individual students who were not seeing the connections I intended.

The last bias that I had to realize and understand is my assumption that all students would participate in the activities and come prepared to work. Again, this was an honors class, so my expectations were high. My students did not always want to participate in the given activities. When this happened I needed to re-evaluate the logistics and design of the groups and activities but also maintain my high expectations.

OUR STORY

The First Day of School

My students entered the classroom on the first day of school talking quite excitedly to each other as I gave them assigned seats. When I started to explain my expectations for the year and handed out a sheet of guidelines, they settled down immediately and listened intently. Doug noticed that the graph on the student handout didn't make sense (see Figure 1), a mistake I had purposefully made to show them from day one that statistics should be meaningful.

4. Marking Period Grades

Exams.....30%
Homework.....25%
Open Book Quiz.....10%
Closed Book Quiz.....10
Participation.....5%

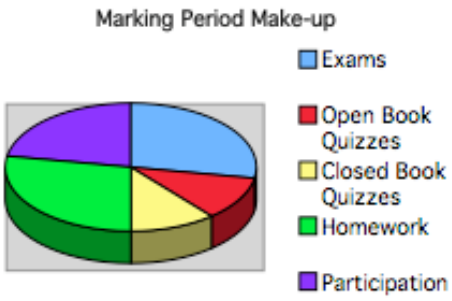


Figure 1. Marking period grades and pie chart

He called out, "This graph doesn't make any sense!" and another student agreed. While I was pleased that the group seemed to be filled with active participants, I thought to myself, "I may have a lot to work on with this class. They call out, talk to each other and seem like they might be a handful." As I pondered how I'd go on to deal with their exuberance, I explained that the graph was constructed incorrectly, and I also complimented Doug on his

ability to pick up on the mistake, noting that engaging in critical thinking and making observations would be quite important in this class.

When the end of the first class period neared, someone called out, "Are we going to have a lot of homework in this class?" When I explained the assignment for that first night, Kyle added, "You're giving us homework on the first night?! Man, that's harsh!" I explained to students that this first assignment would help me get to know them better as they told me about themselves and briefly described their likes or dislikes in math. As they left the room, they again had a lot of interaction with each other and I wondered if this particular class would exhaust me this year.

Class Continues

As I planned for the next day, I thought a lot about how I might use their talkative nature to my advantage. The first unit of instruction was titled "Describing and Displaying Data," which covered displaying quantitative and categorical data in graphs and tables, and describing the distribution of data using statistical terms and calculations. The first lesson the students would encounter was an overview of different methods of displaying categorical data.

As our second class got underway, John, Doug, and Melissa freely offered comments, but the others were silent unless I directly called on them to speak.

"Can anyone define the word *categorical*?" I ask the students eagerly.

The class sat and stared at me without a response.

"Well, you have heard the word *category* before. Can you think of something that fits into a category?"

Doug raised his hand, "Male and female?"

"That's great. Gender is categorical. Can you think of any others?"

The class again sat and stared at me with blank looks on their faces.

John broke the silence, "What about black or white?"

"That's great. Now that you see some examples of categorical data, can you think of any displays of data that you have seen in newspapers, on TV, or in magazines or books?"

The class sat and stared at me as if I had asked them to solve some complex math problem. They seemed to be trying to think of examples, but no one offered a response.

Finally, Melissa broke the silence, "Pie Charts?," she offered with hesitation.

I quickly wondered if they were not interested in what I was teaching, if they were not used to participating in class, or if they just didn't feel like talking. I also wondered, based on Melissa's answer, if they opted not to participate because they weren't confident in what they had to say. I decided that I would work on my questioning by asking more open ended questions and also had planned a few group activities, which I had hoped would create an environment where they feel they would feel more comfortable to talk freely.

Introducing the Study

When I introduced the action research study to the class, all of the students seemed very interested, hanging on my every word, quietly listening as I handed out the consent forms and talked through the implications of participation in the study. I made sure they understood that their participation was voluntary and that they could withdraw from the study at any point without consequence. I told them that they would be presented with real world examples throughout the semester and that I hoped they would see that statistics is very applicable to their lives. I commented that I hoped that they would enjoy the real world applications and see that this class is meaningful and engaging. As I talked several heads nodded with excitement. The only comment throughout the period was from Kyle, "Can I make up my own pseudonym?" Although there was still little verbal response, their facial expressions told me that they were excited to embark on this journey. I was eager to embark on the journey with them, and within three class periods, I had received all 21 signed consent forms.

Initial Survey

To gather their initial thoughts about statistics, I handed out the Statistics Survey (see Appendix D). This survey included statements about statistics that students rated from a scale of one to seven, one being strongly agree, four indicating neither disagreement nor agreement, and seven being

strongly disagree. The first statement was "I will like Statistics". The average answer was a 3.2, which showed that the students had a positive attitude about statistics before starting the class. Table 1 highlights five key questions from the survey and the average response.

Table 1

Initial Survey

Question	Average rating (out of seven)
I will like statistics	3.2
Statistics is worthless	5.9
I use statistics in my everyday life	3.4
I am interested in using statistics	3.1
Statistical skills will help me in my future career	2.8

Overall, students' answers were fairly positive. Most students agreed that they would like statistics and had positive attitudes about taking statistics class. Also, for the most part, students did not think that statistics was worthless. They also agreed that they already use statistics in their everyday lives and they were interested in using statistics in new ways. Students seemed to also think that statistics would help them in their future careers, perhaps contributing to their positive attitude towards statistics. It was exciting to realize that my students already agreed that statistics could be related to their lives and that they thought they might actually like the class.

First Hands on Activities

Within the first week of the study, I presented the students with their first hands on activity, which involved students collecting data about the color distribution in M&M's packages. There were three objectives for this lesson. First, I had hoped the students would be more verbal in class as they processed the information. Second, the students would be given an opportunity to collect data and organize that data into tables and graphs. Third, students needed to become proficient in making tables and graphs on Microsoft Excel, which was covered on the second day of the activity.

I placed students into pairs and gave each student three bags of M&M's which contained plain, peanut and mini M&M's respectively. The students were to keep track of how many of each color appeared in each bag. They were to organize this data into a contingency table and answer the following questions:

> *1. What percent of plain M&M's are blue?*
> *(total amount of blue plain M&M's divided by total amount of plain M&M's)*
> *2. What percent of green M&M's are mini? Plain? Peanut?*
> *3. What percent of mini M&M's are red?*
> *4. What percent of plain M&M's are yellow?*
> *5. What percent of brown M&M's are peanut?*
> *6. Write a brief description of the association between type of M&M and color distribution.*
> *7. Comment on the problems (if any) with these findings.*
> *8. Create a better plan for finding the association between type and color of M&M's.*

On the second day of the activity the students were to take the information collected on the previous day and create a contingency table, bar

graph, and segmented bar chart using Microsoft Excel. The students were given the choice to make another type of graph of their choice. Figure 2 is an example of what one student constructed on the computer.

	Blue	Red	Brown	Green	Orange	Yellow	Total
Mini	4	9	10	14	9	15	61
Plain	15	4	7	5	11	5	47
Peanut	6	6	3	5	4	0	24
Total	25	19	20	24	224	20	132

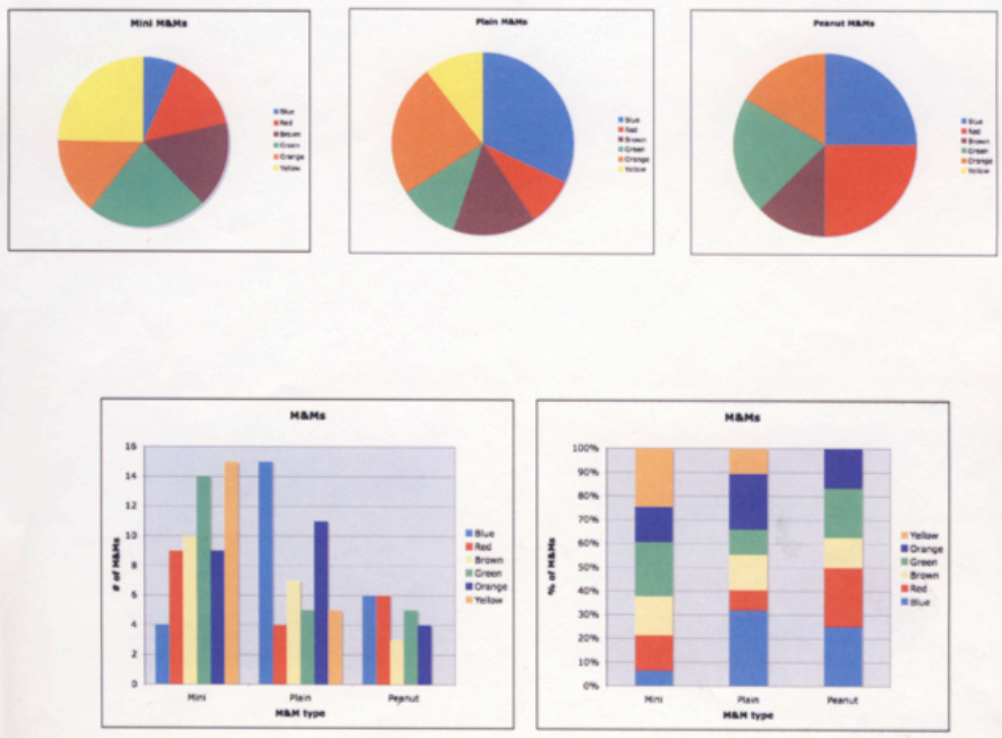


Figure 2. M&M graphs

This student constructed the graphs correctly and even spent extra time to match the colors of the charts with the respective colors of the M&M's. This student's work impressed me and showed that she understood how to construct the graphs on Excel properly. This student chose to add a fifth graph, the bar graph on the bottom left of the sheet. This graph I thought was a wise decision and clearly displayed the distribution of colors in each bag and

was one of the best graphs students could have chosen to display these data. Other graphs chosen were typically not appropriate. For example, Kyle chose a surface graph (see Figure 3), which inappropriately displayed the data.

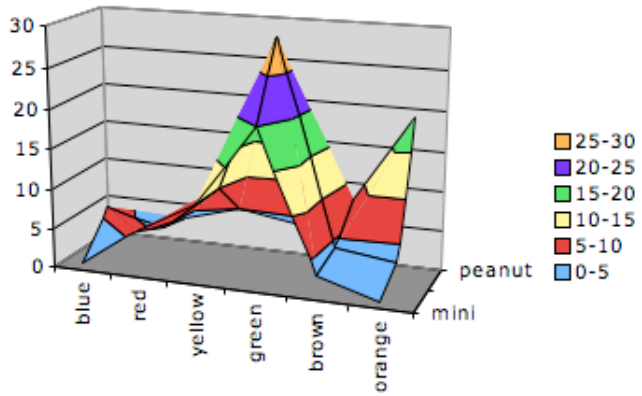


Figure 3. M&M surface graph

When asked why he chose this graph, he stated, "It's cool looking." While it was reassuring that he did not believe this graph was an appropriate display, it was disappointing that he had not connected the data more clearly to the display.

The next day, after posing reflective questions about their problems and thoughts, several students raised their hands.

"What did you like about this activity?"

"I liked how we used real things instead of just using numbers that are already given to us, like in the book," responded Doug.

"It was fun to work with the M&M's. I think it is better that way," John added.

Mike chimed in, “Going to the computer lab was good because we got to leave the classroom.”

“And I’m glad we learned how to graph,” added Cory.

Overall, students seemed to be happy to be doing something hands on and felt involved in their learning of the concept of collecting data and displaying it appropriately. Also, counting the M&M’s kept their attention and students seemed to work well with their peers.

They were also able to raise problems that occurred in their data collection, and I attempted to discuss the implications of these problems.

“We only had one green M&M,” explained Doug.

“One of our M&M’s was broken!” offered Kyle

As students responded, I realized that just because they were all engaged in the activity didn’t necessarily mean that they were processing what was happening as they collected data. I was happy that *during* the activity they were engaged, but afterwards they were not all able to process the activity as well as I would have liked. The activity gave them something to be engaged in, but not something to help them process. I realized that asking more thoughtful questions and communicating my high expectations for them could improve the activity.

As I prepared my second hands on activity, I made sure I had thoughtful questions for them and also made sure I remembered to communicate the high expectations I had for them. They would be collecting data on the weights of at least 30 pennies and using that data to create and

describe histograms. The purpose of this activity was for students to be able to describe distributions using the terms associated with the shape, center, and spread of the histograms. The students were also expected to be able to construct their own histograms and be able to use various scales when constructing their graphs. For this activity, students were placed in groups of threes. The students received a bag containing 30 American pennies minted in various years, with a few bags containing one Canadian penny. Students were asked to weigh pennies, graph the results and describe the distribution. Since the newer pennies were made of zinc instead of copper, the distribution would be bimodal with a gap. Also, the students receiving the Canadian penny would see another gap in the graph. After weighing the pennies, every group member made a different histogram of the weights based on different bin widths.

As the class was given their assignment, I heard Melissa call out, "Why do we have to weigh the pennies? They all weigh the same!!"

This posed an interesting question that I had hoped the students would bring up. I asked the students what they thought and they nodded their heads in agreement. When I suggested that the weights actually might vary a bit, Melissa nodded and seemed excited to see if they really would, her skeptical look still on her face. Melissa seemed unsure of the connection between the real world and what we were learning in class. My hope was that she would see that we are learning about the real world.

Based on Melissa's comment, I planned on changing the activity for next year so that the students would guess what the weights would be, how they would vary, and what the histogram would look like before they drew it. I listened in as Joe, Betty and John worked together.

Joe: Let's make the y axis the year

John: Year? What does year have to do with anything?

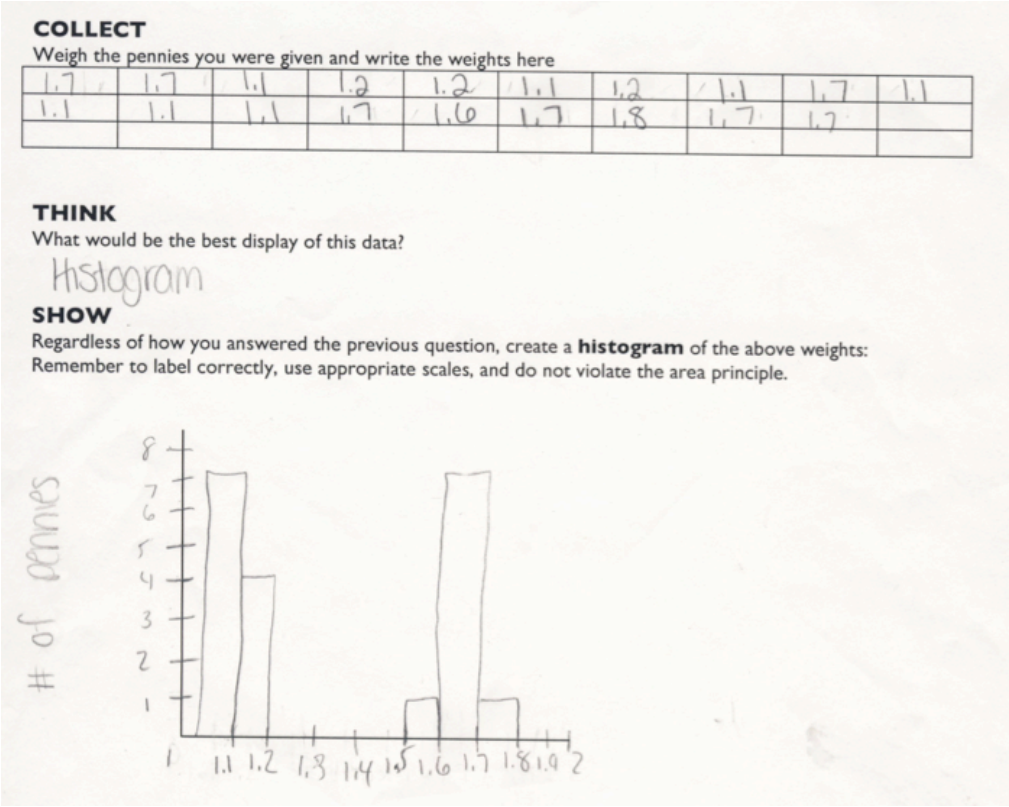
Betty: You're right

John: We should use height and weight instead.

Joe: Ok

This small interaction revealed to me that although this group knew how to construct a histogram, they were not able to take the data of penny weights they had collected and transfer it clearly into a graph. When they agreed on using height and weight, they realized they had no height, but were simply used to weight being paired with height.

Overall, all students were engaged in the activity and were able to create histograms with different scales. These histograms were very accurate and the best I had seen in the class thus far (see Figure 4).



COLLECT

Weigh the pennies you were given and write the weights here

1.7	1.7	1.1	1.2	1.2	1.1	1.2	1.1	1.7	1.1
1.1	1.1	1.1	1.7	1.6	1.7	1.8	1.7	1.7	

THINK

What would be the best display of this data?

Histogram

SHOW

Regardless of how you answered the previous question, create a **histogram** of the above weights: Remember to label correctly, use appropriate scales, and do not violate the area principle.

Figure 4. Weighing pennies

Once I asked questions the *next day* (I allowed them time to process this time), the entire class was silent. They were not able to tell me what they learned from the different bin widths of the histograms. Finally, though, Doug volunteered, explaining, "It shows that you have to be careful when you make your histograms. The bin widths can't be too skinny because then it doesn't show the gaps." Doug had just demonstrated that he understood the concept by describing the difference in the various bin widths.

I was happy that students were able to make fantastic histograms, but I was disappointed that they lacked the insights I was looking for. I wanted them to be able to understand that varying bin widths created very different

graphs. While students other than Doug might also have picked up on this concept, Doug was the only student who was willing to verbalize what he had found in his group. For the next activity, I decided that I would ask them to reflect on paper before of sharing their thoughts aloud.

Later, I did have them reflect on paper:

Kara: "It was fun working in bigger groups. It helped me learn how to graph things better."

Melissa: "It was surprising to see that the pennies weighed differently."

Kara: "It taught us to use different methods of graphing data."

Data Collection in Class

"I like hearing real examples and studies done on real people or things, and not just a hypothetical situation." -Joe

Since the first major activities were hands on and I still had questions as to whether that was a good use of time, for the next activities we collected data about members of the class. The first activities were focused on students collecting their own data and the data displaying it using graphs and tables. As we began next activities, we focused more on describing the graphs using the center, spread, and unusual features. We used the data collected about students in the class to construct the graphs together and then spent the majority of the time describing those graphs. At the end of the activities,

students should be able to graph data appropriately and describe the features of those graphs.

States Visited: Boxplot Construction

The first activity was titled "States Visited: Boxplot Construction." Since we collected data about their lives- the number of states students had visited in their lifetime, they were interested in what we could find about the data. Every student was involved and engaged in this activity as they learned about their peers. We discussed and organized the data using a stem and leaf plot. When they talked about outliers, they named the specific person, instead of the data point, which seemed to help them derive a deeper meaning from the data.

Discussing the distribution of the data in using a stem and leaf plot went well and there was increased participation. Once I started to discuss the technical definition and process to finding an outlier, I noticed Kyle staring at his paper, doodling, without taking notes. Once the conversation turned technical, he seemed to lose interest. As I continued my discussion of how to find an outlier, I also saw Mike start to doodle and cease taking notes. It seemed as if I had lost him because we weren't talking about the specific data values- the people he could relate to and learn from. I was disappointed that I had lost their interest and hoped their interest would increase as they saw the value of what we were learning.

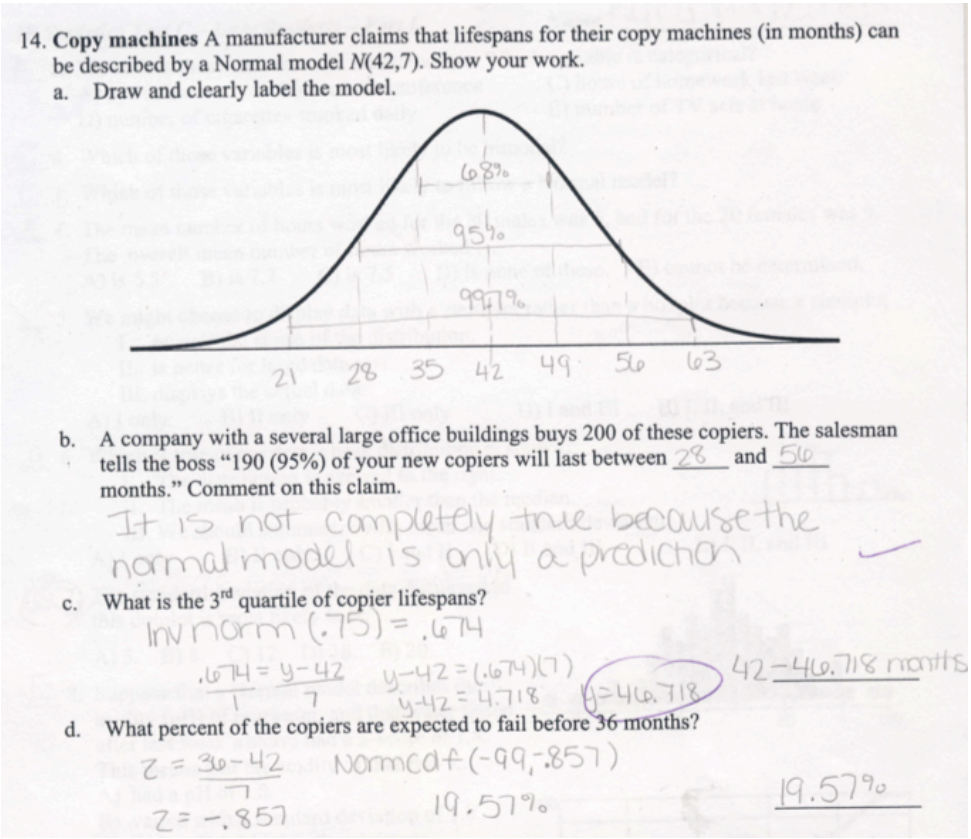
Using marking period grades

In order to teach standard deviation and z-score, I gave the students their current marking period grade. They then compared their marking period grade to the mean marking period grade. I told them the standard deviation of the marking period grades, so they were able to find their personal z-score.

Instead of teaching them the formula for z-score immediately, I told them that z-score was the amount of standard deviations you are from the mean. I then directed them to calculate their own z-score, and eight students were able to do so with no further instruction. I asked Melissa to explain how to do it to the class, and she explained that she took her score subtracted the mean from it and divided by the standard deviation. She was demonstrating an understanding of the concept of z-score and basically teaching the class the formula. I hoped Melissa had seen the connection between the concept and the real world. I later introduced the formula but did not want to lean on the formula, but instead understand the *concept*. As I introduced the formula and students took notes, I looked over to Kyle and noticed he had nodded off.

As we reviewed the concept throughout the unit, most students indicated that they understood z-score on homework and review sheets. John, Melissa, and Kyle indicated that they were having trouble, and John and Melissa were seeking extra help. Kyle assured me that he understood but seemed disengaged when we reviewed. On the unit exam, 18 out of 21 students were able to answer the opened ended question relating to z-score on the exam correctly. Figure 5 shows the work of a student who proved that

they understood z-score and was able to apply it to the question. The majority of students answering this question correctly showed me that they did understand the concept of z-score and were able to use z-score in the appropriate question, including Melissa.


14. **Copy machines** A manufacturer claims that lifespans for their copy machines (in months) can be described by a Normal model $N(42,7)$. Show your work.

a. Draw and clearly label the model.

b. A company with a several large office buildings buys 200 of these copiers. The salesman tells the boss "190 (95%) of your new copiers will last between 28 and 56 months." Comment on this claim.

It is not completely true because the normal model is only a prediction

c. What is the 3rd quartile of copier lifespans?

Inv norm (.75) = .674

$\frac{.674}{1} = \frac{y-42}{7}$ $y-42 = (.674)(7)$ $y-42 = 4.718$ $y = 46.718$ 42 – 46.718 months

d. What percent of the copiers are expected to fail before 36 months?

$z = \frac{36-42}{7}$ Normcdf(-99,-.857)

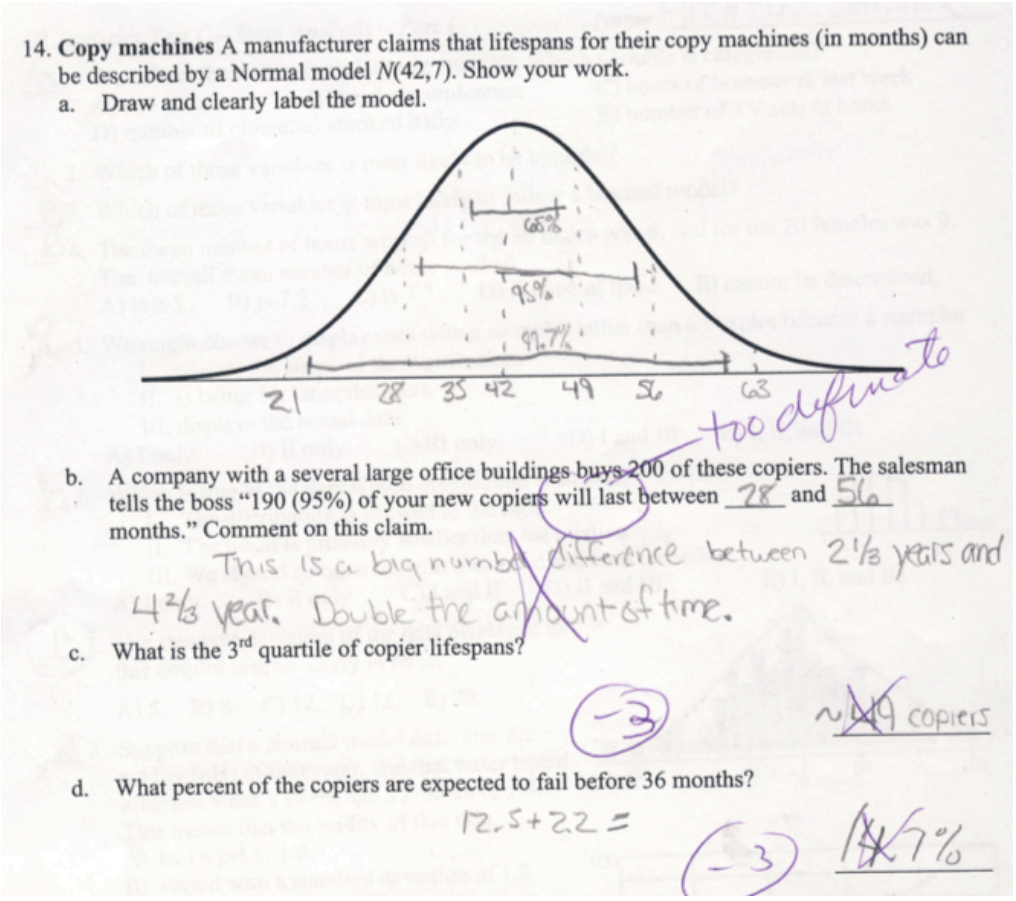
$z = -.857$ 19.57%

19.57%

Figure 5. Z-score 1

Unfortunately, there were still a few students who did not understand z-score, as demonstrated in Figure 6. These students included Kyle and John, both of whom needed extra attention. John did stay after school for help with the concept and seemed to be able to answer questions I posed him. When it came to the exam, though, he seemed not to understand and did not know where to start. My hope was that as the semester progressed, John would

begin to grasp the concept. Kyle apparently had not understood the concept, which was predictable from his disengagement in class.


14. **Copy machines** A manufacturer claims that lifespans for their copy machines (in months) can be described by a Normal model $N(42,7)$. Show your work.

a. Draw and clearly label the model.

too definate

b. A company with a several large office buildings buys 200 of these copiers. The salesman tells the boss "190 (95%) of your new copiers will last between 28 and 56 months." Comment on this claim.

This is a big number difference between 2 1/3 years and 4 2/3 year. Double the amount of time.

c. What is the 3rd quartile of copier lifespans?

-3

~49 copiers

d. What percent of the copiers are expected to fail before 36 months?

12.5+2.2 =

-3

17%

Figure 6. Z-score 2

Impromptu Real World Examples

"With all the activities we did and real world examples in class we made spur of the moment connects to the real world." Tara *Gretzky*

As the students continued learning about organizing data into stem and left plots and describing the shape, center, and spread of the data, students were assigned a problem to work on from the textbook. I choose the question

because I liked the amount of data that was presented and I thought the questions were appropriate for their level of understanding. As I picked this problem, I was not thinking about the real world implications as much as the conceptual features of the question.

12. The Great One. During his 20 seasons in the NHL, Wayne Gretzky scored 50% more points than anyone who ever played professional hockey. He accomplished this amazing feat while playing in 280 fewer games than Gordie Howe, the previous record holder. Here are the number of games Gretzky played during each season:

79, 80, 80, 80, 74, 80, 80, 79, 64, 78, 73, 78, 74, 45, 81, 48, 80, 82, 82, 70

a) Create a stem-and-leaf display for these data using split stems.
b) Describe the shape of the distribution.
c) Describe the center and spread of this distribution.
d) What unusual feature do you see? What might explain this?

Figure 7. Gretzky problem (Bock, 2007, p. 66)

While the class was completing this problem I noted this conversation between Cory, Ed, and Doug.

Cory said, "Ed, this problem is about hockey!"

Ed replied, "Oh cool."

They were apparently interested in the data that was given.

Then Doug turned around, "Gretzky, has played an unbelievable amount of games!"

"Well, he's a great hockey player," Cory noted.

This short conversation taught me that a small sports example using a familiar hockey player could grab a student's interest and attention. As soon

as Cory and Ed found out the example was about hockey, they were immediately interested. The three of them were able to answer the questions more readily than anyone else in the class, seemingly because they fully understood what the meaning of each datum was. Doug explained that the data were skewed to the left and typically Gretzky played around 80 games. I asked the class if they picked up on the unusual features. Cory noticed that there are a few outliers. When I asked why there might be outliers, Doug knew immediately that Gretzky could have been injured or a new player during those seasons.

While the Gretzky problem had not been selected as one of my "real world activities," my students' responses helped me to realize that such a small example would keep them interested in the activity. We did not collect data, and the activity was not hands on, but because they could relate they were instantly engaged. I began to wonder what other examples I might create to get others involved in a similar way.

Mustang

The next day, I presented students with an example about fuel economy and cylinders in a car to further our discussion of distributions and boxplot constructions.

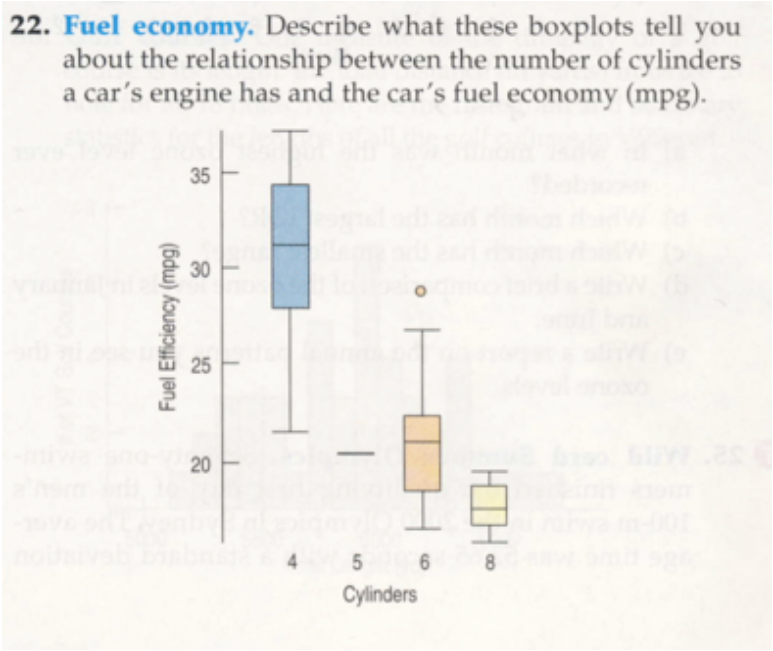


Figure 8: Fuel economy (Bock, 2007, p. 93)

The question prompted the answer that the more cylinders the car, the less mpg's the car had based on the boxplots. I noticed that several students in the class looked like they were zoning out, indicating that they most likely did not understand the question and did not find it engaging. Not purposefully, just impromptu, I gave them the example of a Mustang convertible, trying to clarify the question. I explained that a Mustang can have eight cylinders but my Civic has four. I asked them what they know about the gas mileage of the two cars. Four heads- Doug, Ed, Mike and Cory immediately looked up and were very visibly engaged in the lesson, no longer staring into space. I left the conversation there and asked the students to see if they could use that real world knowledge to better answer the question.

A few days later in a discussion of outliers and skewed data, I again noticed Kyle and Mike staring into space. Because I had learned that a small tie to the real world increases student engagement, I explained that Alex Rodriguez's salary skews our data. I had read about Alex's high salary recently in an article and how his salary makes people believe that baseball players are making a lot of money. When finding the average Major League Baseball salary, Alex's high salary inflates the average. When I brought up Alex Rodriguez, they became visibly engaged and, in fact, the entire class was interested in learning more. I used this example to show them the difference between mean and median and the importance of discerning the difference between the two measures of center. They were able to tell me that Alex's salary would inflate the average salary but when shown how much it skewed the average salary they were amazed. They had prior knowledge of outliers and their effect on data, but were not aware of how much of a difference an outlier would make.

Price of Shoes

My lesson on stem and leaf plots was not related to the real world. I told my students that we were to be leaning about a stem and leaf plot, but this day I had not come prepared to use real world examples, and instead I was going to use made up numbers.

"But everything has to be REAL! You can't make up numbers, we have to relate it to the REAL WORLD!" Doug exclaimed.

"But I don't know what we can use."

Immediately, ideas were flying. I told them the numbers had to contain one, two, and three digits.

Mike, suggests, "Lets use the price of our shoes."

"That will work," I stated.

The price of our shoes worked and we were able to construct a stem and leaf plot from this data.

"What features do you see from this plot?"

"The shape of the plot is bimodal because a lot of people spend around $40 on their shoes," Doug commented.

"The distribution is skewed to the right because there are less people who spend a lot of money on their shoes," Rich noticed.

John explained, "The graph has an outlier at $10. Eric doesn't spend a lot of money on his shoes."

The class continued to comment on the shape, center, and spread of the distribution accurately. This turned out to be a great real world example and one example where the students really took ownership and became engaged. At the end of the study, students still remembered this activity.

Mid-Study Results

The responses to the six week survey were overwhelmingly positive. Students commented about examples that related to the real world and activities they thought were the most interesting:

Doug: “In the Penny lab we learned about the copper that was used in earlier pennies”

Kara: “Many of the examples we see are real world related and this just makes the data more interesting to look at”

Claire: “Weighing pennies- it helped me better understand a histogram because we acquired our own info to asses in a graph”

Claire: “I liked when we compared dollars spent on shoes in our class because it was interesting to see what different people spent. I also liked finding our own z-score for the first quiz because then I knew how I did compared to others.”

Joe: “Shoe size vs. height- scatter plot and cost of shoes- stem and leaf, they were both interesting because you could compare yourself to your classmates.”

Melissa: “We use examples of the price of our shoe size- easier to understand a graph when we acquire our own info as a class and height- made it easier to see the x and y axis relation.”

Sue: “Sports examples- because I am a huge sports fan.”

Students also answered the question, “Have you seen the connection between Stats and the real world?”

Eric: “Yes, I see examples of statistics much more often now that I am learning about it. For example, the 70% stat in our school may not be accurate because it was conducted last year.”

Mike: “I see graphs and percentages that we work on in class.”

Ed: “We see Statistics on TV and in the newspaper every day.”

Sue: “Almost all of our in class examples can be useful in the real world- percentiles, mean, median, histograms.”

Joe: “Yes, because stats help describe and explain how and why numbers are the way they are. For example, I didn’t know how to read graphs, let alone know they could lie.”

Kara: “Yes, I have started to realize how often I see graphs and polls on TV and in magazines/newspapers.”

Cory: “Timeplots and stock market, mean and sd or grades.”

Betty: “People always use things related to statistics.”

Megan: “When I read the newspaper, I comment on how they’re probably trying to trick us and certain factors could be skewing results.”

David: “Yes, stats can help explain particular patterns in the real world.”

While these comments were positive and the majority of students commented on ways they had seen our class connect the real world, there was one student who commented that she was not able to see the connection to the real world. Melissa wrote, “No, I don’t know the connection between statistics and the real world. Not yet, anyway.” Later, in an interview with Melissa she commented that she hadn’t really seen how the statistical concepts that we were learning in class could be seen outside of class or relate to her specifically. She said she would keep an open mind and maybe she

would change her mind after seeing more material. This is what I had suspected and I had hoped that her time would come.

Students also commented on their overall impression of statistics. Here are some comments that I received.

Kyle: "STATS RULE!"

Eric: "[Statistics] is interesting, I enjoy learning about Stats in the real world situations and having the ability to recognize it."

Mike: "Challenging but still fun to learn."

Doug: "I LOVE IT (literally)"

Kyle: "Fantastic!"

Joe: "It's been a fun, interesting class"

Sue: "It is the most useful math class I have ever taken, and I can actually apply these skills to the real world."

Claire: "At times difficult, but understandable and easy to relate to. The class itself is more interesting because of your own excitement in the class."

Cathy: "Stats is much more applicable to the real world than any math class I've taken so far. I like the class. It seems like it will be getting more difficult."

Cathy commented on how she thought statistics was applicable to the real world but she couldn't think of any specific examples of what we've done or what related to the real world. It's interesting that she knows it relates but did not know specifically how it related. I wondered if she knew it related

because I told them or because she saw others making connections, or because she was actually seeing the connections for herself.

Outside of Class Examples

Weekend Statistics

Claire was a great student, always participating in class and taking notes, but her grades did not always reflect her great effort. One day she came to class very excited, almost jumping out of her skin. She couldn't wait to tell me that she actually used what she learned in class over the weekend while she was driving with her friends.

"I saw statistics over the weekend!

We had learned about scatterplots and correlations and I had told them that an example of a curved plot is the graph of the relationship between miles per gallon and miles per hour. She said that her friend was driving fast and she told him to slow down because she learned that as you go above around 60 mph, the mpg would decrease. She told him that the graph of a scatterplot would be curved.

This was a great moment and my students were excited to see that they could use what they had learned to help them outside of class! Claire had the entire class's interest and her enthusiasm was energizing.

Association, Not Correlation

A few days later, hours before Statistics class was to start, Julie came into my class to tell me that she had just used what we were learning in

Statistics class to correct her physics teacher. Her teacher had been talking about the correlation between two things and she corrected him and explained that what he had called a correlation was actually an association. To be honest, she was a little confused about the reasoning as to why he was supposed to say association, but she knew what a correlation had not been established. It was great to know that she recognized the word *correlation* and saw that it's used in the real world. Julie was thrilled that she had used our class material outside of our class and went out of her way to tell me. I knew that we were making progress.

History Class

Two weeks after Claire came to class excited about seeing Statistics outside of class and a week after Julie came to me excited about her physics class, John came to class with new of his own:

"Mrs. Chen, I have something to tell you and you're going to like it."

"Today we were reading an article in history class and the article talked about skewed distributions. I saved the article for you."

The article stated, "…lower income households fewer people than higher income households, thereby skewing the income distribution." This was another example of how the students were seeing the connection between statistics class and the real world and they were becoming aware of the terms we were using. I used this moment to explain to the class that in the past they might have read this article and not fully understood what skewed meant, but

now they have a better understanding of the concept. "Statistics is important, I explained, "and used in the outside world!"

After those three students found examples of Statistics outside of class, other students casually commented on ways they also were seeing statistics as the study continued:

Sue: "Did you see the survey that we took this morning in homeroom? It was a voluntary response survey!"

Megan: "The alcohol survey that they gave last year was not representative of the entire school"

I was waiting for the day that Melissa would be able to see the connection between what we were learning in class and what she sees outside of class. These students who were making connections were really getting a meaningful experience and I was hoping that Melissa too would see these examples.

Mistake During Class

We continued working with the height and shoe size data. I asked students to open up their lists on their calculator to have the calculator give them the equation of the line. I was able to use prior knowledge and build off of what they knew about slope and y-intercept. All of the students were involved because they understood the equation of a line. We used what the calculator gave us for the slope and y-intercept. We then used that equation to predict the height of someone with a shoe size of 10. The students all worked

on their calculators to predict the height. As I walked around, everyone was working. I gradually heard comments like, "WHAT?" John laughed when he saw his value. A few others said, "I don't understand." So something was wrong, but at this point I didn't know where the mistake came from or even what was wrong.

I asked them what they had calculated, and they said they had a negative number. They obviously thought something was strange because there is no such thing as a negative height. Rich said that he knew what happened: the x and y were switched in their lists. It was true. We had switched the x and the y, and when they looked in their statplot list, they noticed where they made the mistake. I believe that because we had linked their leaning to the real world, they caught the fact that there was a mistake. Then, we were able to analyze our procedures to see why. If I hadn't connected their learning to something they could relate to, I doubt that the students would have picked up on the mistake. Often they will take a negative number as a correct number, without seeing what it MEANS.

Random Numbers

"The blob things were interesting because it showed random numbers and predicting"- Tara

One of the last concepts we covered within the time frame of the study was random numbers. To introduce the concept the students were to estimate the size of a "Rover Blob":

Figure 9: Rover Blobs

There were 100 Rover Blobs on the pages, all numbered 1 to 100. The students used several different techniques including educated guessing, measuring a sample of 10 Blobs, and measuring one of each size and taking the average.

I then introduced the concept of random numbers used to take a random sample. They generated 10 random numbers from their calculator, measured those Blobs and took the average size. This technique gave them the closest estimate of the average size of a Rover Blob out of all the techniques they used. Throughout the activity, all students were actively engaged. Even Kyle was awake and alert throughout the entire activity, although he did break the ruler he was given. Most of the students became very curious as to what the best technique was and really wanted to get as close to the true mean as possible. Once I showed them random numbers and they measured those Blobs, their answers were very close to the true mean. Later, I asked them what they learned from the activity and asked for general comments about the activity:

Ed: “I did not like measuring the Blobs.”

Julie: “It was my favorite lab to data and it really helped me understand [the concept].”

Claire: “FUN!”

Kyle: “I learned that the best way to get an accurate representation of a group is by using random numbers.”

Betty: “One of my favorites [because it was] interesting and fun and caught our class’s attention.”

Kara: “It was neat to see that my estimate was wrong.”

Cereal Box Prize Activity

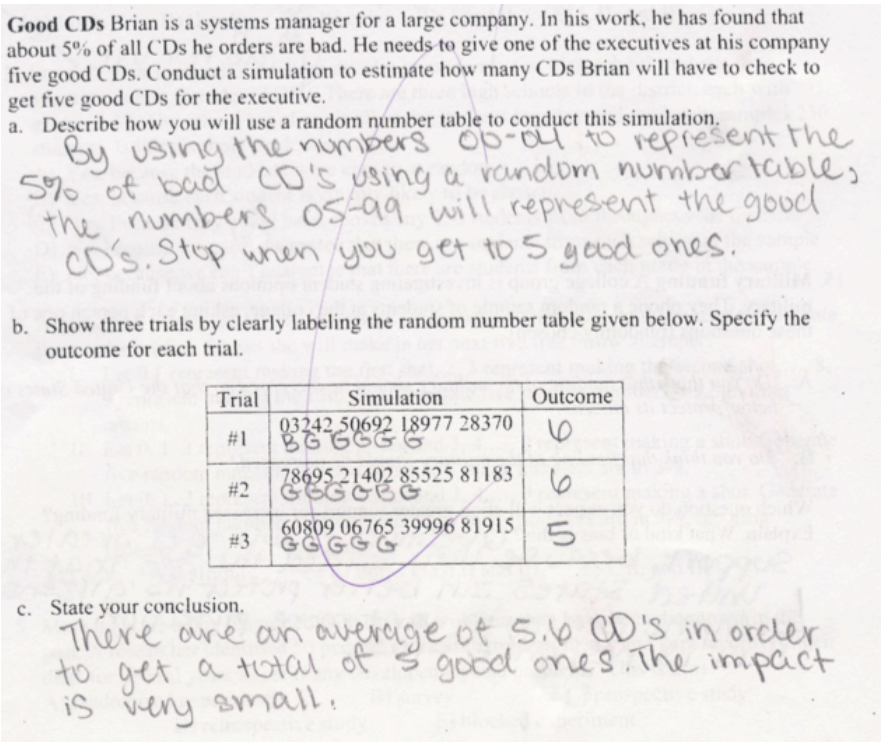
> “In the cereal box toy activity I learned that those are scams because you have to open way too many to get any of the good toys.” – Kyle

The goal of the cereal box activity was to show students that instead of actually conducting a study, they can instead perform a simulation. This simulation would save time and money. Students were to simulate opening the boxes by using random digits. Their goal was to get one of each prize possible in the cereal boxes. Instead of opening the cereal boxes, they simulated opening the boxes. Each digit represented a different prize. They ran many trials and took the average amount of boxes they “opened”. Every student was involved in this activity and they related to wanting prizes that were in the various cereal boxes and wanting to collect all the prizes. They

were interested in how many boxes it would take to collect all three and admitted that they did not want to open real boxes in order to find out.

Figure 10. Cereal box activity

Not only did the students enjoy this example we used in class, but the students also demonstrated an understanding of how to use random numbers to simulate events on homework, quizzes, and the exam. On the comprehensive exam students demonstrated their knowledge of using random numbers to simulate events. Nineteen students answered the question about using random numbers correctly. Figure 11 shows an example of the question given on the exam and how one student was able to answer the question completely and correctly. This is representative of most other answers that were given on the exam.



Good CDs Brian is a systems manager for a large company. In his work, he has found that about 5% of all CDs he orders are bad. He needs to give one of the executives at his company five good CDs. Conduct a simulation to estimate how many CDs Brian will have to check to get five good CDs for the executive.

a. Describe how you will use a random number table to conduct this simulation.

By using the numbers 00-04 to represent the 5% of bad CD's using a random number table, the numbers 05-99 will represent the good CD's. Stop when you get to 5 good ones.

b. Show three trials by clearly labeling the random number table given below. Specify the outcome for each trial.

Trial	Simulation	Outcome
#1	03242 50692 18977 28370 BGGGGG	6
#2	78695 21402 85525 81183 GGGGGG	6
#3	60809 06765 39996 81915 GGGGG	5

c. State your conclusion.

There are an average of 5.6 CD's in order to get a total of 5 good ones. The impact is very small.

Figure 11: Random numbers

End of Study Survey

At the close of the study, students again responded to the same survey questions. They listed any hands on activities that we'd done in class that related to the real world, wrote what they learned from the activity, and commented on the activities. Even Melissa responded with "Everything we do relates to the real world." It seemed that as more students were making connections to the real world, she too had made the connection. It was great to see that she had realized that what we were learning in class actually applied to her outside of class.

Students then commented on connections they had seen between Statistics and the outside world. Doug explained, "I now view every stat,

graph, question, and survey differently because of the stats class. I'm glad I learned about various bias also. It will prevent me from believing every stat that I hear."

Every student made positive comments about statistics class. There was not one survey that was returned that had a negative comment about the class or what they were learning. Most students responded that they enjoyed the activities and had enjoyed learning about real world statistics.

When I asked students about their impression of statistics thus far, Ed responded, "It is my favorite math class because of the real world connections and it isn't boring like most math classes."

As the study came to a close and I reviewed the comments of my students throughout the semester, four students stuck out. The following sums up their experience in Honors Statistics.

Doug: "If I were to be asked what I thought of the color of math was last year, I would have said red, the color of my teacher's pen. I struggled in Pre-Calculus but looked forward to Statistics this year. Now, I believe the color of math is yellow. This is because there is hope and inspiration this year for math class. There is actually a chance that it won't be the lowest grade on my report card. I used to think of Math as gray and dull, but that has changed this year. I love Statistics (literally). I think that it relates to the real world in so many different ways."

Mike: "I believe that the color of math is grey because grey often symbolizes confusion. Boredom can be referred to as grey, too, which is what

I think of math most of the time. Although I do have some fun times in math class, most days I find boring. I like Statistics. I think that it is interesting. I like the weighing pennies activity, it was interesting. I thought the activity with the price of our shoes was good."

Julie: "Black is dull and boring, just like math. I can't recall a time when doing math was ever really fun. The color black reminds me of a dark hole and a dark hole reminds me of my average plummeting due to another C- in Math. I think that Statistics is fun and I can see how it relates to the real world. I like Statistics. I have found it to be an interesting class. I think that it will become more difficult."

Melissa: "No, I don't know the connection between statistics and the real world. Not yet anyway. (six weeks into the study) Yes, statistics does relate to the real world. The examples we do in class relate to the real world." (twelve weeks into the study)

Overall, students saw Statistics as an interesting subject that does relate to the real world. These four students came into the class with several different preconceptions about math and left with the idea that math could be fun and interesting.

METHODS OF ANALYSIS

I began data analysis concurrent with data collection as suggested by Hendricks (2006). It was important to use the data that I collected to reflect on what happened in the classroom to determine how best to adjust my teaching. The data that I analyzed included my field log, which contained participant observation entries, student work, student surveys, and reflective memos.

The field logs that I kept not only included a record of what the students said and did, but it also included my observations and analysis. I wrote my reflections on the student interactions in the field log and set them apart from what I observed by brackets. I was careful to separate my objective and subjective notes to aide in my trustworthiness as a researcher.

I also read over my field log throughout the study looking for themes and patterns that emerged as recommended by Ely, Vinz, Downing, & Anzul (1997). I was able to gain new insights into the study as I saw the major themes that were emerging. The field log was designed with large margins in order to identify key topics with a code. These codes were then organized alphabetically in a spreadsheet with the corresponding page numbers and other associated codes. This allowed me to see the most prominent ideas that emerged and how they related to each other. I organized the codes into consisting of all the codes that were related to each other in some way (Ely, et al 1997). Through the creation of the bins, I developed theme statements which summarized the main idea of the code contained within each bin. The

theme statements represent the initial findings of the teacher action research study.

In addition to coding my field log, I separately analyzed student work throughout the course of the study. Exams helped me to see what concepts the students understood in what ways. I tallied the number of students who answered each test item correctly and noted the students who answered those items incorrectly. This allowed me to reflect upon what activities seemed to aid the students' understanding of the concepts and what concepts were not understood by which students. It also allowed me to focus more on students who might need more assistance and reflect on how I could adjust my teaching to meet their needs.

Students also answered question in surveys throughout the study, and I analyzed these survey results immediately. Students' feedback was important to me, and I valued their responses. I used these responses to improve my teaching. I tallied responses to the quantifiable surveys and recorded answers to the open response questions. I looked for common themes among the responses. If students were commenting that they liked the activities and these activities helped them understand the concepts, I continued using the same or analogous activities. If students were unable to say what they learned from an activity, I considered different activities to fit their needs.

Finally, I analyzed the data I collected through reflective memos written in response to the readings of Dewey (1997), Freire (2003), Vygotsky (1978), and Delpit & Dowdy (2002). As I read these works, I identified key

quotations that pertained to my study. I then wrote a reflective memo analyzing how the quotes applied to my study. It was helpful to see how pedagogical experts supported the kind of teaching I was implementing.

FINDINGS

There were many things that I learned throughout my study about the implementation of real world statistics in the secondary school mathematics classroom.

First, *when in class examples are connected to the real world (whether impromptu or planned), students are more engaged, the curriculum becomes substantive, students are able to build upon prior knowledge and constructivist practices begin to emerge.*

When students in my study were presented with material that was connected to their lives, they became more engaged in the class discussions and class work than the times they were presented with examples that did not connect to their lives. The examples presented were not all planned and some were discussed as the opportunities arose out of the need to connect their learning to something they could relate to. For example, when weighing pennies, analyzing M&M distributions, or looking at the price of shoes, the students were all engaged in taking notes and participating in the discussions. In contrast, when notes were taken on the formulas or steps to find the z-score, there were students who lost interest. For example, when taking notes on z-score, Kyle and Mike were zoning out, not engaged in the notes.

According to Newmann, et al. (1995), authentic academic achievement happens as students construct their own knowledge, which leads students to a deeper understanding of the material. Merely reproducing knowledge does

not call for evaluation or synthesis of information, which are indicators of a more in depth understanding of concepts. In presenting the concept of finding z-scores, the students were to construct their own knowledge using the prior knowledge of standard deviation, mean and even basic subtraction and division. As students began to construct their own knowledge of the concept of z-score, a deeper understanding of the concept began to emerge. The curriculum became more substantive as students create those meanings for themselves and they were able to relate to it directly.

Researchers have found that engaged students learn and retain more of what they are learning in the classroom (Akey, 2006). A direct link has been made between engagement and student achievement in math. Research suggests that, when students are engaged, they are more successful in standardized tests (Akey, 2006). I found such a link between engagement and achievement throughout the course of my study. In the z-score lessons, for example, the students were engaged in the presentation and finding of the z-score. As a result, their understanding of z-score was demonstrated as examples were presented in class and finally, on the comprehensive exam.

Another example of how the link between student engagement and achievement was demonstrated was when the concept of using random numbers to simulate events was presented. As we simulated opening cereal boxes, all of the students were engaged in the activity. Their engagement continued as we discussed the example and reviewed it for quizzes and the comprehensive exam. On the exam, the majority of students answered the

simulated question correctly.

Students were also able to build upon prior knowledge as we covered topics such as z-score and quantitative and categorical data. When students were presented with the topic of z-score they were not given the formula but instead were asked to build upon their prior knowledge of basic addition and subtraction. As we studies outlier and skewed data students were also given the opportunity to build upon their prior knowledge of outliers. The topics we were learning about were often expanding their current understanding.

The practice of building upon prior knowledge was effective and supported what the research claimed about constructivism. As stated by Brooks & Brooks (1993), using a constructivist approach can help clear up misconceptions associated certain concepts. When presenting outliers and skewed data, using prior knowledge enabled students to understand their past knowledge and clear up any misconceptions they had.

As a variety of real world examples was presented in the classroom, I found that when we collected data from the class the students were the most engaged and were able to gain the most understanding of the concepts. I found that o*ne way of using real world examples in class is through collecting and using data from the class, which allows students to acquire new understandings of concepts, become more aware of their mistakes, and demonstrate an overall positive attitude towards the material.*

I have experienced two quite different approaches to the teaching of statistics. One way is to use the book's pre-made worksheets and examples solely in class. While these examples are valuable, they are not always examples my students can relate to. This is not uncommon practice, as the 2003 TIMSS (National, 2004) report documented that 64% of teachers reported using their textbook as their primary basis for lesson. The other way to teach is to give students examples that relate directly to them. In the TIMSS report, only 33% reported using the textbook as a supplemental resource. Throughout the study we collected data from our class and analyzed it in many different ways. We collected data about what interested the students: the price of their shoes, the number of states they had visited, their shopping habits, etc.

Delpit (2002) understands the need to connect learning with the students' personal lives. She states, "With some attention and thought, any teacher should be able to create a curriculum for many school-based subjects…The object is not to lower standards to just teach what is interesting to the students, but to find the students' interests and build an academic program around them" (p. 45).

Delpit is correct when she says that this does not lower the standards, it's just a way of using what interests the students. Throughout the study instead of lowering my standards, I took the same topics and concepts and created a curriculum that caused students to become more engaged by using

more interesting, pertinent examples. These examples kept students interested more than topics that they were unable to relate to.

Another benefit to collecting and using class data was that students were able to pick up on mistakes they were making because they understood the nature of the data they were analyzing. When John found out that he had made a mistake when predicting height given a person's shoe size, he was able to pick up quickly on the mistake and understood what he had done wrong. He knew that because he had gotten an unrealistic height, he had made a mistake. John and his partner, Rich, were able to come to the realization that they had switched the x and y values in their calculators. Throughout the study, students continually were aware of their mistakes because they knew their answers had to make sense. They understood what we were trying to find and conceptually how we were coming to these conclusions.

Students also indicated that they enjoyed statistics class and the material that had been presented during class. When students filled out the six and twelve week survey they made comments like, "I love statistics" and "Stats class is the best math class I've been in". At the twelve week survey, students unanimously agreed that they enjoyed the activities in class and enjoyed learning statistics. Their positive attitudes continued as they explored the real world.

As more and more examples were presented to the students that were connected to their lives, the students began to look for these examples as they

left the classroom. Because of this, I have found that *when learning is tied to their lives, students take ownership by discussing examples of statistics material seen in other classes and outside of school, becoming independent thinkers, all the while seeing the value in the material beyond school.*

Cornell (1999) asserts that, "Effective math instruction can be enhanced by increasing real-world applications…to ensure continuous learning" (p. 255). The students demonstrated a desire for continual learning by discussing examples of statistical concepts that they had seen outside of the classroom. They became more aware of how the concepts we were learning related to their everyday lives.

There were several examples throughout the study where students saw that what we were learning was found outside of the classroom. These students came to class excited about what they had found and eager to discuss with the class. These students continually showed signs of becoming independent thinkers as they reflected on what they had seen and heard in their interactions outside of class.

Freire (1970) asserts that students need to be presented with material that relates to them directly. He states, "Students, as they are increasingly posed with problems relating to themselves in the world and with the world, will feel increasingly challenged and obliged to respond to that challenge… Their response to the challenge evokes new challenges, followed by new understandings; and gradually the students come to regard themselves as committed" (p. 81).

As my students were continually presented with real world examples, they became more committed to the learning of statistics. In the example of constructing a stem and leaf plot early on in the study where I had planned on using random numbers, Doug exclaimed, "But everything has to be REAL! You can't make up numbers, we have to relate it to the REAL WORLD!" Doug, along with other students in the class was committed to the learning of real world math. They had been challenged to think about statistics through the real world and wanted to continue to be challenged to connect their learning to their own lives.

I was not always prepared or able to tie student learning to the real world. When examples came up that were not tied to the world outside of class, I noticed a lack of engagement. These times led me to the finding that *when instruction is not tied to the real world, students may still remain involved, but they often appear to be less interested and demonstrate only partial comprehension of mathematical concepts.*

It is important that students stay engaged in the classroom, and it is student disengagement that Newmann (1992) considers the biggest issue in need of attention. Throughout the study when material was presented that was not directly tied to the student, there were a few students who became disengaged. As we discussed outliers and skewed data in class one day, I noticed Kyle and Mike staring into space. When I asked probing questions about what happens when outliers are present and data is skewed, both Kyle

and Mike demonstrated a lack of genuine lack of conceptual understanding. They were not able to describe what the significance of the two would be.

Newmann, et al. (1995) also assert that the absence of meaning in student work produces little student engagement. In this example, because I had learned that a small tie to the real world increases student engagement and because I knew that this concept was devoid of meaning for these students, I explained that Alex Rodriguez's salary skews our data. When I brought up Alex Rodriguez, they became visibly engaged and, in fact, the entire class demonstrated understanding of a concept that had eluded them.

WHERE DO I GO FROM HERE?

As I continue to teach statistics, the use of real world examples to aid in teaching students statistical concepts has not ceased. I continue to use examples in class that relate directly to my students. We continuously collect data in class and use statistical data found outside of class.

The first activity that the students participated in after the study concluded was the midterm project. Students picked a topic they were interested in, devised a research question, and collected data to answer the question they posed. The projects included conducting a study in order to find out whether students preferred Starbucks or Dunkin Donuts coffee, surveys to find out whether previous findings relating to students in our school drinking were valid, and a survey to find whether participating in sports increased grade point averages.

Utilizing the statistical concepts we had examined together in class, students included survey and sampling design, choosing survey participants randomly, when possible. One group numbered every student in the entire school and selected random numbers to identify the students who would receive an invitation to take part in their survey. This particular group of students indicated that they enjoyed the hours they poured into their project because they felt it was meaningful and something they were very interested in.

As I write this, my students are currently working on statistical inference. As I look ahead at upcoming topics, I can see many ways in which I can implement real world examples. For example, one hands on project my students will participate in is an activity that involves them using an inflatable globe to make educated guesses as to what percent of the world is made of water. They will construct a hypothesis test and a confidence interval based on their estimates and the true proportion of water make-up. Another activity will involve them researching statistics on the Internet and comparing sample data they will collect in our school.

I realize that the use of real world examples is especially important when teaching an Honors-level statistics course. I plan on using this knowledge and implementing real world examples in my AP statistics classes next year. I had initially feared that implementing this teaching strategy in my AP class might take up valuable time without providing commensurate gains in student achievement. I now realize that using real world examples, working on hands on activities, and collecting data in class does not take up as much extra time as I had initially thought it would. I have not gone any slower in my Honors Statistics class this year than I had last year. I hope that as I use real world examples in my AP Statistics class next year, the students will respond as positively as did my current Statistics students.

As I look ahead to next year's implementation in my AP Statistics classes, I have a few questions that I would like to clarify. One question is whether hands on data collection improves student achievement. To answer

this question, I plan on implementing several hands on activities and comparing test results from this year with results from next year to see what improvement, if any, was made. Another question I would like to answer is whether students in the AP classes will enjoy data collection as much as the Honors students did. The Honors students enjoyed learning about their classmates while learning the concept in the process. I hope to learn whether this type of activity is a good fit for the AP students as well.

While next year will not consist of as formal data collection as this year, I will still collect data as I observe my students. I plan on keeping a field log of the students' reactions to class activities. I also plan on collecting data from their exams in order to compare them to this year's classes. My hope is that as I collect and compare data, my teaching methods will improve and student achievement will improve.

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Appendixes

Appendix A: HSIRB Approval

MORAVIAN COLLEGE

September 2, 2008

Beth Ann Chen
[redacted]

Dear Beth Ann Chen:

The Moravian College Human Subjects Internal Review Board has reviewed your proposal: "Increasing Motivation in a High School Math Class Through Real World Examples." Although the committee cannot give its complete approval at this time, your research is conditionally approved, pending revision to your Informed Consent form. The form should provide names and telephone numbers of individuals or agencies that subjects may contact in the event of unanticipated psychological distress that may occur as a result of this study.

Although this issue did not affect the committee's decision, HSIRB committee members also urge you to consider the manner in which you discuss your researcher project with your students. Although ethical standards require consent only from parents or guardians of those under the age of 18, the students must give their assent as well. In other words, children who do not wish to participate should have the ability to inform you of their wishes without having to rely upon their parents do so. Thus, they should know that they can inform you directly if they wish to refuse full participation in or to withdraw from the study once data collection has begun.

Upon satisfactory revision to these portions of your proposal, the committee expects to fully approve your submission.

This letter has been sent to you through U.S. Mail and e-mail. Please do not hesitate to contact me by telephone [redacted]) or through e-mail [redacted]) should you have any questions about the committee's requests.

[redacted]
Chair, Human Subjects Internal Review Board
Moravian College
[redacted]

Appendix B: Principal Approval

August 25, 2008

Dear [redacted]

Currently, I am working towards earning a Master's degree in Curriculum and Instruction at Moravian College. The courses that I am taking allow me to stay current with the most effective teaching methods in order to provide the best learning experience for students in my classes. In order to earn my degree this spring I am required to conduct a systematic study of my own teaching practices.

This semester (September 2-December 20) I plan to study the effects of implementing real word examples and activities in my Honors Statistics class. In doing this, I hope to learn an effective way of motivating students in the classroom. Statistics is a valuable subject that will apply to many aspects of their lives.

For this study, I will be collecting data from student writing, observed behaviors, and interviews. I am asking your permission to use this data gathered in classroom activities. All students in my classroom will be involved with the real world examples and activities and must participate in these activities, as it is a part of my regular classroom activities. There are no anticipated risks. Participation is entirely voluntary and will not affect the students' grades in any way. Students may withdraw from the study at any time without penalty. All student names, faculty members, and the school name will be kept confidential by using pseudonyms in the published report. All research materials will be kept secure in a protected location and at the conclusion of this research all data will be destroyed.

If you have any questions about my research please contact me at [redacted]. My faculty sponsor is Dr. Joseph Shosh. He can be contacted at Moravian College by phone at [redacted] or e-mail [redacted]. Please sign and return one copy of this letter indicating that you grant me approval for this study.

Thank you for your cooperation.

Sincerely,

Beth Ann Chen
Mathematics Teacher

Appendix C: Parental Consent Form

September 3, 2008

Dear Parents/Guardians,

Currently, I am working towards earning a Master's degree in Curriculum and Instruction at Moravian College. The courses that I am taking allow me to stay current with the most effective teaching methods in order to provide the best learning experience for your child. In order to earn my degree this spring I am required to conduct a systematic study of my own teaching practices.

This semester (September 2-December 20) I plan to study the effects implementing real world examples and activities in your child's Honors Statistics class. In doing this, I hope to learn an effective way of motivating students in our class. Statistics is an important class that will apply to their lives and will benefit them in the real world.

For this study, I will be collecting data from student writing, observed behaviors, and interviews. I am asking your permission to use data gathered pertaining to your child's involvement in classroom activities. All students in my classroom must be involved with the real world examples and activities as it is a part of my regular classroom activities. There are no anticipated risks. Participation in my research study is entirely voluntary and will not affect your child's grade in any way. Students may withdraw from the study at any time without penalty. All student names, faculty members, and the school name will be kept confidential by using pseudonyms in the research report. All research materials will be kept secure in a protected location and at the conclusion of this research all data will be destroyed. If students have any concerns, counselors and principles are available to talk to about these concerns. [redacted] and all guidance counselors can be reached at [redacted] if students need to talk about these concerns.

If you have any questions about my research please contact me at school at [redacted] or e-mail me at [redacted] My faculty sponsor is Dr. Joseph Shosh who can be contacted at Moravian College by phone at [redacted] or e-mail [redacted]. Our principal, [redacted], has approved my study. If you have no questions, please sign and return the consent form below. Thank you for your cooperation.
Sincerely,

Beth Ann Chen
Mathematics Teacher

Please detach and return to Mrs. Chen by FRIDAY September 5, 2007

I attest that I am the student's legally authorized representative and that I have read and understand this consent form.
I am willing to have my child participate in this action research study. Please check one.

_____ yes _____ no

Parent/guardian signature _____

Child's name _____

Child's signature _____

Date _____

Appendix D: Statistics Pre-Survey

STATISTICS SURVEY-PRE

	Strongly agree						Strongly disagree
I will like statistics	1	2	3	4	5	6	7
I will feel insecure when I have to do statistics problems	1	2	3	4	5	6	7
I will have trouble understanding statistics because of how I think	1	2	3	4	5	6	7
Statistics formulas are easy to understand	1	2	3	4	5	6	7
Statistics is worthless	1	2	3	4	5	6	7
Statistics class should be a required course	1	2	3	4	5	6	7
Statistical skills will help me in my future career	1	2	3	4	5	6	7
I will have no idea of what's doing on in this statistics course	1	2	3	4	5	6	7
I am interested in being able to communicate statistical information to others	1	2	3	4	5	6	7
I use statistics in my everyday life	1	2	3	4	5	6	7
I will enjoy taking statistics	1	2	3	4	5	6	7
I am interested in using statistics	1	2	3	4	5	6	7
Statistics conclusions are rarely presented in everyday life	1	2	3	4	5	6	7
Statistics is irrelevant in my life	1	2	3	4	5	6	7

Appendix E: Six and twelve week survey

Statistics 12 week Survey Name _____

Please answer the following questions honestly.

List any hands on activities that we've done in class that related to the real world.
Next to each activity, please write what you learned from the activity.

List any in class/book examples that you've participated in that related to the real world:
Next to each example, write what you learned from the activity.

What were the most interesting examples or activities we've done in class? Why?

Have you seen the connection between Statistics and the real world? Why or why not? Please site specific examples.

What has been your impression of statistics class thus far?

Appendix F: List of activities survey side one

Next to each activity, comment on the significance of the activity (what you learned, how it applied to the concepts learned). Then comment on the activity- did you like it, did it help you learn and remember the concept?

Activity	Significance	Comments
M&M's lab		
Using Excel to make displays of data		
Weighing Pennies		
States Visited: constructing boxplots		
Price of Shoes: constructing stem and leaf plots		
Using your marking period grade to find z-score		

Appendix G: List of activities survey side two

Finding associations in class example: collecting shoe size and height, finding the correlation		
Finding associations: collecting data from the class and analyzing		
Outliers: Student in class typing an incorrect number into list		
Rover Blubbers activity		
Using random digits to pick students to call on		
Designing an experiment based on your claim of effects of the cafeteria food		
Any other examples in class where we collected data about the class, then analyzed it.		