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Impact of Kinesthetic Learning on Student Knowledge Retention and Attitudes toward Mathematics

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Abstract

This research study examines the impact of kinesthetic learning on student knowledge retention and attitudes toward mathematics. Specifically, this study focuses on teaching mathematics to secondary students through dance. Quantitative data was collected and analyzed regarding student mathematics knowledge retention and student attitudes towards mathematics. Although student mathematics knowledge retention increased for both the control and treatment groups, student attitudes toward mathematics decreased after the intervention for the treatment group.

Key Words: kinesthetic learning, mathematics education, student attitudes, dance

Introduction

According to the National Association of Geoscience Teachers (NAGT), “Kinesthetic learning occurs as students engage [in] a physical activity: learning by doing, exploring, discovering” (NAGT, n.d.). Kinesthetic learning is a strategy I have always wanted to incorporate into my future mathematics classroom. My collegiate experiences through Bowling Green State University’s (BGSU) student-led Math Camp have inspired me to conduct action research on this topic. At the beginning of Math Camp, K-12 students are given a survey inquiring about their current attitudes and self-efficacies toward mathematics. Throughout the camp, students learn and perform a Math Camp dance to remember the order of operations. During these camps, I often wonder if learning through movement has a positive impact on students’ education both academically and psychologically. This led me to formulate the following research question: How does learning through movement (kinesthetic learning) impact secondary students’ mathematics knowledge retention and attitudes towards mathematics?

Additionally, an article I read compelled me to further research this topic. In an article titled “Kinesthetic Learning: Moving toward a New Model for Education,” author Kirin Sinha highlighted the idea of mathematics and creativity being closely-related. Sinha (2014) emphasizes, “There is a widespread misconception that STEM fields stifle creativity. But math also requires creativity and a willingness to approach a problem from multiple angles” (Math and Movement section, para. 1). Sinha’s perspective on the interconnectedness of mathematics and creativity motivated me to incorporate dance into students’ learning of mathematics.

Furthermore, in an article titled, “Classroom Choreography, Enhancing Learning through Movement,” Donna Furmanek (2014) reflected on various research studies regarding the benefits of incorporating kinesthetic learning into the classroom. She argued for the inclusion of movement in lessons due to a “mind-body connection that enhances children’s learning” (Furmanek, 2014, p. 80). She made suggestions of ways to combine movement and learning within the elementary school classroom. For the elementary school setting, she recommended educators can teach patterns through purposeful movement by creating sequences with repeated motions. Furmanek encouraged teachers to be “classroom choreographers.” She also discussed the integration of movement into the science curriculum. She suggested elementary school students act out weather terms. While Furmanek advocated learning through movement within the elementary classroom, I aspire to investigate the effect of teachers serving as “classroom choreographers” has for students in a secondary mathematics classroom.

The purpose of the results from my research is to inform my instruction as a mathematics educator. While my findings are not intended to be generalizable to all students, research on this topic will be beneficial to the field because it may encourage teachers to conduct this type of action research in their own classrooms. In Richard Gage’s article titled “Excuse Me, You’re Cramping my Style: Kinesthetics for the Classroom,” he reminded his readers that 15% of school-age students are kinesthetic leaners (Gage, 1995). Gage argued if educators fail to provide students with kinesthetic learning experiences, “…then we are consistently denying the same set of students the education which they deserve” (p. 53). Therefore, the kinesthetic ideas presented in my research study will be beneficial for the field in that other educators can adopt these mathematical dances to facilitate kinesthetic learning activities in their own classrooms.

This study will pair music/lyrics and dance moves together in order to teach mathematics. Some mathematical skills conducive to learning through movement include the structure of parent functions and their resulting graphical changes from alterations made to their functions, types of angles and polygons, order of operations, patterns, and sequences and series. The following picture (Dance Moves, n.d.) illustrates some examples of arm movements one could incorporate into mathematical dances:

Therefore, the purpose of this study is to investigate the effects incorporating dance into mathematics instruction has on students' mathematical knowledge retention and attitudes towards mathematics. Does the integration of dance into mathematics improve students' retention of knowledge? If so, which students show the greatest gains and why? Does the integration of dance into mathematics improve students' attitudes toward learning mathematics? If so, which students show the greatest improvement and why?

Literature Review

The purpose of this action research is to assess the impact of kinesthetic leaning, specifically through dance, on secondary students' mathematics knowledge retention and attitudes toward mathematics. Prior to conducting this study, background on this topic was researched. Specifically, the biology behind movement, kinesthetic learning, unrelated vs. purposeful movement, interdisciplinary learning, mathematical dancing, existing kinesthetic mathematics programs, and student attitudes toward mathematics were examined.

Biological Benefits of Movement

Not only does bodily movement improve one's physical health, but it also strengthens one's mental health. When people exercise, it results in an increase in blood flow to the brain. Consequently, this amplified blood flow to the brain causes an increase in oxygen levels (Kitchen & Kitchen, 2013). Furthermore, research supports that kinesthetic learning increases both brain use and student memory (Kitchen & Kitchen, 2013). In addition to an increased oxygen level, physical activity creates changes to one's brain cells. Learning through creativity causes brain cells to bind together which encourage people to adjust appropriately when faced with a difficult task (Hanna, 2008). These results suggest positive benefits may come from the incorporation of movement into classroom activities.

In an article titled, "Dance and Mathematics: Engaging Senses in Learning," the author mentioned, "If we act out what we think, then the mind has richer information from which to make connections with previous experience, and from which to develop memory, and a deeper connection with the event" (Watson, 2005, p. 18). An example is teachers having students walk around imaginary polygons on the floor to get a sense of the sum of exterior angles and the outlining shape of the polygon (Watson, 2005). Students' physical experience with the polygons makes this concept more significant. Since movement can benefit students biologically, incorporating kinesthetic activities into the classroom may support all types of learners.

Kinesthetic Learning

As previously described, students who physically like to manipulate objects and participate in tactile activities are said to be kinesthetic learners. Historically, students receive education through a lecture-based teaching style in which educators vocalize the concepts while writing on a board. In his article "Excuse Me, You're Cramping My Style: Kinesthetics for the

Classroom," Richard Gage (1995) highlighted the importance of educators selecting activities to benefit kinesthetic learners since the traditional lecture-based teaching style only supports auditory or visual learners. Reiff (1992) asserted, "Our society's emphasis on other intelligences may alienate many gifted bodily-kinesthetic students from school. For example, an inappropriate label is that a child is hyperactive. A variety of mobile activities would recognize the bodily-kinesthetic intelligence" (pp. 20-21). Gage (1995) suggested employing the following activities to engage kinesthetic learners in the English classroom: making library displays or plot diagrams, creating a talk show with moderators for a "Meet the Poets" symposium, role playing, videotaping persuasive commercials, creating a compact disc album cover with song lyrics, and making comic books to interpret texts. Hanna (2008) implied how activities fostering kinesthetic learning can enhance teachers' knowledge of students' thought processes. She expressed, "A study of children not visually or aurally challenged found that a child's gestures convey information to ordinary listeners that is different from speech. Gestures thus offer insight into a child's thoughts, mental processes, and representations by reflecting knowledge that the child possesses but does not verbalize" (Hanna, 2008, p. 495). Although all types of movement seem to benefit one's cognition, purposeful movement may be more suitable for classroom instruction than unintentional movement.

Unrelated vs. Purposeful Movement

An article titled, "The Impact of Purposeful Movement in Algebra Instruction," defined unrelated movement as "…movement that is not specifically related to content instruction" (Beaudoin & Johnston, 2011, p. 82). There have been numerous studies investigating the impacts of unintentional movement. For example, Stalvey and Brasell (2006) investigated the impact of using a stress ball on students' attention spans and distraction tendencies. The results of this study included reduced distractions, improved writing performance, and better peer interactions during group work (Stalvey & Brasell, 2006). The results from this study, as well as others, make it plausible to think the biological effects of movement (described above) positively impact achievement levels, even if the movement is unrelated to the academic content.

On the other hand, purposeful movement is "…movement that is directly related to the content being taught" (Beaudoin & Johnston, 2011). For example, Nemirovsky and Rasmussen (2005) conducted a study which suggests the positive impact of using a water wheel to learn about equations has on students' understanding of equations when represented symbolically. Nemirovsky and Rasmussen (2005) revealed, "It is one thing to know, for example, that the slope of the graph of a certain function obeys a certain equation, while it is another thing to sense bodily the need to slow down and the different ways of slowing down" (p. 15). In addition, Noble (2003) studied a students' use of gestures to understand the characteristics of graphs and to match the physical properties of a graph with that created by a motion detector. The results of this study reveal, "Gestures that trace a line shape, or reenact a motion, can help to connect the visual attributes of the graph with physical motions, becoming part of the story of the graph, and part of the fusion of the shape of the graph with the motion which created it" (Noble, 2003, p. 35).

Beaudoin & Johnston (2011) hypothesized that "…purposeful movement in mathematics classrooms could yield similar results, increased learner outcomes and better attitudes" (p. 87). This study took place in an Algebra II class situated in a Title 1 school in Florida. The researchers were interested in assessing students' knowledge of how the values of "a" and "c" change the graphs of quadratic functions (Beaudoin & Johnston, 2011). The control group practiced their understanding of quadratic function transformations through a traditional worksheet with exercises while the experimental group viewed pictures of people modeling the transformations with gestures. In addition, the experimental group had the opportunity to cut out the graph of the parent function ($y = x^2$) to physically represent the various transformations. Based on the results from a pretest and posttest, "The treatment group's gains on the posttest had a mean of 84%, as compared to the control group's mean gain of 65.9%" (p. 90). Surprisingly, the students who were traditionally weaker in mathematical competency revealed to benefit the most from the implementation of purposeful movement. In addition, the students who had the opportunity to physically manipulate the parabola had more positive attitudes toward the lesson than those who received the traditional practice problems.

Another study concerning purposeful movement involved learning about angles in a cooperative learning environment. One of the hypotheses Shoval (2010) explored was "Using mindful movement in cooperative learning will improve learners' achievements to a greater extent than conventional learning" (p. 457), where mindful movement refers to "…the use of body movement to aid academic learning" (p. 453). This study was conducted with second and third grade students. One group of students learned about angles through movement in cooperative learning groups, while the other group experienced the more traditional teaching style (Shoval, 2010). Based on pretest and posttest results, the students who experienced learning through movement scored much higher than those who received lecture-based teaching.

Interdisciplinary Learning

Integrating content from two or more subjects to encourage students to foster connections between them is a continuing theme within education. One way to support interdisciplinary learning is to integrate physical education content with mathematics content. While this seems like a far stretch, there are many ways to incorporate physical activity into the mathematics classroom and vice versa. One activity is to use bar graphs to record the resting, active, and recovery heart rates before, during, and after exercise (Kitchen & Kitchen, 2013). One document that supports the integration of curriculum is the National Council of Teachers of Mathematics' (NCTM) *Principles and Standards for School Mathematics* (2000). NCTM claims it is important for students to be able to use mathematics to solve real-world problems (Kitchen & Kitchen, 2013). Darrin and Julie Kuehl Kitchen (2013) describe lessons incorporating football activities to learn about classifications of triangles, distance between coordinates, and parallel and perpendicular lines. In theory, students will be so wrapped up in the football activities, they will forget they are learning mathematics.

Another interdisciplinary project integrated physical education, mathematics, and physics. Hatch and Smith (2004) developed a collaborative project with projectile motion as its theme. Students threw a shot put (physical education), plotted the parabolic path of the shot put using the concept of ratios (mathematics), and determined the equation of the flight path by using Newton's Laws of Motion (physics). Comments from students revealed learners' positive attitudes toward this lesson. One student expressed, "Parabolas seemed abstract, and I thought it was pointless, but now I see a purpose in them" (p. 50).

Mathematical Dancing

Karen Wood (2008) conducted action research in her classroom regarding the incorporation of dance into her classroom. Her data consisted of anecdotal notes, video recordings, and reflective journal entries. Wood focused primarily on scaffolding student learning about shapes through movement. Wood noticed her students truly enjoyed learning mathematics through movement. For example, her students engaged in a Square Dance activity to learn about the properties of squares. She expressed, "By placing the concept in a context, I was able to scaffold the students' learning toward new ideas" (p. 21). Wood also noted, "They did not learn a square had 4 sides by saying it over and over again. They knew because they moved around a square…and had to really think about a square and its attributes when doing so. I found this led to deeper understanding and longer term retention of information" (p. 21).

Mathematical dancing can also take the form of imagination. For example, Choreographer Trisha Brown had her dancers imagine themselves inside of a cube, and she had them touch the vertices and midpoints of the object with different body parts (Watson, 2005). This kinesthetic activity carried out through one's imagination can benefit visual and kinesthetic learners alike by building on their initial, surface-level understanding of the content presented.

Kinesthetic Mathematics Programs

Math & Movement™ is a current kinesthetic mathematics program for elementary school students. It is a research-based program integrating exercise and cross-body movements with mathematics. This program enhances students' multiplication, addition, subtraction, and skip counting skills (among others). More information regarding this program can be found at http://www.mathandmovement.com/whatis.html. I believe elementary school students generally express a greater sense of a love for learning than secondary students. In general, I feel there is a stronger presence of kinesthetic learning in the elementary school classroom compared to secondary classrooms. Therefore, I desire to explore whether adapting kinesthetic learning found in the elementary school to the secondary mathematics curriculum has similar effects on secondary students' educational experiences.

In addition, the Department of Public Instruction for the Public Schools of North Carolina offers various lessons for integrating movement with mathematics on their website. One of the ideas on their website is to have Algebra students present an equation to the class through dance movements. Another idea is to have students determine the area and perimeter of a dance space they create. These ideas, along with others, are further explained at http://www.dpi.state.nc.us/curriculum/artsed/resources/handbook/dance/28integration#accumulation.

Student Attitudes toward Mathematics

It is no secret many people have strong opinions regarding mathematics. While some see the true beauty and value of mathematics, most turn up their noses once they hear the word. In articles previously discussed (Beaudoin & Johnston, 2011; Hatch & Smith, 2004), research supports that learning through movement improves student attitudes toward mathematics. Research on student attitudes is abundant. Specifically, some factors affecting student attitudes that have been widely studied are social support and group work.

One such study was comprised of eighth grade mathematics students from the United States and Thailand who participated in the Second International Mathematics Study (SIMS) (Tocci & Engelhard, 1991). One of the research questions in this study examined the relationships between achievement, parental support, and student attitudes toward mathematics. The following four different scales with Likert-formatted questions were used to measure student attitudes: Mathematics and Myself (measures students' enjoyment of and confidence in mathematics), Mathematics and Society (measures students' views of the practicality of mathematics), Mathematics as a Male Domain (measures the level at which students view mathematics as a male domain), and Mathematics Anxiety (measures students' levels of apprehension towards mathematics). The Parental Support for Mathematics scale was used to measure students' perceptions of parental behaviors, including encouraging students to succeed in mathematics. There was a positive correlation between perceived parental support and student enjoyment of and confidence in mathematics, usefulness in society, and mathematics not being viewed as a male-domain. There was a negative correlation between perceived parental support and mathematical anxiety. These results were consistent for both countries. Also, it was interesting that male and female students in Thailand perceived more parental support than did students in the United States.

Another study examined the role of social support in students' attitudes toward mathematics. In a cross-sectional study with fifth grade students, eighth grade students, high school juniors, and early college students, the effect of support from teachers, parents, and friends on student attitudes towards STEM (Science, Technology, Engineering, and Mathematics) fields was analyzed (Rice, Barth, Guadagno, Smith, & McCallum, 2013). One of the results of this study was fifth grade students perceived a higher level of support from teachers and friends than did older students. The most drastic decline in teacher and friend support occurred between elementary and middle school. While elementary school students perceived a higher level of parental support than high school students, college students felt they received the most parental support. This study found students receiving higher levels of support from parents, teachers, and friends have greater confidence and more positive attitudes towards mathematics and science. This research study also suggested positive attitudes toward mathematics and science may encourage students to pursue STEM-related careers.

Cooperative learning is another factor research supports to lead to students having more positive attitudes toward mathematics. In a study using eighth grade student data from the 2007 Trends in International Mathematics and Science Study (TIMSS), the relationships between group work, student achievement, and attitudes was investigated (Smith, McKenna, & Hines, 2014). Students' attitudes were accessed using questions from the TIMSS Student Background survey. One of the results of this study was students who engaged in cooperative learning during some lessons performed better on mathematics achievement tests and expressed more positive attitudes toward mathematics than did those who were not involved in group work. This study stressed the importance of using cooperative learning as one of many strategies, rather than the only strategy, to improve student achievement and attitudes in the mathematics classroom.

In addition, research reveals females, typically, have more negative attitudes toward mathematics than males, thus, possibly impacting their future career choices (Asante, 2012). A study conducted in Ghana with 181 high school students used the Attitude towards Mathematics Inventory (ATMI) (developed by Tapia & Marsh) to measure student attitudes toward mathematics (Asante, 2012). The males scored much higher on the ATMI than the females.

These studies exposed the importance of discovering ways to improve students' attitudes toward mathematics. While research on the benefits of kinesthetic learning is abundant, there are very few studies exploring the impact of teaching mathematics through dance on students' mathematics knowledge retention and attitudes toward mathematics. There are even fewer studies in regards to secondary students. My research will focus on teaching mathematics to secondary students through dance.

Methodology

Participants

I conducted my action research in a high school Algebra II classroom. Prior to teaching the unit on quadratic functions, I administered a pre-survey to all three Algebra II class periods which consisted of two parts (See Appendix A). The first part of the survey was a Likert scale requiring students to circle the number that most appropriately corresponded to their beliefs regarding ten statements assessing their attitudes towards mathematics. The second part consisted of an achievement test in which students answered questions about their current knowledge of quadratic transformations. There were nine questions in total on the achievement test. Based on the quantitative data I collected, I selected two periods that proved to be well-matched groups for my action research. The control group consisted of twelve students, and the group receiving treatment consisted of ten students.

Procedure

Prior to my lesson regarding quadratic transformations, I asked each of my students to find and email me a real-world example of parabolic motion. For example, some students emailed me pictures of McDonald's arches, water fountains, rainbows, bananas, dolphins, and roller coasters. For both the control group and the treatment group, I began my lesson with having students work in pairs to use Desmos.com and the images their classmates emailed me to adjust the equation of the parent function ($y = x^2$) to match the parabolic paths created by the real-world examples of quadratic functions. Each student was responsible for recording the name of the image they used, the vertex-form of the equation that matched the picture, and a brief explanation of why this equation fits the graph.

After this portion of my lesson, I administered the post-survey to my control group (See Appendix A). The post-survey included the same items as the pre-survey. In contrast, I showed my treatment group the following music video I created to support their learning of quadratic transformations: https://www.youtube.com/watch?v=oEI0ArCKfDk (Lustgarten, 2016). After viewing this music video, I asked my students to stand up and learn the song and dance. The lyrics to the song represent a parody of Meghan Trainor's popular song, "Me Too." The lyrics to the Quadratic Transformation Song can be found in Appendix B. Step-by-step, I taught the treatment group the lyrics and the motions to the Quadratic Transformation Song. Students were required to use their bodies to represent quadratic functions. Students moved positions to represent the different quadratic transformations. After learning the song, the students performed the song in its entirety. Lastly, I administered the same post-survey as I administered to the control group.

Because I used human subjects, I did not want my treatment group to have any advantage over my control group. Therefore, after all post-surveys were collected, I taught my control group the lyrics and motions to the Quadratic Transformation Song too. This way, it is guaranteed that any differences in unit test scores will not be due to differences in instruction.

Data Collection

Because my pre- and post-surveys consisted of two parts, I needed to analyze two sets of data. I quantified my students' attitudes towards mathematics by asking students to circle "1" if they "agree a lot" with the given statement, "2" if they "agree a little," "3" if they "disagree a little," or "4" if they "disagree a lot." I entered each student's numerical rating for each question into a Microsoft Excel spreadsheet. I also looked at the average numerical rating per question for each group of students. I compared these to the favorable response for each statement regarding mathematical dispositions.

For the items assessing knowledge of quadratic transformations, I totaled each student's number of correct responses out of nine questions. I looked at the average number of questions each class answered correctly to determine the average mathematical content knowledge for the control group compared to the treatment group.

Data and Analysis

Results

As I analyzed my data regarding student attitudes towards mathematics, I noticed six out of the ten questions had “1” as the favorable response, and the other four had “4” as the favorable response. To analyze the data accurately, I switched students’ responses for questions two, three, seven, and ten on both the pre-survey and post-survey spreadsheets. For example, all ones became fours, all twos became threes, and vis versa. This adjusted the averages accordingly. I formulated the spreadsheets in such a way so “1” would be the favorable response for all disposition items assessed on the pre- and post-surveys.

Charts #1 and #2 summarize my findings. I will refer to them throughout this section.

Chart #1

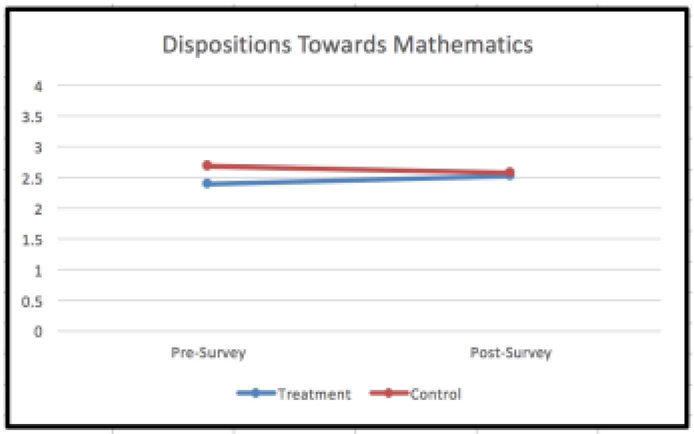
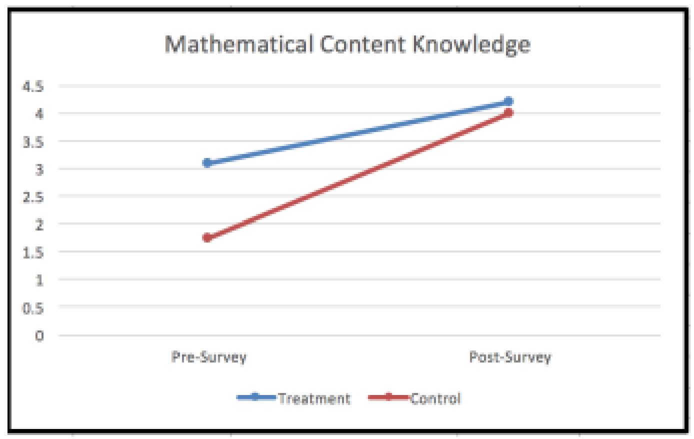


Chart #2



The lower a group’s disposition score, the better their attitudes toward mathematics. The control group’s disposition score on the pre-survey was 2.69. This group’s disposition score on the post survey was 2.59. As you can see from Chart #1, this decrease in disposition score led to an approximately 3.72% increase in student attitudes towards mathematics (since the favorable outcome was “1”). In contrast, the treatment’s disposition score on the pre-survey was 2.39. This group’s disposition score on the post survey was 2.52. As you can see from Chart #1, this increase in disposition score led to an approximately 5.44% decrease in student attitudes towards mathematics (since the favorable outcome was “1”). On average, students’ attitudes towards mathematics increased for the control group and decreased for the treatment group.

In regards to the items on the survey assessing students’ mathematical content knowledge, students received a score out of nine total questions. The more questions they answered correctly, the higher their score. The control group’s content score on the pre-survey was 1.75. This group’s content score on the post-survey was 4. The treatment group’s content score on the pre-survey was 3.1. This group’s content score on the post-survey was 4.2. As Chart #2 depicts, both the control and treatment group’s scores regarding mathematical content knowledge improved.

Conclusions and Implications

Discussion and Limitations

As my data shows, on average, student attitudes increased for those who were in the control group while student attitudes decreased for those who learned quadratic transformations through kinesthetic learning experiences. In regards to knowledge retention, both groups showed an increase in their understanding of content knowledge. It was to my surprise that my findings did not support the past research described in my literature review. There are multiple possible reasons for this discrepancy. Primarily, my sample size was very small. Because my class sizes were very small (ten and twelve students), it was difficult to acquire a large amount of data and make effective comparisons. The differences in the averages of both data sets were also small, resulting in a lack of significance.

Additionally, because of the small sample sizes, unusual results for three students had a disparate impact on the averages in both disposition and mathematical content knowledge. For example, in the control group one student had a dramatic gain in content knowledge, improving from one correct answer on the pre-survey data to eight correct answers on the post-survey data. Since the average number correct was calculated for only 12 students, outlier results skewed the data positively in the control group.

In regards to the disposition results, there was a similar concern; one student in the treatment group indicated a considerably more negative attitude after the lesson and answered several of the questions in contradictory ways, which had a distorting impact on the data calculated for only 10 students. For example, s/he indicated strong agreement in response to the question “Math is one of my favorite subjects” while also indicating strong agreement with “I wish I did not have to study mathematics.” This could reflect the students’ true feelings about mathematics after the lesson, or it could reflect confusion over the numbering system in the survey. While reverse wording is typically used to minimize response bias in attitude surveys, with a small sample size the impact of a misunderstanding in this instance would be magnified.

In addition, the small sample size combined with absences on the day of the treatment resulted in a significant difference between the control and treatment groups. Originally, I had eleven students in the control group and thirteen students in the treatment group and the pre-survey data was very comparable between these groups. When two students were absent on the day of the post-survey, it skewed the data I could use and due to the small sample size, this resulted in a substantial difference between the mathematical content knowledge in the two groups at the start of the research. Specifically, the remaining students in the treatment group had greater mathematical content knowledge as compared to the control group, and therefore the gains from the control group were more apparent.

Lastly, I believe that my choice in activities for the first part of my lesson may have skewed my data. Because I introduced quadratic transformations with an interactive Desmos Activity to both groups, my students who are visual learners may have benefited from this instruction too. If I taught quadratic transformations through lecture before differentiating between my control and treatment groups, I believe my data would show a more favorable response from students who participated in the Quadratic Transformation Song than those who did not.

Lessons Learned

Through this research study, I learned that I can be creative when planning my lessons. I also learned I enjoy teaching my students through song and dance. Through my students' facial expressions and body language, it was evident they enjoyed the kinesthetic learning experience I created for them. Although the data did not show it, many students have requested for me to create a song and dance for mathematical concepts in the future. Many of my students were still humming the lyrics and doing the dance moves when we discussed vocabulary terms related to transformations in later lessons.

Future Steps

In the future, I would like to conduct similar action research with more classes. As the students were verbalizing a positive response to the kinesthetic learning experience, I feel that incorporating a qualitative research component would more completely frame the experience. Furthermore, it would allow more exploration into contradictory results and any possible concerns regarding the survey instrument.

Another reason why I feel my data may not have been consistent with past research is because my group of students were not used to learning mathematics through ways other than lecture, and their response was measured after only one lesson. Because my students have been conditioned to learn mathematics through lecture, some of the students may have preferred familiarity and routine as opposed to a new teaching strategy. When I have my own classroom, I will be able to set classroom norms that fit my kinesthetic style of teaching from the start. This way, students are not resistant to or surprised by non-lecture-based teaching approaches. In the future, I would like to incorporate more kinesthetic learning experiences into my classroom. Then, I would like to conduct more of a long-term study in which the control group learns mathematics in a traditional manner while the treatment group learns mathematics through various kinesthetic experiences.

While my research told me the effect of learning quadratic transformations through dance had on my small group of students, it is not generalizable to all schools, classrooms, mathematical concepts, grade levels, or content areas. Although my results did not necessarily support teaching mathematics through kinesthetic learning experiences, I would still like to use kinesthetic activities in my classroom. Because research supports kinesthetic learning, I plan to incorporate more activities into my classroom as well as learn to perfect my implementation of them. While my action research focused on students' immediate recall of content knowledge, I wonder if the gap between the control and treatment groups would widen if I assessed long-term retention of content knowledge. I encourage others to use my music video to teach quadratic transformations and to make your own parodies of popular songs to determine if learning through dance works for you and your students.

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Appendix A

Pre-Survey/Post-Survey

Part 1: Attitudes Toward Mathematics

Directions: Circle the number that most appropriately corresponds to your belief regarding the statements below.

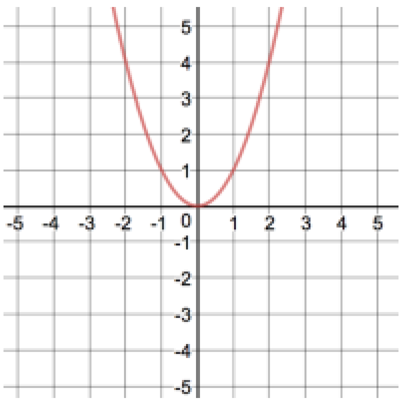
Key:
1 – Agree a lot, 2 – Agree a little, 3 – Disagree a little, 4 – Disagree a lot

1. I enjoy learning mathematics.	1	2	3	4
2. I wish I did not have to study mathematics.	1	2	3	4
3. Mathematics is boring.	1	2	3	4
4. I learn many interesting things in mathematics.	1	2	3	4
5. I like mathematics.	1	2	3	4
6. Mathematics is one of my favorite subjects.	1	2	3	4
7. Mathematics makes me nervous.	1	2	3	4
8. I am good at working out difficult mathematics problems.	1	2	3	4
9. I think learning mathematics will help me in my daily life.	1	2	3	4
10. Mathematics is not one of my strengths.	1	2	3	4

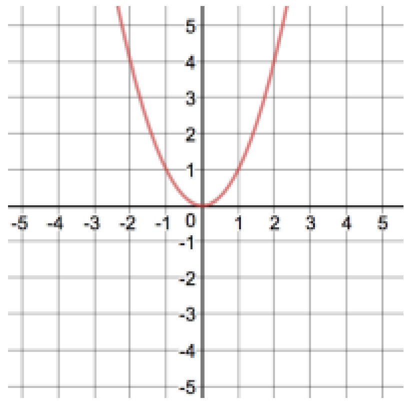
Part 2: Knowledge of Transformations of Quadratic Functions

Directions: For questions #1-7, sketch the graph of the following quadratic functions on the same coordinate grid as the graph of the parent function.

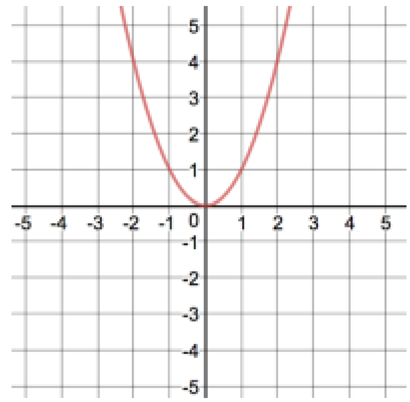
1. $f(x) = -x^2$



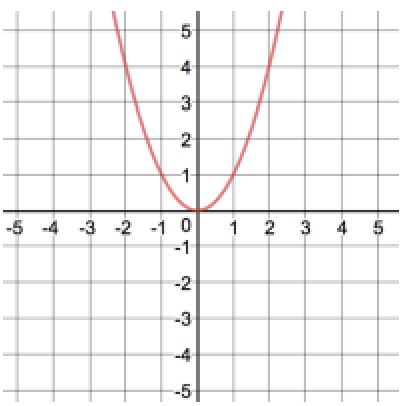
2. $f(x) = (x + 3)^2$



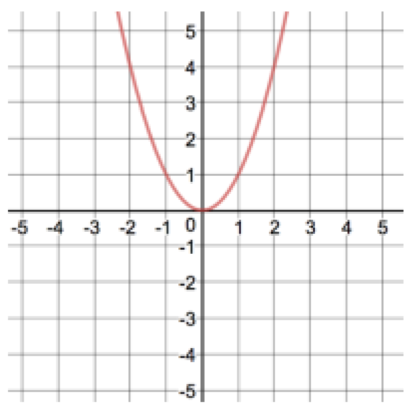
3. $f(x) = (x - 3)^2$



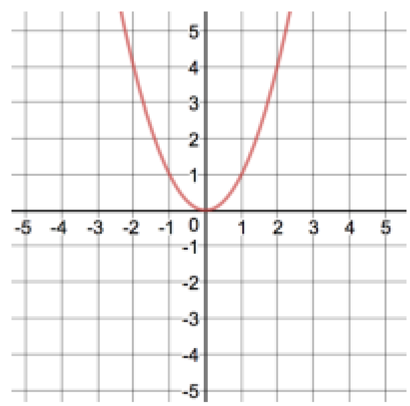
4. $f(x) = x^2 + 2$



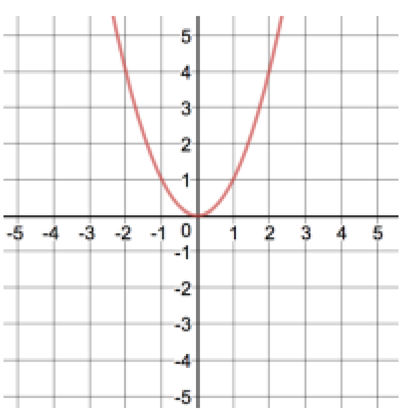
5. $f(x) = x^2 - 2$



6. $f(x) = 4x^2$



7. $f(x) = \frac{1}{3}x^2$



8. What is the formula for the vertex form of a quadratic equation?

9. What is the parent function of a quadratic equation?

Appendix B

Quadratic Transformation Song Lyrics

"Me Too" by Meghan Trainor

Ow
Who's that quadratic standing over there?
That's the parent, standin' at the origin.
What's that flat base hanging in the middle?
That's the vertex, being symmetrical.

I graph curves every day
And transform graphs in this way.
And I can't help connecting the points
And I don't need nobody else, nuh uh.

A times the quantity of x minus h squared plus k
Of x minus h squared plus k
Of x minus h squared plus k
If a was negative, I'd reflect over the x
Reflect over the x
Reflect over the x.

I add h to the x.
I go h to the left.
I subtract h to the x.
I go h to the right.
I add k and I go up.
I subtract k and I move down.
I add k and I go up
I subtract k and I move down.

I graph curves every day
And transform graphs in this way.
And I can't help connecting the points
And I don't need nobody else, nuh uh.

A times the quantity of x minus h squared plus k
Of x minus h squared plus k
Of x minus h squared plus k
If a was negative, I'd reflect over the x
Reflect over the x
Reflect over the x.

Ow
(Turn the calculator on)
Turn the calculator on
Ow
(Turn the calculator on)
Let's go!

I graph curves every day
And transform graphs in this way.
And I can't help connecting the points
And I don't need nobody else, nuh uh.

If the absolute value of a is greater than one,
I'd wanna stretch vertically
I'd wanna stretch vertically
If the absolute value of a is between zero and one,
I'd wanna compress vertically
I'd wanna compress vertically

A times the quantity of x minus h squared plus k
Of x minus h squared plus k
Of x minus h squared plus k
If a was negative, I'd reflect over the x
Reflect over the x
Reflect over the x.