ACTIVE LEARNING OF SCALE AND PROPORTIONALITY: A STEM APPROACH

by

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STATEMENT OF PERMISSION TO USE

In presenting this professional paper in partial fulfillment of the requirements for a master's degree at Montana State University, I agree that the MSSE Program shall make it available to borrowers under rules of the program.

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ABSTRACT

It is oftentimes difficult for students to transfer and use prior knowledge in one subject into another class. In the middle school setting, the math concepts that are needed to conduct many science labs are a challenge for students to complete, or students find it difficult to make connections through the problem solving component in a science activity. This study was implemented with a sixth grade class that has math and science as a block of time with the same teacher, (math 50 minutes and then science 50 minutes), and none of the students had individual education plans. The major focus of this study wanted to determine if using an integration of Science, Technology, Engineering and Math (STEM) principles develops a deeper understanding of scaling and proportional reasoning by using interactive computer and online simulations (three lessons online for part of a unit called “Scale City”). This study also wanted to determine whether students would gain self confidence in both solving math problems as well as being more comfortable using simulations. Student attitude and confidence surveys were given pre and post treatment. At the beginning and end of each of the lessons, students completed a pre-and post-assessment. During days of the lesson where students used the interactive computer or online simulations, a brief end-of-the class feedback/reflection form was used to analyze possible fluctuations in confidence level using simulations and interactives as well as problem solving confidence levels. Data was triangulated and analyzed to determine results.

INTRODUCTION AND BACKGROUND

The focus group for this action research project was with sixth grade students. I have taught math and science for fourteen years at Sleeping Giant Middle School located in Livingston, Montana. The classroom environment for our sixth grade students is unique in our middle school. Rather than changing classroom teachers for every 50 minute subject, sixth grade students have the same teacher for math and science, and the same teacher for language arts and social studies. The benefit of this class structure is the opportunity to create a longer block of time for outdoor science or for labs if needed, and the ability to integrate the two subjects.

It is an expectation in my school that the two math and science teachers integrate math into the science curriculum, focusing on data collection, data interpretation and analysis, graphing and proportional reasoning. Our sixth grade content for math has a heavy emphasis on decimals and fractions. Sleeping Giant Middle School is approximately 95% Caucasian and approximately 50% of our students qualify for free or reduced lunch. This data is consistent with the median household income for Montana at $33,937 compared to the national average of $49,445. Our school population is slowly decreasing, and retiring teachers are not being replaced. According to our state Criterion Referenced Test (CRT) results, students scored at or slightly above the state average in math and science scores in 2011. Math and science teachers have used the CRT results in the last few years to learn which concepts students are struggling with. Skills and concepts that students struggle with in both math and science are word problems using ratios, proportions and dimensional analysis. I have found that students become very engaged in problem solving when they are more invested in what they are doing, such as when I teach the robotics camps/programs. I have learned that robotics uses STEM (Science, Technology, Engineering and Math) seamlessly. In following with a STEM approach, my action research proposal investigated strategies to increase success in proportional reasoning and scaling.

Focus Questions

The primary focus question is listed first and the supporting questions follow.

- Will the integration of a STEM approach (using interactive simulations) increase students' understanding of scaling and proportional reasoning?
- Will the use of computer simulations encourage students to use interactive resources for problem solving?
- How will the math confidence level of students be affected by the STEM approach?

CONCEPTUAL FRAMEWORK

In reviewing the literature on the topic of the effects of Science, Technology, Engineering and Math (STEM) in engaging students in the active learning of scaling and proportionality, three discussions can be addressed. First, STEM is explained. Then, there is an explanation of proportionality and scaling and its relevance in education. Finally, a discussion on the emphasis of teaching scale and proportionality is presented. There is much concern in the United States that in order to continue to be competitive on the world stage, we must be creative problem solvers. Brophy et al. (2008) states:

> Engineering as a profession faces the challenge of making the use of technology ubiquitous and transparent in society while at the same time raising young learners' interest and understanding of how technology works. Educational efforts in science, technology, engineering and mathematics (i.e., STEM disciplines) continue to grow in pre-kindergarten through 12th grade (P-12) as part of addressing this challenge (p. 369).

When integrating STEM, teachers should provide students the opportunity to practice and understand the steps of the design process in order to build critical thinking skills. With this practice, as students move through elementary and then to middle and high school, students can learn to critically evaluate their designs as they progress to more complex systems. According to Brophy et al. (2008), students learn to notice and reflect on structure, function, and behavior of processes (e.g., mechanics, human interactions), devices (artificial system) or natural phenomena (natural system) (p.371). Initial design questions can then be asked, but it is important to realize that novices will not have the content knowledge to answer the questions. Fortunately, through intentional learning activities they can be taught what they need to know to progress to design solution.

Classroom-based initiatives have emerged that enable young learners to develop literacy, competency and interest in engineering thinking and technology proficiency (Raizen et al., 1995). These initiatives are critical to the STEM education of all students and fundamental in supporting the growing demand for a workforce who can *adapt to* and *innovate for* a rapidly changing world (Duderstadt, 2008).

Taylor & Jones (2009) found that the National Science Education Standards emphasize teaching unifying concepts and processes such as basic functions of living organisms, the living environment, and scale. Scale is one of the major themes that span chemistry, physics, earth/space science, and biology (p.1231). Fundamentally, scale and proportions are mathematically tied to ratios and their proportional equivalence as they "shrink or grow", and their multiplicative nature. For example, two quantities are proportional if they vary in such a way that one of them is a constant multiple of the other. Sometimes a proportion is a comparison of a specific quantity to "the whole". As described by Vasilyeva and Huttenlocher (2004), "mapping is a form of scaling. A map is a smaller-scaled version of the space it represents. It has been argued that children have difficulty interpreting maps because they do not understand scale relations (p.682)." These scale relations have an inverse relationship when a map is being scaled up or down, and this becomes confusing for children when they are typically most familiar with a basic proportionality of the constant multiple [e.g. the father is two times taller than the child (multiply by two) or the child is half as tall as the father (divide by two)].

The scale relationship of surface area to volume affects behavior across the science domains and whether the topic is in biology, chemistry, physics, earth or space science, issues of scale are central to understanding science phenomena (Jones, Taylor, Minogue, Wiebe, & Carter, 2007). Proportional reasoning is a topic that bridges arithmetic and higher mathematics and is essential for later work in the sciences. It is often considered one of the "big ideas" in middle school math. As noted in the *Principles and Standards for School Mathematics* document by the National Council of Teachers of Mathematics, NCTM (2000).

> Curricular focus and integration are also evident in the proposed emphasis on proportionality develops through work in many areas of the curriculum, including ratio and proportion, percent, similarity, scaling, linear equations, slope, relative-frequency histograms, and probability. The understanding of proportionality should also emerge through problem solving and reasoning, and it is important in connecting mathematical topics and in connecting mathematics and other domains such as science and art. (p.211)

There are few studies of proportional reasoning in science contexts even though it plays a significant role in the different domains of science (Taylor & Jones, 2009). However, in science instruction, proportional reasoning is important because it allows students to construct the meaning of scientific concepts that are being demonstrated (such as scaling of very large or extremely small sizes, density, and unit rates). Since many of the studies on proportionality and scale are through the mathematical context, it is important for math and science teachers to collaborate and understand how each curriculum supports the other.

In a study by Hingant, Benedicte and Albe, Virginie (2010), there was a consensus reached regarding “big ideas of nanoscience” and presented at a NSF workshop. Four of the nine core concepts: Size and Scale, Size-Dependent Properties, Models and Simulations, and Science, Technology and Society support this study. Taylor and Jones (2009) provide additional support as its approach to proportional reasoning connects to the application of the success to scale in the science class. The powers of 10 are related to all three studies and are used commonly in both math and science classes for scaling, unit rates, and scientific notation, to name a few.

Research indicates that science educators should embrace the task of applying mathematical concepts that are implemented using STEM, which Brophy et al. (2008) supports as a “wide range of knowledge and skills associated with comprehending and using STEM knowledge to accomplish real world problem solving through design, troubleshooting, and analysis activities (p. 369).” Researchers Bell, Gess-Newsome & Luft (2007) looked at the use of computer simulations to enhance science teaching and learning. Numerous studies assessed how simulations affected process skill development, such as identifying variables, measuring, graphing, interpreting data, and designing experiments. Their findings showed that ‘interaction with computer simulations resulted in measurable achievement gains and indicates that simulations are equally, if not more effective than traditional methods” (p.24).

Success in understanding proportionality and scale are fundamental to many disciplines of science such as biology, chemistry, earth and space, and physics. Proportional reasoning and scaling are multiplicative in nature. For effective teaching of proportionality students need to become more proficient at scaling, like using such factors as Powers of 10, and students should also get many opportunities to build a conceptual understanding of proportionality of the very, very small scale to the very, very large scale. In order for students to be successful in learning proportionality, they should first be able to master the skills of dividing whole numbers, simplifying fractions, ordering decimals, multiplying mixed numbers, dividing fractions and understanding percent.

Multiplicative and proportional reasoning are the fundamental ideas of many of the mathematics topics studied in grades 6-8 (NCTM, 2000). To help students understand the meaning of ratio and proportion, Yetkiner & Capraro (2009) indicate that teachers need to know the ways in which students develop proportional understanding and provide them with conceptual curricula and meaningful classroom experiences. According to the National Council of Teachers of Mathematics [NCTM](1989) *Curriculum and Evaluation Standards*, "[Proportional reasoning] is of such great importance that it merits whatever time and effort that must be expended to insure its careful development" (p.82). In order for effective teaching of proportional reasoning to happen, Yetkiner & Capraro (2009) believe that middle school teachers need to possess a fluid and flexible understanding of division of fractions, a conceptual understanding of fractional operations, and have an in-depth understanding of multiplicative reasoning.

For this action research, my study will use STEM methods which include interactives and computer simulations to determine if the active learning of scale and proportionality increases students' understanding.

METHODOLOGY

For this study, the focus is on the integration of a STEM approach in online and computer interactives. The primary question that was answered was whether the integration of a STEM approach in online and computer interactives increases students' understanding of scaling and proportional reasoning. Secondary questions that were answered included whether the use of computer simulations encourages students to use interactive resources for problem solving and whether the math confidence level of students would be affected by the use of a STEM approach.

Participants

The sixth grade students in this study include one section of a math/science block. There were twenty-two students in this class (15 boys, 7 girls), and none of the students in this class were considered "struggling" math or science students. There was an even distribution of regular and somewhat advanced students with all of the students reading at, or above, grade-level. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained.

Intervention

This study began just after the beginning of third quarter and lasted for four weeks. Each week, students completed a web-based interactive activity in-class in addition to normal instruction including hands-on activities and group work or discussions. They also received a list of additional interactive activities and related websites that they could complete at home. Table 1 summarizes the instructional activities for this study.

Table 1

Instructional Activities and Strategies

Week 1	Scale City: Dinosaur World *Teacher Feedback Form will be given each day of the online simulation work	Day 1	Dinosaur Greetings; interactive online “Size-O-Rama”; list of interactive websites to visit
		Day 2	Explore and calculate phase for Dioramas and “Din-O-Rama” interactive
		Day 3	Begin Performance Assessment: Dioramas
		Day 4	Complete Dioramas; Post-Assessment
		Days 5 & 6	Presentations
Week 2	Scale City: Louisville Slugger *Teacher Feedback Form on Days 1and 2	Day 1	Online: Babe Ruth stats and video; “Batting Practice & Sizing Up the Team” practice handouts w/ calculator; “Remembering Triangles” homework
		Day 2	Video again w/ “Batter Up! Pay Attention” handout; Interactive “Similar Shadows”; list of interactive websites for review/practice
		Days 3& 4	Game Time w/ “ Questions” handout
		Day 5	Group Performance Activity/Assessment: Comparing Baseball Fields then exploring 3-4-5 triangle
		Day 6	Post-Assessment
Week 3	Scale City: Mural Math *Teacher Feedback Form on Days 1and 2	Day 1	Mural Painting Video; Mural Math interactive; list of interactive learning websites
		Days 2 & 3	Mural Math game (teams of 4); Open Response homework handout
		Day 4 & 5	Performance Assessment-Collaborative Class Mural
		Day 6	Complete Class Mural-display it in the school hallway and Post Assessment

Data Collection

In order to determine the effectiveness of this action research, the teacher conducted a Student Attitude and Opinion Survey (see Appendix A) at the beginning and end of the treatment period, as well as having students complete a Teacher Feedback Form (see Appendix B) surveying them on their comfort, confidence and frequency of use of the interactives during the lesson when interactive online simulations were used. Students were also given a pre and post-test for each lesson, along with the teacher administering a performance assessment as a form of formative assessment. The teacher also began and followed up the treatment by conducting interviews with three girls and three boys. The triangulation matrix (Table 2) reveals the methods used to collect and analyze the success of this study.

Table 2
Data Triangulation Matrix

Focus Questions	Data Source 1	Data Source 2	Data Source 3
Primary Question: 1. Will the integration in a STEM approach in online and computer interactives increase students' understanding of scaling and proportional reasoning?	Summative Pre Assessment	Formative (Performance) Assessments	Summative Post Assessment
Secondary Questions: 2. Will the use of computer simulations encourage students to use interactive resources for problem solving?	Student interviews	Pre and post attitude and opinion survey	Teacher Designed Feedback Form
3. How will the math confidence level of students be affected by the use of the STEM approach?	Teacher Designed Feedback Form	Pre and post attitude and opinion survey	Student interviews

Surveys

To measure any changes in students' math self-confidence level, two Likert-type scale surveys were conducted. The Student Attitude and Opinion Survey was given to students before and after the four week treatment, and compared to the Teacher Feedback

Form “Self Confidence and Interactive/Simulations Survey”. The two surveys also provided insight into students’ likeliness to apply and use interactive computer and online simulations to aide in understanding how to solve problems.

Interviews

The teacher conducted interviews with six students to determine if students’ developed an increased level of confidence in their ability to solve math problems and their likeliness to continue using interactive computer and online simulations. This interview was conducted at the beginning and the end of the treatment. An even number of male and female students were interviewed, with one male and one female regarded as above average and the other students as average. The interviews took place during the teachers’ planning period, as students chosen were those coming from a common study skills time and were those who were likely to offer open and honest replies.

Pre and Post Tests

At the start of each lesson, students were given a pre-test to measure prior knowledge. Also, following each performance assessment, students were given the post-test. Using these summative assessments, in combination with the all of the other data collection methods, the teacher was able to determine if there was an increase in students’ ability to solve problems with confidence and improved accuracy through the use of interactive and online simulations.

Formative Assessments

At the end of each of the three lessons, a formative performance assessment was conducted by the students. Through these design, troubleshooting, and analysis activities, the teacher attempted to draw comparisons of knowledge gained when using summative assessments and the STEM approach.

DATA AND ANALYSIS

In order to determine the effectiveness of the intervention and to answer the focus questions, data will be utilized from various sources; pre and post assessments, student attitude and opinion surveys, and self confidence surveys. As students worked through the weekly units the author was able to address any misconceptions or deficiencies that emerged.

Use of simulations and computer interactives to increase students' understanding of scaling and proportional reasoning

Using various sources to determine the success of the action research project and answer the focus question such as pre and post assessments, formative assessments, teacher feedback forms, and confidence surveys were analyzed. The pre and post assessments were the primary tool to understand the impact of simulations and computer interactives on students' understanding of scaling and proportional reasoning. There were twenty-two students in this class, but only twenty students signed the IRB permission form (see Appendix A) to be part of this action research (so the two were not used in these results). After reviewing the data, it was found that there was a statistically significant difference between students on the post tests for the second and third lessons, Louisville Slugger, ($M=68.42\%$, $SD=22.18$) than on its pre test ($M=35.26\%$, $SD=17.75$), $t(19)=4.8878$, $p=0.0001$ and Mural Math, ($M=76.32\%$, $SD=22.41$) than on the its pre test ($M=54.5\%$, $SD=23.28$), $t(20)=4.0645$, $p=0.0007$, but for the first lesson (DinoWorld) was not statistically significant as the results showed it could be just from chance with the post test (M=68.95%, SD=19.41) than on the pre test (M=64.21%, SD=16.1), t(19)=1.2712, p=0.2208. Each of the lessons' assessment results are listed below in Figure 1.

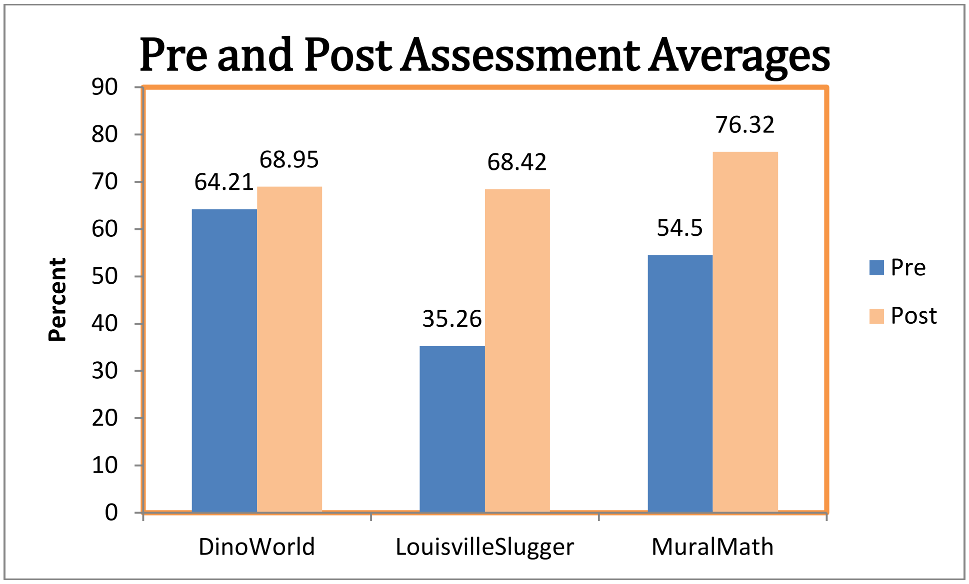

Figure 1. Pre and Post Assessment averages for each lesson, (*N*=20).

<u>Using interactive computer simulations encourages students to use interactive resources for problem solving</u>

Although students felt comfortable using online simulations, they did not perceive an increase in confidence from using them. As a result, most students did not use the optional interactive resources at home. Specific sections on the Teacher Feedback form, Student Attitude and Opinion Survey and the student interviews were used to determine whether using computer simulations and online interactives in the classroom encourages students to seek and use interactive resources outside of the classroom for problem solving. In the pre and post Student Attitude and Opinion Surveys, 7 of 20 (35%) and 9 of 20 (45%) students report that they use computer interactive/simulations to help them understand math (35%) as well as help them with problem solving (45%). The Teacher Feedback form was given to students twice during each lesson, for six total forms to gather results in trends. The data shows that for lesson one, Dino World, three students (or 15%) used the resources at home. This improved to 25% (five students) for the second lesson Louisville Slugger, but decreased to 0% for the final lesson Mural Math. Even though only 6 of 20 students reported on the Teacher Feedback Form that they used the interactive simulations outside of class, the extra comments section of the form had students asking to use Scale City again and again because "it helped me make sense of the math". Figure 2 below shows the number of minutes for those students who used simulations and interactive resources at home. Although some students used it outside of class, many did not.

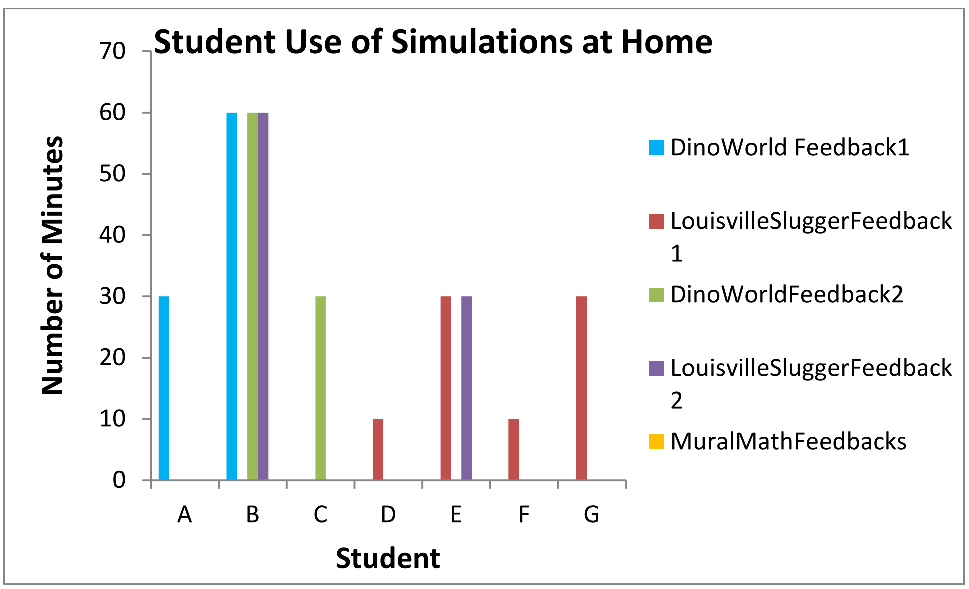

Figure 2 Seven students online 10 to 60 minutes, (*N*=20).

The use of computer simulations did not have an impact on student perception of confidence or ability to problem solve. In relation to problem solving, for question sixteen "I am more confident about a math concept when I use math interactive/simulations" there was no real gain from the pre-treatment Student Attitude and Opinion (SAO) Survey where eight students agreed to this statement, and the post treatment SAO Survey which showed nine students agreed to this statement (an increase of confidence by one, or 5%). At the same time, this question also showed a decrease of confidence by one (or 5%). This was possibly due to the fact that there were eight neutral student responses in the pre-treatment and for the post treatment five were neutral. Question number 20 on the SAO Survey "Interactives and simulations don't help me with problem solving" results indicated there were no gains shown in confidence connecting the simulations' use to the student's view of increasing their problem solving skills. SAO Survey question 18 "I am a good problem solver" showed 85% of students agreeing to this statement pre-treatment, and 90% of students agreeing on the post treatment.

In comparison, when checking to see whether students were comfortable using simulations, the Teacher Feedback Form results showed that on all three lessons, an average of 70% of students were always comfortable working with the interactive/simulation as well as 64% of the students were always comfortable with their problem solving skills during the simulations in class. These results suggest that the students were comfortable about doing the interactives and simulations in class, but won't seek it out on their own time for problem solving.

<u>The math confidence of students will be affected by the use of the STEM approach</u>

Results show the math confidence of students is affected (in one way or another) by the STEM approach, and it varies in each student's personal experience with their struggles or success with the hands-on approach. The Teacher Feedback Form results on all three lessons reveal that an average of 75% of the students were confident using the interactive/simulation and an average of 66% were confident working with scaling and proportions. Along with the formative feedback, students responses indicated on the Attitude and Opinion Survey that for Question 9 “I am able to make/draw items proportionally larger or smaller” increased a slight 5% from 12 of 20 (60%) to 13 of 20 (65%) as well as Question 10 “I am not good at math” 19 of 20 (95%) students were confident with their math skills on the pre assessment decreasing 15%t to 16 of 20 (80%) confident (with two students changing from their pre-treatment survey score to “neither” showing a slight decrease in confidence) and finally Question 7 “I like solving math problems” indicating the sharpest decrease from pre-treatment survey (13 of 20, or 65% liking to solve math problems) declining 20% on the post treatment survey (9 of 20, or 45% liking to solve math problems) where two students changed from 5 “Agree” to 3 “Neither”, two students changed from 4 “Somewhat Agree” to 2 “Somewhat Disagree”, and one student changing from 4 “Somewhat Agree” to 1 “Disagree”. Some of the students who were more inclined to indicate their decreasing confidence were those who had been absent during a simulation as lab times were hard for them to make up.

INTERPRETATION AND CONCLUSION

As we become a more increasingly technologically-driven society, teachers of math and science must find ways to integrate STEM into their classrooms in order to help foster a new workforce of problem solvers. Many of the students in the study reported that they enjoyed the simulations and interactives to help them understand scaling and proportional reasoning, but they didn’t have the time outside of class to use simulations online to help them with problem solving. I have found that middle school math and science students can easily bounce in and out of feeling confident in their math skills, and can easily give up if they don't have enough of, or recognize the "tools in their toolbox" to go about solving problems. Proportional reasoning skills are an important middle school math skill that lays the foundation for success in algebra and geometry, as well as scientific concepts in biology, chemistry, and physics, to name a few. As the mathematical demands increase as students progress through those upper level science classes (of chemistry and physics), students tend to lose interest in science.

One solution would be to allow students more opportunities for problem solving activities in the middle school setting. Using the STEM approach allows students the opportunity to practice and understand the design process, while building critical thinking and problem solving skills. Simulations and interactives allow students to model and manipulate information and data that can be cumbersome or impossible to conceptualize especially when thinking about science on a nano-scale size.

Throughout the intervention, students were introduced to a proportional scale lesson using ScaleCity on the computer which utilized simulations to help students manipulate data and were also encouraged to access ScaleCity and other interactive websites to help them build their self confidence in problem solving. My research assessed their learning after four weeks.

The intervention was successful regarding summative pre and post assessment (see website http://www.ket.org/scalecity for online assessments) for two of the three units, and the comfort level of students using simulations and interactives improved, but they did not perceive a level of confidence using them. I think one reason for the limited success of this treatment is that I underestimated students' readiness skills in order to be successful with proportional reasoning. Students had been working with fractions (and spend a considerable amount of their sixth grade school year) focused on success with fractions, but were not as proficient with their use of ratios. According to Howe et al. (2011), research suggests that when students work only with fractions focus on the numerical values rather than the relations (part-to-part) perspective that the students oftentimes misunderstand what the numbers represent.

VALUE

I have learned that just because students have learned fractions and have been introduced to ratios in their mathematics textbooks, they can be unprepared to apply these concepts of proportional reasoning when students are trying to think spatially even with simulations. One of the benefits of this study is that I will be teaching either eighth grade math, or eighth grade science after this year. Since I have already taught this group of students, I will be able to pick up where I left off in implementing STEM strategies. Through this research, I have grown in my knowledge of integrating STEM and have a greater understanding of the steps needed in the design process.

Additionally, I have grown professionally through the MSSE program as it has encouraged me to critically analyze my teaching methods to see if I am using the most current research in the field to help me determine which instructional practices will provide me beneficial uses needed for my students to maximize their success.

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APPENDICES

APPENDIX A

IRB FORM

Appendix A
IRB Form

Informed Consent to Participate in a Research Study at Montana State University, Bozeman, Montana

Title of research investigation: Scaling and Proportional Reasoning: A STEM Approach

My name is Lori Chapman and I am conducting research in partial fulfillment of the requirements of a Master of Science in Science Education degree from Montana State University. I am conducting a research study designed to improve student achievement and learning of scaling and proportional reasoning through the use of interactives and computer simulations. Students will be using computers for simulations and hands-on interactives to create dioramas, murals and maps. I am inviting your child to take part in this research study because the study is designed for math and science students and the topics we will be studying.

If you agree to have your child participate in this research study, the following will occur. During our normal class activities, your child will be given a pre and post survey, interviewed once, observed in class during the progress of the study, and tested on the lessons they have completed. I will be testing the students during the study and those tests will be treated as normal assessments.

If you agree for your child to participate in this research study, there is a potential risk of loss of privacy. However, no names or identities will be used in any published reports of the research. The research data will be kept on a flash drive, and only the Principle Investigator of the research (Mrs. Chapman) will have direct access to the data. At the conclusion of the study, all identifying information will be removed and the data will be archived at Montana State University. There are no foreseen risks and the participant will only be asked to answer questions dealing with normal classroom learning topics and only those questions he/she chooses to answer, and can stop their participation in the research at any time.

If you agree for your child to participate in this research study, there are some benefits in participation. They involve gaining knowledge about the teaching/learning process, obtaining a deeper understanding of the subject matter we are studying (scaling and proportional reasoning, as well as mapping). There is no cost for your child to participate in this research study. If your child participates in this research study there is no direct compensation.

If you do not wish for your child to participate, the alternative is not to participate in the research. Since this research will replace our typical lessons, your student will still complete the activities, however, he or she will not be interviewed and any test scores or other feedback will not be included in my study.

If you have any further questions about the study, you may contact me by email at lchapman@livingston.k12.mt.us, or by phone at 406-222-3292.

You have been given a copy of this consent form to keep.

PARTICIPATION IN THIS RESEARCH IS VOLUNTARY. You are free to decline to have your child participate in this research study, or to withdraw their participation at any point, without penalty.

Authorization: I have read the above and understand the discomforts, inconvenience and risk of the study.

I ______________________________ (*name of parent or guardian*) related to the subject as ________________ (*relationship*) agree to participation of ______________________ (*name of subject*) in this research. I understand that the subject, through his/her own action or mine, may refuse to participate in this research, and that I may withdraw from the study at any time. I have received a copy of this consent form for my own records.

Parent/Guardian Signature ____________ Date:

Child's Assent Signature: ______________________________ Investigator: ____________

APPROVED
MSU IRB
11-28-2011
Date approved
N/A
Expiration date

APPENDIX B

STUDENT ATTITUDE AND OPINION SURVEY

Appendix B
Student Attitude and Opinion Survey

Student Attitude and Opinion Survey
Computer Simulations and Confidence in Scaling & Proportional Reasoning

To what extent do you agree with the following statements about computers and math. Please circle one choice for each statement.

1 = Disagree **2** = Somewhat Disagree **3** = Neither **4** = Somewhat Agree **5** = Agree

I have access to a computer outside of school.	1	2	3	4	5
I am comfortable using computers.	1	2	3	4	5
I use a computer three or more times a week.	1	2	3	4	5
I am comfortable using computer interactive/simulations.	1	2	3	4	5
I play interactive simulations with other technology. (X-Box, NES, PS2, iPad, cell phone, etc.)	1	2	3	4	5
Math is a subject I am good at.	1	2	3	4	5
I like solving math problems.	1	2	3	4	5
I am comfortable using a map.	1	2	3	4	5
I am able to make/draw items proportionally larger or smaller.	1	2	3	4	5
I am not good at math.	1	2	3	4	5
I do not like to use computers.	1	2	3	4	5
I like to play on the computer outside of school time.	1	2	3	4	5
I only use the computer at home or library to look up information.	1	2	3	4	5
I only use the computer at home or library to type papers.	1	2	3	4	5
I use computer interactive/simulations to help me understand math.	1	2	3	4	5
I am more confident about a math concept when I use math interactive/simulations.	1	2	3	4	5
I am able to read the scale on a map.	1	2	3	4	5
I am a good problem-solver.	1	2	3	4	5
I am able to use an interactive device or simulation to set a scale.	1	2	3	4	5
Interactives and simulations do not help me with problem solving.	1	2	3	4	5

APPENDIX C

TEACHER FEEDBACK FORM: SELF CONFIDENCE AND INTERACTIVE/SIMULATIONS SURVEY

Appendix C
Teacher Feedback Form: Self Confidence and Interactive/Simulations Survey

Teacher Feedback Form: Self Confidence and Interactive/Simulations Survey Date:____				
Please give your answer to questions #1-6 with a check on each line	Always	Most of the time	Some of the time	Not at all
How often did you feel **comfortable** today working with the interactive/simulation?	☐	☐	☐	☐
How **comfortable** did you feel today with your problem solving skills?	☐	☐	☐	☐
How **confident** were you today using the interactive/simulation?	☐	☐	☐	☐
How **confident** were you today working with scaling and proportions?	☐	☐	☐	☐
Do you **plan** to use one or more of today's interactive/simulations or list of website links outside of class time?	Yes ☐	No ☐		
How **frequently** (using length of time as your frequency) did you use any of the interactive/simulations or other website links you received since your last scale and proportions lesson? (check one)	No Minutes ☐	15-30 minutes ☐	30-60 minutes ☐	Over 1 hour ☐

APPENDIX D

POST TREATMENT INTERVIEW QUESTIONS

Appendix D
Pre and Post Treatment Interview Questions

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.
Thank you for participating in this interview! Please respond honestly and constructively to the questions below.

Do you enjoy using the computer? If yes, explain why. If no, explain why not.

How many technology devices do you have? Name them, and tell which one(s) you like the most and why.

Do you play any video games (on your phone, TV, computer or other device)? If yes, are they interactive? (explain)

How has your experience with computer simulations helped your confidence with math?

Thinking about yourself as a successful math student, rate yourself on a scale of 1-4 (circle your choice)

1 = *I Always Struggle*
2 = *I Struggle Most of the Time*
3 = *I Struggle Some of the Time*
4 = *I Usually Never Struggle*
Explain why you gave yourself this rating.

Do you feel using simulations or interactive technology helps you in learning about/understanding math concepts? (explain your reasoning)