Elementary Student Engagement Through STEM Lessons

Leigh Blankenship
University of Nebraska - Lincoln, lblankenship@fallscityps.org

Follow this and additional works at: https://digitalcommons.unl.edu/cehsdiss

Part of the Other Education Commons

https://digitalcommons.unl.edu/cehsdiss/345
ELEMENTARY STUDENT ENGAGEMENT THROUGH STEM LESSONS

by

Leigh Anne Blankenship

A THESIS

Presented to the Faculty of
The Graduate College at the University of Nebraska
In Partial Fulfillment of Requirements
For the Degree of Master of Arts

Major: Teaching, Learning and Teacher Education

Under the Supervision of Professor Amanda Thomas

Lincoln, Nebraska

August 2019
Integrating science, technology, engineering, and mathematics (STEM) subjects can be engaging for students and can help build real-world connections. Integration of STEM disciplines can also promote student engagement, as well as promote problem-solving and critical thinking skills. This action research study employed qualitative methods to investigate whether student participation in content areas changes when integrated STEM lessons are introduced in an elementary classroom. The participants of this study were nine students in a fourth-grade rural elementary classroom. Data sources included student surveys, a teacher journal, student work samples, and student interviews before and after each STEM lesson over a three-month period. Major findings from this study, evidenced by teacher journals and student self-perceived participation surveys, show that student participation increased through STEM integrated lessons. Also evidenced by student work samples and student pre and post lesson interviews, this study found that teaching changed when STEM integrated lessons were taught.

*Keywords*: Elementary, Motivation, Participation, STEM Education
DEDICATION

I dedicate my thesis to all of my friends, family, and co-workers who have encouraged me throughout this process, I am very thankful for your love and support. A very special thanks to Amanda Thomas, my adviser, who supported me and guided me throughout this project. Her assistance and encouragement helped me create this project and make it a success. I greatly appreciate you. Thank you to my classmates for all the support throughout our entire program. We helped each other through all the blood, sweat, and tears. For that, I am extremely thankful.
GRANT INFORMATION

This material is based on work supported by the National Science Foundation under Grant No. 1758496. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.
# TABLE OF CONTENTS

ABSTRACT ...................................................................................................................... ERROR! BOOKMARK NOT DEFINED.

DEDICATION .................................................................................................................... III

GRANT INFORMATION .................................................................................................... IV

CHAPTER 1: INTRODUCTION ......................................................................................... 1

  PROBLEM STATEMENT ................................................................................................ 1
  PURPOSE AND RESEARCH QUESTIONS ..................................................................... 1
  METHODS OVERVIEW ............................................................................................... 2
  DEFINITION OF KEY TERMS .................................................................................. 3

CHAPTER 2: LITERATURE REVIEW ............................................................................... 4

  OVERVIEW .................................................................................................................. 4
  STEM AND PROBLEM-BASED LEARNING .................................................................. 4
  STUDENT ENGAGEMENT AND MOTIVATION .......................................................... 6
  STEM LESSONS IN AND OUT OF SCHOOL ............................................................... 7
  SUMMARY .................................................................................................................. 10

CHAPTER 3: METHODS ................................................................................................. 11

  OVERVIEW .................................................................................................................. 11
  CONTEXT OF THE STUDY ...................................................................................... 11
  PARTICIPANTS .......................................................................................................... 14
  DATA COLLECTION ................................................................................................... 14
  DATA SOURCES ......................................................................................................... 15
LIST OF TABLES

TABLE 1 ................................................................................................................................. 12
TABLE 2 ................................................................................................................................. 12
TABLE 3 ................................................................................................................................. 13
TABLE 4 ................................................................................................................................. 15
TABLE 5 ................................................................................................................................. 23
TABLE 6 .................................................................................................................................. 32
LIST OF FIGURES

FIGURE 1. STUDENT-PERCEIVED PARTICIPATION DURING THE WATER CYCLE LESSON ........................................ 21
FIGURE 2. STUDENT-PERCEIVED PARTICIPATION DURING THE IRRIGATION SYSTEM LESSON .................... 22
FIGURE 3. STUDENT A WORK SAMPLE FROM WATER CYCLE LESSON .......................................................... 25
FIGURE 4. STUDENT B WORK SAMPLE FROM WATER CYCLE LESSON .......................................................... 26
FIGURE 5. STUDENT A WORK SAMPLE FROM IRRIGATION SYSTEM LESSON ............................................. 27
FIGURE 6. STUDENT B WORK SAMPLE FROM IRRIGATION SYSTEM LESSON ............................................. 28
FIGURE 7. STUDENT-PERCEIVED GROWTH FOR THE WATER CYCLE LESSON QUESTION ONE (HOW WELL DO
YOU THINK YOU UNDERSTAND THE WATER CYCLE?) .................................................................................. 29
FIGURE 8. STUDENT-PERCEIVED GROWTH FOR THE HURRICANE TOWER LESSON, QUESTION FOUR (HOW WELL
WOULD YOU BE PREPARED FOR A HURRICANE IF YOU LIVED NEAR THE OCEAN?) ............................ 30
FIGURE 9. STUDENT-PERCEIVED GROWTH FOR THE RAIN CLOUD LESSON, QUESTION ONE (HOW WELL DO YOU
UNDERSTAND HOW A CLOUD PRODUCES RAIN?) .................................................................................... 30
FIGURE 10. STUDENT-PERCEIVED GROWTH FOR THE IRRIGATION SYSTEM LESSON, QUESTION TWO (DO YOU
KNOW WHAT IRRIGATION SYSTEMS ARE USED FOR?) ............................................................................. 31
CHAPTER 1: INTRODUCTION

Problem Statement

What is a great way to increase student participation in upper elementary classrooms? One possible way to help increase student participation is by integrating science, technology, engineering, and mathematics (STEM) lessons into the curriculum. The purpose of this study is to determine whether integrating STEM lessons positively impacts student participation, by introducing students to real-world problems and teaching with a hands-on approach. This research is important for identifying whether student participation changes during integrated STEM lessons. It provides educators with evidence of how STEM lessons work and how they can be beneficial for their students. This study investigates the need for these types of lessons to help get students ready for future careers and help support student interest in STEM careers.

Purpose and Research Questions

Bybee (2013) found that STEM occupations are growing faster than other occupations within the U.S. STEM workers play a key role in the growth and stability of the U.S. economy, and are a critical component to helping with our future. By exposing students to STEM and giving them opportunities to explore STEM-related concepts, they have an opportunity to develop a passion for it and potentially pursue a job in a STEM field. A curriculum that is STEM-based has real-life situations to help the student learn. STEM education has the potential to create critical thinkers, increase science literacy, and enable the next generation of innovators. Innovation leads to new products and processes that may help sustain our economy. It is clear that citizenship and work require a basic
understanding of math and science, and that will continue in our future. STEM pushes us beyond the basic needs. It will push our students to have a deeper understanding of the process of how things work and what skills are needed in order to solve complex, authentic problems in the 21st century. Thus, STEM education is very important for promoting student participation in order for our society’s future to be successful. The purpose of this study is to determine whether including STEM-integrated lessons in the classroom increases student participation. The specific research questions that are addressed in this study are the following:

1. What happens to the level of student participation, as measured by students via a daily participation rubric, during lessons with integrated STEM topics?

2. What happens to my teaching when I implement integrated STEM lessons in place of separate science, technology, engineering, and mathematics lessons?

Methods Overview

This action research study uses qualitative methods to yield insight into the research questions previously identified. Data sources include surveys, interviews, and work samples from nine 4th grade students in a class taught by the researcher. This study took place in a rural elementary school in Southeast Nebraska. This study took place for three months with two integrated STEM lessons taught each month. As the researcher, I read through our regular classroom curriculum and then carefully selected a STEM lesson that was appropriate to go along with that curriculum to expand further knowledge of the content.
Definition of Key Terms

For the purpose of this study the following terms are defined:

**STEM**- Science, Technology, Engineering, and Mathematics. When teaching a given lesson it is important to integrate all of those subject areas into one lesson. It is also important for you to ask your students if they can identify each subject area in the given lesson that is being taught.

**High Ability Learners (HAL)**- A learner who shows evidence of a higher level of learning or shows high performance in areas of intelligence, creativeness, or even artistic areas within subject and require accelerated curriculum in order to develop those capabilities fully.

**Integrating**- including multiple subject areas in one given lesson.

**Participation**- When someone engages and adds to an activity, lesson, or discussion.
CHAPTER 2: LITERATURE REVIEW

Overview

It is hypothesized that STEM integrated lessons increase student participation within the classroom. This literature review examines research to better understand what is known about STEM integration and student participation. This chapter includes sections about STEM and Problem-Based Learning (PBL), student engagement and motivation, and STEM in and out of school settings. Much of the STEM-related research focuses on secondary classrooms, which I draw upon to inform this study that takes place in an elementary classroom. Similarly, many STEM-related studies take place in out-of-school contexts. Insights from these studies can also inform research about STEM within classrooms.

Kids (2016) concluded that STEM education is critical to help the United States remain a world leader. If STEM education is not improved, the United States will continue to fall in world ranking with math and science scores and will not be able to maintain its global position. STEM education in school is important to spark an interest in pursuing a STEM career in students.

STEM and Problem-Based Learning

This section will discuss research about how STEM-integrated lessons reinforce content of STEM, project-based learning, real-world connections, and integration. While this section provides a lot of information about project-based learning those other topics are also important and supported throughout this section.

Alumbaugh (2015) found that STEM integration should include a process: reinforcement of content (science, technology, engineering, and math), project-based,
real-world connections, and integration. This process is important to help achieve the goals of STEM. Berry, Chalmers, & Chandra (2012) found that project-based learning (PBL) in the STEM content areas helped foster student-directed inquiry and was effective in increasing student motivation. Berry, Chalmers, and Chandra (2012) concluded that PBL is a learner-centered approach where students are encouraged to integrate knowledge, take responsibility for their learning and work in teams to investigate real issues and construct products. PBL has been shown to be effective in increasing motivation and higher order thinking skills. Using PBL projects that integrate STEM fosters a student-directed inquiry and has been effective in increasing student motivation and problem-solving skills (Blumenfeld, Soloway, Marx, Krajcik, Guzdail, & Palincsar, 1991).

Blumenfeld et al. (1991) found that project-based education requires active engagement of students’ effort over an extended period of time. PBL also promotes links among subject matter disciplines and presents an expanded, rather than narrow, view of subject matter. STEM integrated lessons represent an expansion on a given lesson instead of just focusing on one subject area within a given lesson. Students are able to expand their knowledge and their understanding across multiple topics within one lesson.

“A number of factors should be considered in project design that affect whether students will be motivated to do projects in a manner that fosters understanding. These factors include whether students find the project to be interesting and valuable, whether they perceive that they have the competence to engage in and complete the project, and whether they focus on learning rather than outcomes and grades.” (Blumenfeld, et al. 1991, p. 375)
PBL and STEM integrated lessons allow students to have choice and control. Things they can choose are what materials they would like in order to complete the lesson, and how much participation they will have during the activity. Things that may be a constraint to them would be time and a choice of who their collaboration/group partners would be.

While both studies of Blumenfeld, et al. (1991), and Berry, Chalmers, and Chandra (2012) focused on PBL, Alumbaugh (2015) found that STEM lessons reinforce content, project-based learning, real world connections and integration. So, all of these researchers found that project-based learning in important in the classroom.

These researchers indicate that PBL is very important as it connects to STEM. It also allows learning to be connected to the real world and allows students to see a variety of opportunities.

**Student Engagement and Motivation**

This section talks about student engagement and motivation. It highlights that the students need to be motivated and engaged in their learning in order for them to be successful. It provides support that teachers can create environments for the students to be engaged and motivated in the learning that is taking place.

Blumenfeld, et al. (1991) concluded that technology can also play a powerful role in enhancing student and teacher motivation to do projects, and in helping students and teachers implement projects. Technology is one of the focus areas for STEM. Technology is any tool that you use to complete a task. It is hypothesized that if students are motivated, then they are more likely to participate.
Blumenfeld, et al. (1991) found that projects might be designed to increase the likelihood that most students will be motivated by them. The interests and value students attribute to the problem and elements in projects will affect how motivated they will be to engage in the project. These researchers said that teachers can create environments that promote motivation to learn and encourage inquiry, risk taking, and thoughtfulness by minimizing ability-related information and focusing on learning and not performance (Blumenfeld, et al., 1991).

STEM programs help promote student outcomes including increases in engagement with science, mathematics, and Information and Communication Technology learning and reasoning, student interest and enjoyment, and knowledge and confidence in STEM subjects (Tytler et al., 2016). Educators are helping students make connections to real-world problems by piquing student interest in STEM-related career fields. STEM programs can motivate students to strive for a STEM-based careers by supporting faculty with building student identity and establishing a sense of community (Chiu, Price, & Oyrahim, 2015).

In conclusion, this section shows that several researchers concluded that student engagement and motivation is created by the environment in which the students are placed.

**STEM Lessons In and Out of School**

This section of the literature review will discuss the importance of STEM learning experiences in and out of school. This section also indicates importance of how programs will help prepare students for college in STEM career areas. Afterschool Alliance (2011)
concluded that identifying trends and strengths within an afterschool programs can be helpful by increasing different areas within the school.

STEM learning is important at an early age, both in and out of school. Chittum, Jones, Akaline, and Schram (2017) found that after school programs can help facilitate students’ future career intentions and STEM fields by targeting student interest and motivation before the eighth grade. Chiu, Price, and Olrahim (2015), reviewed studies with STEM programs within schools to gain insight into how to make STEM programs successful for kindergarten to 8th grade. They found that collaboration, planning time, curriculum and instruction, professional development learning, communication, and technology support are all important factors when integrating STEM programs. In an evaluation of STEM programs at fourteen elementary schools in Australia, Tytler et al. (2016) found that a key strength in integrating STEM was partnerships and collaboration.

Programs outside of school can help children see that STEM education is more than just another class to finish. Having activities that show real-life implication of STEM can pull together the ideas presented in school and help to show how they benefit our society and even our world as a whole. An evaluation by After School Alliance (2011) studied an afterschool STEM program across the US to identify common trends and strengths that afterschool learning brought to STEM education. This evaluation showed the following: increased enrollment in STEM related courses, continued participation, increases in self-confidence, increasing of test scores, gains in knowledge about STEM careers, gains in computer and technology skills, and high rate of high school graduation.
College of Education-FSU (2019) concluded that teaching STEM in elementary grades opens the door for teachers and students to become tomorrow’s movers and shakers. Young children with a strong foundation in science, technology, engineering, and mathematics will go on to play an integral role in our nation’s global competitiveness and economic stability. Teachers can foster critical thinking through problem solving in elementary STEM education and provide students with an academic edge over the competition.

STEM taught early on can help mold a student and build the student’s interest into a STEM career field (College of Education-FSU, 2019). By teaching STEM in one’s classroom, students can become problem solvers as they investigate real world problems in the global sphere. Teachers can help by modeling the importance of STEM careers in the world that we live in today, along with teaching the students about future jobs that don’t yet exist. Likewise, Kids (2016) found that having activities that show real-life implications of STEM can pull together the ideas presented in school and help to show how they benefit our society and even our world as a whole. Children can see that what they are learning now is pertinent to their future and the future of the whole world, creating an interest often lacking when learning new concepts that do not seem to carry real-world application.

Cutuchase, Luhr, Nelson, Grandgenett, and Taprich (2016) found that, given a short timeframe for addressing the STEM deficit in the United States, programs that engage in structured, high-quality after school programming are effective. Programs that excite youth about STEM areas through consistent, mentored activities while also training STEM undergrads in career readiness skills have the best chance to make
immediate impact as well as establishing and maintaining a competitive pipeline in STEM. Accordingly, institutions that prepare STEM undergrads have implemented afterschool programming.

Cutuchase, Luhr, Nelson, Grandgenett, and Tapprich (2016) found that, the University of Nebraska in Omaha addressed the STEM needs by implementing an afterschool program called NE STEM 4U. Students from low-income schools, kindergarten through eighth grade, qualify to attend this program. This afterschool program is based on the dynamic of STEM learning activities.

The research highlighted in this section indicates how in- and out-of-school STEM programming is important. STEM integrated lessons are supported in an underlying way in this section. Much of the research supports after school programs in regards to STEM lessons, which can inform STEM success within a regular education classroom.

**Summary**

All of these resources provide support that STEM integrated lessons can increase the student participation within the classroom. Afterschool programs help facilitate student interest in STEM fields. STEM integrated lessons help motivate the students. STEM also helps with student success and content knowledge.

Much of the STEM research base focuses on secondary education. There seems to be fewer articles that pertain to STEM at the elementary school age. More research needs to be conducted to help support the topic of elementary STEM integrated lessons help increase student participation.
CHAPTER 3: METHODS

Overview

This chapter describes the methodology, including the data collection plan, data collection instruments, setting, and data analysis techniques used in this study. This is a qualitative action research study that took place in my classroom over the course of three months. The study addresses the following research questions:

1. What happens to the level of student participation, as measured by students via a daily participation rubric, during lessons with integrated STEM topics?

2. What happens to my teaching when I implement integrated STEM lessons in place of separate science, technology, engineering, and mathematics lessons?

This chapter describes my design for the research project, the context of the study, participants, data sources, data collection, and data analysis.

Context of the Study

This study was conducted at an elementary school in a rural school district located in Southeast Nebraska with a total population of 4187. In this school, 59.9 percent of students received free or reduced lunches at the time of this study. The elementary school has three third-grade classes, three fourth-grade classes, and four fifth-grade classes for a total of ten classroom teachers, one Title I teacher, and two special education teachers, plus paraprofessionals. Tables 1 and 2 summarize the demographics for the school, district, town, and county in which this study takes place.
Table 1

Demographic information about school and district

<table>
<thead>
<tr>
<th></th>
<th>Elementary School</th>
<th>District</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Membership</td>
<td>176</td>
<td>Below District total</td>
</tr>
<tr>
<td>Free &amp; Reduced</td>
<td>59.9%</td>
<td>Above District total</td>
</tr>
<tr>
<td>ELL</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>RACE/ETHNICITY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>American Indian/Alaskan</td>
<td>5</td>
<td>21</td>
</tr>
<tr>
<td>Native</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Hispanic</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Native Hawaiian or Other</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pacific Islander</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 or more</td>
<td>20</td>
<td>22</td>
</tr>
</tbody>
</table>

Table 2

Demographic information about town and county

<table>
<thead>
<tr>
<th></th>
<th>Town</th>
<th>County</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>4325</td>
<td>9531</td>
</tr>
<tr>
<td>American Indian</td>
<td>3.2%</td>
<td>2.3%</td>
</tr>
<tr>
<td>Asian</td>
<td>.5%</td>
<td>.15%</td>
</tr>
<tr>
<td>Black or African American</td>
<td>.3%</td>
<td>.19%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>1.5%</td>
<td>1.05%</td>
</tr>
<tr>
<td>White</td>
<td>93.1%</td>
<td>95.65%</td>
</tr>
<tr>
<td>Other</td>
<td>.5%</td>
<td>.22%</td>
</tr>
<tr>
<td>2 or more</td>
<td>2.5%</td>
<td>1.48%</td>
</tr>
</tbody>
</table>

Socioeconomic Status

<table>
<thead>
<tr>
<th></th>
<th>Town</th>
<th>County</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median Age</td>
<td>41.2</td>
<td>47.4</td>
</tr>
<tr>
<td>Median Household Income</td>
<td>$41,818</td>
<td>$45,929</td>
</tr>
<tr>
<td>Poverty Rate</td>
<td>24.9%</td>
<td>18%</td>
</tr>
<tr>
<td>Number of Employees</td>
<td>1,990</td>
<td>3,982</td>
</tr>
<tr>
<td>Median Property Value</td>
<td>$72,700</td>
<td>$71,300</td>
</tr>
</tbody>
</table>

This study took place in my fourth-grade elementary classroom of 18 students. I am the classroom teacher and I am also a part of the NebraskaSTEM program at the
University of Nebraska in Lincoln, an NSF Noyce Track 3 program for developing Master Teaching Fellows focused on rural elementary STEM education.

As the researcher, I have been teaching within this rural school district located in Southeast Nebraska for two years. I have a total of eight years of experience as a classroom teacher. I taught one year as a Title I assistant in math intervention, one year as the main math intervention teacher, four years teaching first grade, and two years teaching fourth grade. I have one year of experience with student research.

I drew from a variety of resources to create integrated STEM lessons for my classroom. Sources of STEM lessons used in this study included Teachers’ Pay Teachers, Rozzy Learning, and a lesson obtained from an educational technology conference. These lessons were selected for their content, which aligned with state science standards, and were adapted to meet the needs of my classroom and students. Prior to this study, I taught approximately one STEM lesson per month. During this research study, I taught two integrated STEM lessons per month for three months. These lessons and associated data collection are summarized in Table 3.

Table 3

<table>
<thead>
<tr>
<th>Name of STEM Lesson</th>
<th>Date taught</th>
<th>Data Collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>How does Air Move</td>
<td>2-7-19</td>
<td>Teacher Journal</td>
</tr>
<tr>
<td>Humidity in a Cup</td>
<td>2-14-19</td>
<td>Teacher Journal</td>
</tr>
<tr>
<td>Water Cycle</td>
<td>3-1-19</td>
<td>Teacher Journal, Pre and Post interviews, student reflection surveys</td>
</tr>
<tr>
<td>Hurricane Tower</td>
<td>3-13-19</td>
<td>Teacher Journal, Pre and Post interviews, student reflection surveys</td>
</tr>
</tbody>
</table>
Participants

Nine students from my fourth-grade classroom consented to participate in this study. Of those nine students, the study includes seven girls and two boys. There were three below average or struggling learners, two average learners, and four above average learners. Of the four above average learners two of those students are also identified as HAL students. Among the participating students, one is considered a life skills student, two are diagnosed Autism Spectrum Disorders, and two are diagnosed with Attention Hyperactive Deficit Disorder (ADHD). During collaborative work, participating students were grouped together so that data collection did not capture students who did not consent to participate. All of these students participated in individual interviews before and after each lesson.

Data Collection

Every time that I taught a STEM integrated lesson, I collected data, as shown in Table 3. I taught one integrated STEM lesson approximately every two weeks over three months and collected data from the nine students that consented to participate in this study. During the first two lessons, I only collected field notes in my teacher journal of observations involving those lessons. These notes were just for preliminary purposes to help refine the process for data collection throughout the study. In other lessons, I
collected student work samples, teacher journal writings, pre and post lesson interviews, and post lesson student self-reflection surveys.

**Data Sources**

The data that were collected included student work samples, student interviews, teacher journal, and student participation rubrics. See table 4 below.

Table 4

<table>
<thead>
<tr>
<th>Data Sources</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher Journal</td>
<td>The teacher took detailed notes of how the lesson went, and what took place during the lesson.</td>
</tr>
<tr>
<td>Student Work Samples</td>
<td>The teacher took pictures of student work to show the participation of different students work.</td>
</tr>
<tr>
<td>Pre-Lesson Student Interviews</td>
<td>The teacher asked each of the students a series of questions before the STEM lesson what taught to get prior knowledge.</td>
</tr>
<tr>
<td>Post-Lesson Student Interviews</td>
<td>The teacher asked the same questions as the pre-lesson questions to see if the information changed.</td>
</tr>
<tr>
<td>Student Self-Reflection Survey</td>
<td>Students determined how well they felt like they participated in each lesson.</td>
</tr>
</tbody>
</table>
Student Work Samples.

Throughout the study, I photographed student work during integrated STEM lessons and kept samples of student work, when possible. Data collection included examples from students’ work at the beginning of the study and at the end of the study to show how students increased the details within their work across the nine lessons.

Pre- and Post- Student Interviews

Student interviews were conducted before and after each STEM lesson. During these interviews, I asked students to rate their understanding of specific questions on a Likert-type scale from ranging from one to ten, with one being very little knowledge and ten meaning they felt like they fully understood the topic or the question. I developed the interview protocols, incorporating questions that aligned with the school science curriculum *Science a Closer Look (2011)*, content of the individual STEM activities, and state math and science standards. To conduct the interviews, I worked individually with each student, posing questions orally and recording their responses in writing. The interviews were administered before and after each lesson and I asked the same questions to check for perceptions of student knowledge growth. (Appendix A includes the interview protocols used in this study.)

Teacher Journal.

I maintained systematic teacher notes in a journal throughout this project. I would write down what happened before, during, and after the lesson. I observed students to see if they were participating within the lesson, but I also kept notes on student collaboration, if students needed guidance, and noted when students demonstrated creativity and
problem-solving skills within a given lesson. I also noted if students came back later on a different day with comments about the lesson.

**Student Participation Surveys.**

The student participation survey was a self-reflection of how well participants felt like they participated during the lesson. The survey used smiley faces to gauge students’ perceptions of participation. It was designed using a 3-point Likert-type scale. If students felt like they had good participation, they selected a smiling face, a straight face if they felt like they had partial participation, and a frowning face if they felt like they had little or no participation. (See Appendix B).

**Data Analysis**

Interviews from individual students were evaluated and compared. I evaluated the interviews by looking at each student individually to look for patterns within their answers, then I compared each student to all the other student responses. I also compared each student according to their learning level. Survey data were analyzed and represented using bar graphs. These data were analyzed by the researcher to see if there was any student perceived growth in content knowledge for each STEM integrated lesson. I represented all of the student responses in bar graphs in order to interpret the results better. Once they were in bar graphs, it was much easier to read. I was able to compare data by looking at each student individually from question to question, then I was able to compare each student to all the other students per question, and I was able to compare responses according to learning levels (Below, Average, High). The teacher journal was analyzed using a grounded theory approach to code the data and generate themes and patterns. First, the journals were openly coded, line-by-line. Open codes were combined
into axial codes, which were used during the second step of analyzing teacher journal data. Based on axial coding of the teacher journal and analysis of student interview and survey data, themes emerged relating to the two research questions.

**Summary**

Data was collected over the course of three months before and after each STEM integrated lesson. This data was in the form of a teacher journal, pre and post lesson interviews, and student self-reflection surveys. The teacher journal was written before, during, and after each lesson. The interviews were held in the regular education classroom before and after each lesson to see if there was any student perceived growth of content knowledge. Surveys were held in the general education classroom after each lesson.
CHAPTER 4: FINDINGS

Overview

In this portion of the research, I summarized findings from the data that I collected and analyzed. Findings of this study indicate that student participation improved after STEM integrated lessons were taught within my classroom. Some students did not show as much growth on a few questions, but on other questions they showed significant growth. This chapter is organized around what happened to student participation when STEM integrated lessons were taught within the classroom and by what happened to my own teaching during those lessons.

Research Question One: Student Participation during STEM Lessons

This section will show findings that address research question one: What happens to the level of student participation, as measured by students via a daily participation rubric, during lessons with integrated STEM topics? This is evidenced by the teacher journal and student surveys.

Throughout this study, I talked to my students about failure and explained to them that in STEM career fields, experts don’t always get things right the first time. Trial-and-error was a huge part of the process in our lessons. When some students got frustrated, another student would say, “let’s try it this way!” This helped teach the students that they needed to participate and persevere in the lesson and have a voice to help solve problems.

Findings from the teacher journal indicate that the level of student participation did in fact increase. Findings also indicate that all students showed a higher level of engagement during these particular lessons. Data sources indicated that I seemed to
monitor students more during these lessons in order to see if the students were taking part and understand the lesson concepts. Below I provided a few examples from the notebook.

- “I walked around and asked the students questions about their project, and they could answer and explain what was taking place or how they needed to fix what they were doing to make it better.”
- “Student 7 was unsure of what she needed to do so she was asking one of her partners to help her and explain to her what needed to be done.”
- “Student 1 helped another student and allowed them to participate when the other students in the group didn’t want to include her.”
- “I feel like because I am writing in my teacher journal I seem more aware of which students are participating and understanding the lesson and which students seem like they don’t fit in with the peers they are partnered with.”
- “This helps me realize that when teaching any lesson, not just STEM lessons that I need to improve on my monitoring like I do while I am conducting this study.”

The findings from the student self-reflection surveys suggests an increase in students’ perceptions of their participation from the beginning of the research to the end. (See Figures 1 and 2.) This finding supports my first research question of: What happens to the level of student participation, as measured by students via a daily participation rubric, during lessons with integrated STEM topics?

At the beginning, some students didn’t feel like they participated to their full potential but at the end of the research they all felt like they had good participation.
Figure 1. Student-perceived participation during the Water Cycle lesson
Figure 2. Student-perceived participation during the Irrigation System lesson

Below is provided a table summarizing survey findings from all of the lessons. Findings show that there was an increase in student-perceived participation between lessons three and lesson six. This finding shows support for research question one: What happens to the level of student participation, as measured by students via a daily participation rubric, during lessons with integrated STEM topics? Overall, students perceived that they demonstrated high levels of participation throughout the STEM integrated lessons.
Table 5

Summary of students’ self-perceptions of participation in STEM lessons

<table>
<thead>
<tr>
<th>Lesson Name</th>
<th>Good Participation</th>
<th>Fair Participation</th>
<th>Little or no Participation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>7</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Cycle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hurricane</td>
<td>7</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Tower</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rain</td>
<td>8</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Cloud</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrigation</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Station</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Research Question Two: Teaching during STEM Lessons

This section will show findings to support the second research question of: What happens to my teaching when I implement integrated STEM lessons in place of separate science, technology, engineering, and mathematics lessons? This is evidenced by student work samples and student interviews.

Analysis of student work samples suggest that some students participated more in reflection towards the end of the three months than at the beginning of the three months. Work samples were collected in lessons three through six. Some students were unsure at
the beginning how to make notes within their journals. Towards the end of this research, students were more descriptive and detailed within their journals.

Below in Figure 3 and Figure 4, are samples from two of the students at the beginning of teaching STEM integrated lessons, during the third STEM lesson. Figures 5 and 6 show samples from the same students at the end of teaching STEM integrated lessons, during the sixth STEM lesson. Findings indicate that both students showed increase within their note-taking and provided more detail within the drawing of the pictures that were included in those notes. The increasing amount of details provide more evidence of students’ level of understanding at the end of STEM integrated lessons.
Figure 3. Student A work sample from Water Cycle lesson
Figure 4. Student B work sample from Water Cycle lesson
Figure 5. Student A work sample from Irrigation System lesson

Irrigation System

Materials: foam caps, plastic tubes, and a cup full of water.
Findings from the interview questions vary from question to question and lesson to lesson. All students show self-perceived growth in their understanding of the content from beginning to end. However, occasionally a student did have the same perception pre and post lesson. Overall, the student-perceived growth tended to increase from pre to post lesson. Students’ perceptions of their growth during the lessons suggest that my teaching of the lessons were effective ways to engage students in learning STEM. This finding
helps answer my second research question of: What happens to my teaching when I implement integrated STEM lessons in place of separate science, technology, engineering, and mathematics lessons?

Below, are Figures 7 through 10, which show student perceived growth for STEM lessons three through six. Figure 7 is an example from Lesson Three *The Water Cycle*. Figure 8 is an example from Lesson Four *Hurricane Tower*. Figure 9 is an example from Lesson Five *Rain Cloud*. Figure 10 is an example from Lesson Six *Irrigation System*. All of these Figures show that most students had an increase in their perceptions of STEM knowledge from the beginning of each of these lessons to the end of each of these lessons.

*Figure 7. Student-perceived growth for the Water Cycle lesson question one (How well do you think you understand the Water Cycle?)*
Figure 8. Student-perceived growth for the Hurricane Tower lesson, question four (How well would you be prepared for a Hurricane if you lived near the ocean?)

Figure 9. Student-perceived growth for the Rain Cloud lesson, question one (How well do you understand how a cloud produces rain?)
I chose to include the following questions to include in this report because they are representative of what was found throughout the whole study. The questions that I included also had good STEM content knowledge verses a verity of unrelated questions that I asked these students. The findings were consistent throughout the study. According to level of student and lesson topic.

Below Table 5 shows each the mean of students’ responses for pre and post self-perceived student growth for each lesson. The scale for all but the last question was from 1 to 10, with 1 representing the least amount of knowledge and 10 indicating full understanding of the question and content. The last question in the Irrigation System lesson elicited a yes or no response, rather than a rating.

*Figure 10. Student-perceived growth for the Irrigation System lesson, question two (Do you know what irrigation systems are used for?)*
Table 6

Mean of students’ responses to pre- and post-interview questions on scale of 1-10

<table>
<thead>
<tr>
<th>Question</th>
<th>Pre-lesson mean</th>
<th>Post-lesson mean</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water Cycle</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How well do you think you understand the water cycle?</td>
<td>3.2</td>
<td>7.8</td>
<td>+4.6</td>
</tr>
<tr>
<td>How good are you at group projects?</td>
<td>3.5</td>
<td>7.1</td>
<td>+3.6</td>
</tr>
<tr>
<td>How well do you keep notes during class?</td>
<td>2.3</td>
<td>5.4</td>
<td>+3.1</td>
</tr>
<tr>
<td>Do you feel like notes you take during class prepare you for an exam?</td>
<td>2.3</td>
<td>6.3</td>
<td>+4.0</td>
</tr>
<tr>
<td><strong>Hurricane Tower Challenge</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you understand how hurricanes form?</td>
<td>4.1</td>
<td>6.1</td>
<td>+2.0</td>
</tr>
<tr>
<td>How violent are hurricanes on Earth?</td>
<td>6.6</td>
<td>8.9</td>
<td>+2.3</td>
</tr>
<tr>
<td>How well do you understand hydrosphere, atmosphere, biosphere, and geosphere?</td>
<td>2.0</td>
<td>5.0</td>
<td>+3.0</td>
</tr>
<tr>
<td>How well would you be prepared for a hurricane if you lived near the ocean?</td>
<td>3.6</td>
<td>7.1</td>
<td>+3.5</td>
</tr>
<tr>
<td><strong>Rain Cloud</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How well do you understand how a cloud produces rain?</td>
<td>2.3</td>
<td>4.9</td>
<td>+2.6</td>
</tr>
<tr>
<td>Do you know what dense means?</td>
<td>5.6</td>
<td>6.3</td>
<td>+0.7</td>
</tr>
<tr>
<td><strong>Irrigation System</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you know what an irrigation system is?</td>
<td>3.0</td>
<td>9.3</td>
<td>+6.3</td>
</tr>
<tr>
<td>Do you know what irrigation systems are used for?</td>
<td>2.3</td>
<td>6.3</td>
<td>+4.0</td>
</tr>
<tr>
<td>Can irrigation systems be used for more than one reason? (YES responses)</td>
<td>3.0</td>
<td>9.0</td>
<td>+6</td>
</tr>
<tr>
<td>Can irrigation systems be used for more than one reason? (NO responses)</td>
<td>6.0</td>
<td>0.0</td>
<td>-6</td>
</tr>
</tbody>
</table>
Summary

Findings from this study indicate that both research questions were supported and that student participation increased during this study. Teacher journal notes and student self-perceived growth surveys supported research question one. Student work samples and pre and post interviews helped support research question two of how teaching changes when STEM integrated lessons are taught within my classroom.
CHAPTER 5: DISCUSSION AND CONCLUSIONS

Overview

This research suggests that students’ perceptions of participation increased during STEM integrated lessons. This chapter includes discussion of the study’s findings, connecting these findings with what is already known from prior research. Implications for my own practice and other STEM education stakeholders are discussed. The chapter concludes with limitations of this study and ideas for future research relating to student participation in STEM integrated lessons.

Discussion

In this study, fourth grade students were introduced to STEM and their perceptions of participation increased throughout a three-month period. This is consistent with Chiu, Price, and Oyrahim (2015) and Blumenfeld, et.al, (1991) who found that introducing STEM at a young age can help encourage and motivate students to participate. Furthermore, students perceived that their knowledge of STEM concepts grew during the STEM integrated lessons in this study. Increased perceptions of participation and understanding suggest that students developed confidence with STEM throughout this study. This aligns with research from Tytler et al., (2016) and Afterschool Alliance (2011) who found increases in self-confidence throughout teaching STEM integrated lessons.

Blumenfeld et al. (1991) found that project-based education requires active engagement of students’ effort over an extended period of time. To gauge students’ active engagement and effort over an extended period of time, the methods that I chose for this study included a variety of data sources over multiple lessons. Analysis of student work
before and after the lessons yielded important insight as to whether students were actively engaged or if they were just trying to get through the class. The student interviews indicated students’ perceived growth within each lesson, providing their self-assessments of whether they honestly got a grasp for what they did or did not learn throughout the lessons in this study.

Pre- and post-interviews and participation surveys all three indicated student-perceived growth; and, the student work samples were a good indicator for the teacher to conclude that there was growth within the journal entries from beginning lessons to ending lessons. Effective STEM programs help promote student outcomes including: increases in engagement with STEM learning and reasoning, student interest and enjoyment, and knowledge and confidence in STEM subjects (Tytler et al., 2016). Findings from this study indicate that the STEM integrated lessons were indeed effective, according to the criteria outlined by Tytler et al. (2016).

Findings from this study have important implications for elementary school teachers and administrators. For me personally, if I came up with a great idea for our school and the Superintendent wanted evidence that STEM lessons are important, this study provides data to help support my claims that STEM instruction and resources are important for students. In school districts, money and materials are limited and administrators must make decisions about allocating resources for STEM education. This study within a fourth-grade rural classroom adds to existing research that supports the importance of STEM for building student participation and knowledge.

This study is also insightful for STEM education researchers. There is a dearth of studies that relate to STEM at the elementary level, particularly in rural contexts, and this
action research study may be beneficial for others who wish to better understand potential benefits of STEM education and integrated approaches. Chittum, Jones, Akaline, and Schram (2017) found that after school programs can help facilitate students’ future career intentions and STEM fields by targeting student interest and motivation before the eighth grade. While this study did not examine students’ future career intentions, it did provide opportunities for fourth-grade students to develop interest and motivation in STEM at a young age within a school setting. College of Education (2019) concluded STEM taught early on can help mold a student and build the student’s interest in STEM career fields.

Berry, Chalmers, and Chandra (2012) found that project-based learning (PBL) in the STEM content areas helped foster student-directed inquiry and was effective in increasing student motivation. PBL has also been shown to be effective in increasing motivation and higher order thinking skills. Using PBL projects that integrate STEM fosters a student-directed inquiry and has been effective in increasing student motivation and problem-solving skills (Blumenfeld, Soloway, Marx, Krajcik, Guzdail, & Palincsar, 1991). In this study, I created STEM learning opportunities that promoted motivation to learn, encouraged inquiry, risk taking, and thoughtfulness by minimizing ability-related information and focusing on learning and not performance (Blumenfeld, et al., 1991). Doing so resulted in self-perceived growth and participation, as well as increases in students’ self-perceived STEM content knowledge.

Conclusions

In this study I found that STEM integrated lessons can be beneficial for student engagement and participation in STEM learning. Students that did not normally give input to group lessons or were not previously interested in STEM subjects seemed to
come to life during the STEM integrated lessons. The lessons helped and PBL approach them feel like they were a part of something. When they felt like there was no right or wrong way to do something, they had a better attitude to engage and give input to their groups. Research findings in this study showed that students’ participation positively changed during STEM integrated lessons.

Next school year when teaching STEM integrated lessons, I will teach similar lessons, but I will come up with a better way to gage student participation. I believe it would be important as the teacher or the researcher to indicate that participation instead of it being student self-perceived participation.

There are a number of ways I will share my study with others. First, I find it important to share this study with my administration. I feel like conducting a study such as this one can help provide important information that can help our school district as a whole instead of just my individual classroom. This study will provide information that STEM integrated lessons help increase student participation. I will share this study with my fellow teachers. Maybe this study will provide them with information and help motivate them to teach STEM integrated lessons in their own classrooms, and it will allow them to see some of the benefits of STEM integrated lessons. I will reach out to my other NebraskaSTEM fellows and collaborate about my specific STEM related topic and come up with a plan to present our similar findings at state conferences. This will allow other educators within our state to benefit from our findings. This study will also be available as a journal article for other teachers and researchers on STEM topics. Another way that I will share this research is with ESU. I will share this article with ESU 4 and
give them permission to share my findings with other educators that they come in contact with that are wanting to know more about the benefits of STEM integrated lessons.

It is important to give out this information because it does provide good findings, and it allows others to understand the importance of STEM.

**Limitations**

Some limitations for this study that could have played an effect on the outcome would have been weather, an unforeseeable accident, special needs, end of the year state test, rural school district, and data sources. During the time period that this study was conducted our community experienced several weeks of inclement weather. Where we may not have been out 3 consecutive weeks, we were out quite a few days. This could have affected the results of the study due to timing of the lessons and the fact that we had to omit some of the different STEM lessons that the students were looking forward to participating in. During that same time period I as the researcher had an unforeseeable accident and resulted in canceling a very exciting lesson. This was a limitation of the study because the students’ felt let down, so it affected their attitude across the board.

This study also included students with diagnosed special needs for whom outcomes might have been different from students without special needs. End of the year state testing was also scheduled in the middle of this study so it hindered the results. If more time would have been allowed to conduct this study and over a longer period of time results may have been more consistent and accurate.

This study was conducted in a smaller rural school district in a single classroom. Larger scaled studies in a variety of settings may also indicate a different outcome.

Another limitation for this study are my data sources. My study was on student-self
perceived participation, whereas other data sources may indicate different results. Students may want their teacher to think of them as a good student, so the student results may not be accurate to what they truly believe. It is possible that student interview and survey responses were skewed in order to give a good impression to the teacher-researcher.

**Future Research**

Further research should explore the impact of STEM integrated lessons on participation among students at a variety of age levels. There is not a lot of research that has been conducted over this topic and it would be very beneficial to see more researchers explore this particular topic. It would be important to see more studies conducted for teachers and administrators who are unsure about STEM and who have not bought into the idea of teaching integrated STEM.

Other future research that would be helpful for this study would be a wider variety to settings and larger sample sizes. Studies that involve a deeper look at students’ knowledge would also be beneficial for this type of research. This study involved student self-perceived participation growth, but that did not allow the researcher to know if the students fully understood the questions or the content. Future research should examine not only students’ own perceptions of their participation and knowledge in STEM, but also include more valid, reliable measures of student participation and STEM knowledge to determine changes when STEM integrated lessons are implemented.
REFERENCES


Alumbaugh, K. M. (2015). The perceptions of elementary STEM schools in Missouri (Published doctoral dissertation). Lindenwood University, St. Charles, Missouri.


school STEM education at the whole-school level, presented at NARST Annual Conference, Chicago, IL, 2015: Museum of Science + Industry Chicago Publisher.


APPENDIX A: Interview Questions

Interview questions

Lesson one - Water Cycle

Question one: How well do you think you understand the water cycle on a scale of one to ten, with one being that you don’t understand that well and then that you are confident that you know and understand it?

Question two: On a scale of one to ten, how good are you at group projects?

Question three: How well do you keep notes during class?

Question four: Do you feel like notes you take during class prepare you for an assessment?

Lesson 2 - Hurricane Tower Challenge (Using the one to ten scale that was used in previous lessons)

Question one: Do you understand how hurricanes form?

Question two: How violent are hurricanes on Earth?

Question three: How well do you understand hydrosphere, atmosphere, biosphere, and geosphere?

Question four: How well would you be prepared for a hurricane if you lived near the ocean?

Lesson three - Rain Cloud (using the same scale from one to ten)

Question one: How well do you understand how a cloud produces rain?

Question two: Do you know what dense means?
Lesson Four-Irrigation System (using the same scale from one to ten)

Question one: Do you know what an irrigation system is?

Question two: Do you know what irrigation systems are used for?

Question three: Can irrigation systems be used for more than one reason? (This is a yes or no question vs. on a scale of one to ten)
## Appendix B: Student Self-Reflection Survey

<table>
<thead>
<tr>
<th>Smiley Face</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>☺</td>
<td>Good Participation</td>
</tr>
<tr>
<td>😐</td>
<td>Fair Participation</td>
</tr>
<tr>
<td>😞</td>
<td>Little or No Participation</td>
</tr>
</tbody>
</table>