Summer 2018

How Can Student Learning Be Improved Through Project Based Curriculum That Gives Access To All Students?

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HOW CAN STUDENT LEARNING BE IMPROVED THROUGH PROJECT BASED CURRICULUM THAT GIVES ACCESS TO ALL STUDENTS

by

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A capstone submitted in partial fulfillment of the

requirements for the degree of Master of Arts in Teaching.

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Saint Paul, Minnesota

Summer, 2018

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CHAPTER ONE

Introduction

This research paper will investigate the following question when writing curriculum for my 10th grade Geometry course, How can student learning be improved by creating project based curriculum that gives access to all students? I have had many learning by doing experiences that have helped me be successful. I believe that it is the way we learn best. I hope to look at project based curriculum and see how to answer the above question.

Background

Growing up, I would watch others perform tasks and then assume that I too could complete those same tasks. I would watch my father, a plumber, fix broken toilets or burst pipes. Later in life, when living on my own, I tried to complete these same tasks. Because I had not practiced alongside my father, I could not fix my toilet or burst pipe without seeking out help from him or other sources.There was a false sense of knowing how to do something. I thought I could do something I could not. In order to fix a broken drain I had to do it myself. I struggled through the process of unscrewing the trap from the bottom of the sink. After all my errors that were made while fixing the drain, I learned how to unclog and fix a drain. By fixing the drain myself and making mistakes in the process, I had more skills and ability to fix the drain than just observing someone else do it.

I have always learned best by doing and applying the knowledge that I have read about and seen done by doing it myself. This is why when I started graduate school and began the credentialing process, I felt it important to be in the classroom as soon as possible. I became a substitute teacher. I was in the classroom. I was able to apply the theories and knowledge that I was gaining to the work I was doing that was relevant and important to my everyday life. When I learned about standing at the door and greeting students, I applied this technique the next day. I could not greet the students by name, but I did say hi to everyone as they came in. This improved the attention and the focus I received from the students. I learned a new idea and put it into action.

Teachers also student teach before they become licensed. During my time as a student teacher the same thing happened as with the plumbing and the subbing. I learned something new about teaching and learning. I watched my cooperating teacher teach. I had read and learned in class what to do. I did not just watch for a couple of days and then teach all the time alone and all day. Each piece of the teaching was broken up for me to try and learn. I was assisting at first, learning how to be in the classroom with the same kids every day, an experience I did not have subbing. From there I went on to plan a single lesson, then the week, and finally I was teaching the full day every day. I was able to learn how to teach by doing. The steady increase in responsibility made it easier for me to succeed.

My first teaching position was as a math teacher at an urban high school. As any first year teacher I was excited to get started and to help the students learn. I knew the theories about how students learn math: that students learn best by doing, not memorizing. Students need to make mistakes. I did all of these things when I learned how to teach and fix things around the house. What I realized is that when I got in the classroom I felt the most comfortable teaching math the way I was taught. I learned mathematics in my high school classroom by memorizing a set of processes but not really understanding what I was doing or how to really use them. By simply watching my teacher complete a problem I was never able to understand how to use the process outside the context of solving the problem. It gave me a false sense of confidence. Just like when I didn't really know how to fix the pipe until I did it myself and applied the knowledge that I had.

In my first year of teaching mathematics, I tried to have my students participate in some project based learning. One example is in a unit I taught on linear regression. Students learned how to look at a scatter plot, enter the data set into their calculators and create a linear regression. Students learned how to look at a graph and draw a line of best fit. They also learn the vocabulary of positive or negative correlation. They learned about the strength of the correlation. At the end of the unit students could use the words to talk about scatter plots, they could input the data into the calculator and have it come up with a line of best fit. Students were then asked to look at data from the United Nations country data and see if there were correlations between two sets of data. An example would be population growth vs GDP. I collaborated with our geography teacher to align our units. Students were given three days to pick two data sets to make a scatter plot and create a line of best fit and talk about its correlation. The students were immediately overwhelmed by the amount they had to do. They had learned about it before and most had demonstrated their ability to do the mathematical skill needed. The project was a disaster: even if students completed it, a lot of their work did not make sense. I was trying to execute learning by doing, but it was too much for the students all at once.

My interest in creating curriculum for project-based learning stems from this experience. Writing curriculum for project based learning will help to break up the project into smaller pieces. This will improve student learning. I will work on writing a curriculum that helps guide students through a project that will hopefully lead to greater success. This will impact student learning and achievement the most. I want students to be able to leave school college and career ready. They do not need to remember how to solve a quadratic equation in their day to day life, but knowing how to look at a project and break up the pieces into manageable chunks is a life skill.

The impact of this curriculum writing study will help many people. Lessons are co-planned and taught at the school district in which I work. Being able to do this work will not only impact my students' learning abilities it will help my students become better learners and scholars. It will help improve the practices of my colleagues and myself. This curriculum will also be aligned to district wide curriculum and could be used in many area high schools. I strive to be a lifelong learner. Creating the curriculum will allow me to continue learning. I aim to create a way of teaching mathematics that is accessible to all students, leading to improved learning overall.

Summary

I have had many experiences in my life where learning is done best by trial and error. Sometimes projects are difficult enough that they need to be broken down into smaller pieces. I learned this through plumbing, subbing, and teaching. This curriculum that I write will guide students to learn mathematics by doing the work themselves. It will allow students to develop a greater understanding of mathematics and problem solving. The curriculum will not only give fellow teachers who are looking for improved teaching methods a new option, but will also be a way to improve my own teaching practice.

What is the best way for students to learn from this same trial and error method that I experienced while growing up? The method of project-based learning will be looked at to see how people have implemented this method in the past and what are some of the effects that have come from it. This will help answer the guiding question: How can student learning be improved by creating project based curriculum that gives access to all students?

CHAPTER TWO

Introduction

How can student learning be improved through project based curriculum that gives access to all students? The literature and previous research done on the topic have looked at three major ideas. Those topics can be phrased in three questions. First is the question, what is project based-learning? The second question is, what are the standards that needed to be achieved by students in order to determine their learning? The final question is, what does the literature say about the effects of project-based learning on student achievement? By answering these three questions from the literature a better understanding of the essential question of the project will be obtained.

Project-Based and Problem-Based Learning

Problem-based learning and project-based learning are ideas on how to engage students in learning (Karaçalli & Korur, 2014). They are a way to teach and help students learn. As learning tools they are similar, but there are distinct differences. They have been used in many subjects, including science, math and engineering. Both are designed to have students develop their own understanding of the material (Han, Capraro, & Capraro, 2015). The role of the teacher is also changed from more traditional forms of teaching and learning (Dole, Bloom, & Kowalske, 2016).

In project-based learning, students need to develop their own understanding by constructing the knowledge instead of following what a teacher says about something and believing it to be true (Dole et al., 2016). Project and problem-based learning is a way to construct this knowledge and understanding. Students take charge of their own learning and develop understanding through problem solving and social interactions. When students do this they are solving a problem, answering a question that they see relevant to their own lives. When students see this relevance they see the reason why they are learning what they are learning (Cogger & Miley, 2012).

There are two slightly different ways for students to construct this knowledge. One is by being given a problem at the beginning and ask to solve it, problem-based learning. Then there is project based learning, where students are given a project to construct the understanding (Dole, Bloom, & Kowalske, 2016). Problem based learning is usually more open-ended and can require a greater level of student involvement in the learning (Cogger & Miley, 2012).Where project based learning is a little more structured in the requirements and end results for the students. (Cogger & Miley, 2012).

Role of the teacher. What is the role of the teacher when looking at project based learning? In project-based learning, the teacher is now the facilitator of the learning and no longer the giver of the knowledge (Dole et al., 2016). The teacher creates an environment in which students are able to construct their understanding. When teachers want to implement project based learning, "Providing guidance, setting high expectations, and monitoring the progress of groups is essential for success when implementing project based learning" (Dole et al., 2016).

Student learning through project-based curriculum. How can student learning be improved through project based curriculum that gives access to all students? Learning is improved because students are creating their own understanding and therefore develop an understanding that is unique to them (Han et al., 2015) Project based learning can also give access to students because of the structure that the teacher provides (Larmer & Mergendoller, 2010). The goal of project and problem based learning is for students to create their own understanding and knowledge based on a project or problem (Larmer & Mergendoller, 2010). When students are given a project to work on or a problem to solve what are the best ways for a teacher to help students reach that goal?

Project-Based Learning Design

Designing and creating a project based learning environment for students is crucial so that students can develop the understanding that is desired and required through state and district standards. Larmer and Mergendoller (2010) wrote *7 Essentials for Project-Based Learning.* The seven essentials are as follows; A Need to Know, A Driving Question, Student Voice and Choice, 21st Century Skills, Inquiry and Innovation, Feedback and Revision, and A Publicly Presented Project (Larmer & Mergendoller, 2010).

"A Need to Know" is the idea that the teacher should start the introduction to the project with an "Entry Event" (Larmer & Mergendoller, 2010). The entry event should get students to be interested and engaged in what they are learning. Without the interest, "Many students find school work meaningless because they don't perceive a need to know what they're being taught" (Larmer & Mergendoller, 2010, p. 35). When students have a desire to ask questions and are curious about what they are going to learn, they understand why they are learning it (Cogger & Miley, 2012). Students who see the reason to learn what they are learning usually develop a longer lasting understanding of the concept. (Larmer, 2014). When a problem is situated within a real-life context it "brings both vividness and authenticity to students' learning" (Tobias, Campbell &Greco, 2015) which is another way to ensure that students are actively engaged in their learning.

Curiosity of the entry event then leads to the second essential for project based learning, "A Driving Question" (Larmer & Mergendoller, 2010). "Generative questions lie at the heart of project-based learning and frame students' learning throughout an entire project" (Tobias et al., 2015). The teacher generated driving question should be one that is "novel, complex, and open-ended" (Larmer 2016). This question is like the thesis statement of a paper. (Larmer & Mergendoller, 2010, p. 36). When there is no strong essential questions students are left without a direction or understanding of what they should learn. At this point students should have a curiosity for a subject and a deeper question to pursue.

The next important part of project-based learning then is to ensure that students have choice and voice (Larmer & Mergendoller, 2010). Many authors have made this point. Students who are given choice within their project based learning "exhibit increased motivation by planning their learning and organizing their own research in solving real-world problems" (Dole, Bloom & Kowalske, 2016). There can be a varying range of student choice depending on teacher style. It can range from choosing a topic from the essential question to having students control even the driving question (Larmer & Mergendoller, 2010).

Curiosity, an essential question, and student choice have set the stage for students to develop "21st Century Skills" (Larmer & Mergendoller, 2010). 21st Century Skills are a mix of soft skills that are needed to be successful in the real-world. Projects allow a teacher to help develop the skills of collaboration, critical and analytical thinking, and problem solving (Tobias et al., 2015). Project based learning also helps students develop the skills in framing, investigating, and solving problems (Dole, Bloom, & Kowalski, 2016). The teamwork that is brought by project based learning helps develop the skills of communication and collaboration (Larmer & Mergendoller, 2010).

Once students have the Essential Question, and are developing 21st century skills through collaboration is when the “Inquiry and Innovation” happen (Larmer & Mergendoller, 2010). Students need to generate questions together that expand on the essential question. Students should keep generating questions throughout the project. As the students gain understanding and knowledge and one area it should lead to more questions and more inquiry (Larmer & Mergendoller, 2010). “A classroom culture should value questioning, hypothesizing, and openness to new ideas and perspectives” (Larmer & Mergendoller, 2010, p. 37).

“Feedback and Revision” are important to the learning process. The teacher should formalize the feedback process through rubrics and teaching students how to critique each other's work. (Larmer & Mergendoller, 2010). This will make sure that students keep asking the questions that will help them explore the topic in more depth Constant questioning will ensure that critical thinking skills continue to be developed. Have students asked the questions that need to be asked? Does another student see a different question that could be asked?

In the end make sure that the end result is “a publicly presented product” (Larmer & Mergendoller, 2010). This ties a lot of the ideas together from the essential seven parts.

A student who is curious about their project and has had the inquiry will want to share their ideas. This also helps students to care more about the quality of the project when it is shared with more than just their teacher (Larmer & Mergendoller, 2010).

How can student learning be improved through project based curriculum that gives access to all students? The effects on student learning from designing an effective project based learning system teach students 21st century skills. It allows students to develop a deep and lasting understanding of the subject they studied and inquired about. All of these skills are good but require a well-planned execution of a project-based learning curriculum. What are some of the challenges that come with implementing and designing a project-based learning curriculum that does this?

Challenges of Project-Based Learning

Intentional planning of the curriculum and the project based learning experience will make a successful project-based learning experience for students. There are some choices that should be considered when beginning to plan a PBL unit.Teachers shouldn't structure the entire class as all projects all the time (Larmer, 2016). Another obstacle is that most teachers did not learn in a project-based learning environment and need to look at their practice before deciding if this teaching style will work for them (Dole, Bloom, & Kowalske, 2016). Teachers also may feel they don't have the freedom to engage in the instructional creativity that project based learning uses. They feel bound or required to use texts, lessons, and standards created or required by their state or district (Tobias et al., 2015).

Beginning teachers who are looking at starting project-based learning should start small and work from there. Larmer suggests maybe only 1-2 small projects a semester to help students develop the skills necessary. (Larmer, 2016). Project-based learning is not for all skills, basic math skills can be taught in a non-project-based why while making connections to project based work (Larmer, 2016).

Dole et al. (2010) talk about skills that teachers need to have when teaching in a project-based environment. With project based learning the role of the teacher and the student have changed. As stated earlier, the teacher changes from the giver of knowledge to the facilitator of knowledge. The student constructs the knowledge. They do not just absorb what the teacher says. The classroom environment has to be one where both student and teacher feel comfortable asking questions when implementing the project and the teacher needs to have a "tolerance for ambiguity and flexibility" (Dole et al., 2016). Last, the teacher needs to realize how the pedagogy fits within the parameters set by outside forces, such as state and district standards. (Dole et al., 2016).

Project-based learning is not separate from standards based teaching. Project-based learning should be central to the curriculum that develops a constructive investigation that helps students understand a key idea or major understanding of a subject (Tobias et al., 2015). Projects should be designed so that the skills needed when implementing the project help students develop a deeper understanding of the content and standards (Larmer & Mergendoller, 2010).

How can student learning be improved through project based curriculum that gives access to all students? Looking at the challenges to implementation and planning of project-based learning is important to understand how to maximize the effects on student learning. If the challenges are known then most or some can be avoided. For access to all students Larmer (2016) argues that, “Project-based learning works for all students and should not be reserved for special groups or those who lucked out by getting a certain teacher.” (p.). Multiple authors stated that standards were a challenge to project-based learning.

Standards-Based Learning

What is standards-based learning and how does it differ from project-based learning? From the literature there is a suggestion that project-based learning is a part of standards based-learning. This conclusion from Huetinck & Munshin (2008) lists common components of what is found in standards based teaching:

- Students frequently working in small groups during class
- Students working on long-range projects or investigations
- Students having ready access to mathematical tools and technologies
- Students presenting and discussing problem solutions
- Students writing solutions that show their reasoning processes
- Students participating in ongoing assessment activities, including self-assessment (p.10).

A lot of these things we can see present in what Larmer says is involved in project-based learning.

What are some of the standards that mathematical teaching is based upon? According to *Adding it up: Helping Students Learn Mathematics* by Kilpatrick, Swafford, and Findell (2001) there are five different strands of mathematical proficiencies and outcomes to demonstrate student proficiency in each strand.

The first strand is "*conceptual understanding*—comprehension of mathematical concepts, operations, and relations" (Kilpatrick, Swafford, & Findell, 2001, p. 117). If a student is to demonstrate proficiency in this strand they will able to four things. The student will be able to connect to previous learning, understand the purpose of the learning, have a deeper understanding of the learning, and be able to reconstruct things easier (Kilpatrick et al., 2001).

The second strand is "*procedural fluency*—skill in carrying out procedures flexibly, accurately, efficiently, and appropriately" (Kilpatrick et al., 2001, p.117). A student who can demonstrate proficiency in this strand can compute things but with an understanding of why and what they are doing, solve problems in efficient and productive ways, and be able to move between problem solving methods (Kilpatrick et al., 2001).

The third strand is "*strategic competence*—ability to formulate, represent, and solve mathematical problems" (Kilpatrick, Swafford, & Findell, 2001, p.117). Proficiency in this strand is a student who can pick and choose how they want to solve a problem depending on the context while choosing an effective and efficient way to solve it. The student will also be able to start a problem or at least attempt to solve it with a strategy that they know. (Kilpatrick et al., 2001).

The fourth strand is "*adaptive reasoning*—capacity for logical thought, reflection, explanation, and justification (Kilpatrick et al., 2001, p.117). Proficient students will be able to interact with the concepts and ideas that they learn and are able to explain how and why they got to where they did. They will be able to take a concept used to solve one problem and apply a similar idea to another. Students will also be able to explain how and why a concept or model works in a mathematical situation (Kilpatrick et al., 2001).

The final strand is "*productive disposition*—habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy (Kilpatrick et al., 2001, p.117). The proficiency of this strand can be demonstrated by a student who understands that math is worth the pursuit and that they can do it. This proficient student will continue to work on a problem and not give up until they have solved it and not give up. Struggling will feel comfortable to a proficient student when they try to solve a problem. (Kilpatrick et al., 2001).

The National Council of Mathematics Teachers (NCTM) published a book called the *Principles and Standards for School Mathematics.* In this book they listed five process standards for what students when students are learning mathematics. The five process standards are as follows; problem solving, reasoning and proof, communication, connections, and representation (NCTM, 2000). Problem solving is based on how does a student see the world? They should be able to think about problems with a mathematical mindset. They should be able to find multiple strategies to solve problems and they should be able to reflect on how and why they solved the problem (NCTM, 2000). Reasoning and proof is based on the idea that the best way to engage students in what they are learning is to ask questions about what they are doing such as; Will this always work? Can you find a situation where it doesn't? Students should be able to explain things in their own words, but understand that they may not have all of the mathematical knowledge to construct a formal proof (NCTM, 2000). Communication comes from the idea that students should talk in the language of math. By the time they leave high school they should be able to communicate about their procedures and hold discussions about why they do it. Do other students understand what the student is saying? Mathematical writing should also be a focus (NCTM, 2000). Connection is the understanding that mathematics is an interwoven field of study. Students should be able to connect the different ideas that they have learned in geometry to algebra to trigonometry. They should be able to make the connections to what they have learned to the real world (NCTM, 2000). Finally there is representation. Mathematics is a set of symbols and conventions that display meaning. Students should be able to represent their thoughts and their ideas in their own ways but learn and understand the conventions so that their work may be understood by a larger audience (NCTM, 2000).

How can student learning be improved through project based curriculum that gives access to all students? Through project based learning students will still be held to the same standards that mathematics curriculum has been based on. The focus on the 21st century skills as an essential part from Larmer (2016) along with the actions laid out by Huetnick and Munshin (2008). There are some standards that need to be looked at and how they fit into project-based learning. The process standards from the National Council of Mathematics Teachers and the proficiency strands from Kilpatrick, Swafford, and Findell (2001) are a way to understand how students interact and understand mathematics. They are the basis for developing the understanding of mathematics. It will help answer the question by giving a base to what students need to learn and to measure how it has been improved. There are also more specific standards required by the state and local district.

State and District Standards

There are requirements in specific states and districts to what the students need to learn. The state that the curriculum is being developed for has their own set of standards and does not use the common core standards. The standards are broken up into 9-12th grade and then are broken up into subjects. The 9-12 Geometry standards are in Appendix A (MDE, 2007).

The District in which this study and curriculum is taking place is also based on a district wide pacing guide for Geometry. From this guide each unit is broken down into learning targets based on state standards. This course and unit guide with learning standards can be found in Appendix B (MPS, 2017).

How can student learning be improved through project based curriculum that gives access to all students? The state and district standards are the expectations of what students need to learn. In order to measure what student learning has occured, one must first deeply understand the core learnings of the standards.

Student Achievement

Jo Boaler's (2006) article, *Urban Success: a Multidimensional Mathematics Approach with Equitable Outcomes*, looked at a high school who implemented problem based learning, which from earlier literature is similar to project based. The high school used a reform-oriented approach to mathematics instruction where groups of students worked on challenging rich problems (Boaler 2006). Students were engaging in the complex group tasks and problem solving that the teacher had planned in advanced. The results were that the students who participated in these classes were progressing to higher level of mathematics by the end of their high school career and enjoyed the math as well (Boaler, 2006).

Another study done on the effects of project based learning was by Karaçalli and Korur (2014). This was a science based project where the students looked at a project involving electricity. The authors measured two things; Student knowledge and student retention of that knowledge. The findings were that there was a 30% increase in student knowledge based on a pre and posttest and there was a 24% increase in retention of knowledge (Karaçalli & Korur, 2014). Karaçalli & Korur (2014) also discussed the effect it had on students, "In this study, the project-based learning method applied in the experimental group made the students active, so the students constructed their own knowledge and learned by themselves throughout the process" (p. 232). This study also talked about how to track student performance to ensure that students are participating and holding each other accountable. Karaçalli and Korur (2014) reports, "In this particular study, the seven forms made the process precise for the students and they constructed new knowledge since they were aware of every step within the process of undertaking the projects" (p. 233). These forms were as follows; project description form, project team and cooperation form, weekly project progress form, self-evaluation form, peer evaluation form, project evaluation form, and a what we learned from (Karaçalli & Korur, 2014).

How Science, Technology, Engineering, and Mathematics (STEM) Project-Based Learning (PBL) Affects High, Middle, and Low-Achievers Differently: The Impact of Student Factors on Achievement by Han, Capraro, and Capraro (2014) was another study that looked at the effects of a project-based learning curriculum. This study looked at different groups of students and how their achievement changed. Han, Capraro, and Capraro (2014) reported that the results of this study found that, "A student centered learning environment is the main feature of a STEM PBL classroom and we found that the low performing group of students improved at a higher level than the high and middle performing student groups when looking at student achievement on mathematics under a STEM PBL learning environment" (p.1108).

As all three studies have shown project-based learning impacts student learning in the positive direction. There were not any studies that showed only negative consequences of project-based learning. The study by Han, Capraro, and Capraro (2014) showed one negative effect on students with low socioeconomic status. Han et al., 2014 stated that "Students in the low economic status group ultimately received negative impacts from their engagement in STEM PBLs" (p.1108). The suggestion from the study is that educators will need to look at what barriers students with low socioeconomic status have during the project-based learning and how that impacted their participation (Han et al., 2014).

How can student learning be improved through project based curriculum that gives access to all students? The literature suggests that student learning is improved through project-based learning. The three studies emphasized group work as what improved student success (Boaler, 2016; Han et al., 2014; Karaçalli & Korur, 2014). The literature is strongly favoring that all students are being given access to project-based learning that improves their success. Han et al. (2014) were the only ones to show that there is some kind of barrier to access from students from a low socioeconomic status.

Summary

Project-based learning is a method of teaching that allows students to construct their own knowledge and understanding of a topic through the creation of their own product. It works best when it is well planned so that students are curious about what they are learning and see the connection to their real-life (Larmer, 2014). Group work and public presentation of what they learned are important to help develop understanding (Larmer & Mergendoller, 2010). Through project-based learning students can explore more than just procedural fluency but work on all of the math proficiency strands (NCTM, 200).

Grounding project-based learning in the standards of mathematics will help ensure that students are learning and executing strong mathematical skills. Throughout the literature a common argument against project-based learning is that students miss the basic skills and the mathematical depth. Using the five process standards from NCTM, Minnesota State Standards, and previous district curriculum in planning project-based learning should ensure that student learning is effective and they are learning the mathematical skills and understanding along with the soft skills needed to be successful after high school.

The literature has shown that project-based learning can help student learning improve. There is still some debate whether it grants access to all students. This project is going to design a well-planned project-based learning unit to allow access and learning for all students. Once complete a project based unit will help show educators a way to help answer the key question in this paper, how can student learning be improved by creating project based curriculum that gives access to all students?

CHAPTER THREE

Introduction

How can student learning be improved by creating project based curriculum that gives access to all students? This question is answered by a project based unit curriculum. Students have often struggled with project understanding and completion during previous executions. The developed curriculum and future implementation of the curriculum strives to create a resource and example for teachers looking to implement project based learning in their classroom.

The curriculum was written during the summer of 2018 and implemented during the 2018-2019 school year in an urban high school 10th grade geometry classroom. Three teachers will implement the curriculum to 7 different sections of 10th graders. Within the primary classrooms there will be a mix of ability levels, ethnicities, and primary languages. One sections is co-taught with an English as a Second language, ESL, teacher. Some units have projects within them, but are usually at the end of the unit and not effective for student completion or understanding.

Curriculum Development

A needs assessment was done by looking at the standards from the district and the state for the solids units. A list of essential skills and learning targets was created for the 3 dimensional solids unit. Also previous curriculum was analyzed to determine if student needs were met. From the learning targets and standards, a list of skills, knowledge and understanding that students should take away from this unit was developed. These are tp be based on the 5 mathematical proficiency strands (Kilpatrick et al., 2001) and the 5 process standards (NCTM, 2000).

Once the needs were determined a unit was developed based on *7 Essentials for Project-Based Learning.* The seven essentials are as follows; A Need to Know, A Driving Question, Student Voice and Choice, 21st Century Skills, Inquiry and Innovation, Feedback and Revision, and A Publicly Presented Project (Larmer & Mergendoller, 2010). The curriculum was written as a draft for daily execution but project components created. Since the class is taught using the same lesson for all teachers the curriculum for the unit will then be brought to the other two teachers to discuss and make changes during the 2018-2019 school year for daily instructional needs. The curriculum is used as a guide to help inform other teachers, but is not an absolute. The unit uses previous direct instruction lessons to obtain important mathematical skills that project based learning doesn't teach well (Larmer, 2016).

Assessment of Projects Effectiveness

The curriculum's effectiveness should be assessed. There are 3 ways to look at the curriculum to see if it was effective: The curriculum must contain the 7 essential skills for project based learning (Larmer & Mergondoller, 2010), the learning targets will will be based on the 5 mathematical proficiency strands (Kilpatrick et al., 2001) and the 5 process standards (NCTM, 2000), and finally be reviewed by co-workers who will be teaching the same curriculum for any missing gaps or information needed. The curriculum can be judged and assessed by using the research that was completed.

Summary

In summary I answered the research question, How can student learning be improved by creating project based curriculum that gives access to all students?, by creating a sample curriculum for a 10th grade geometry course using the principles and best practices of project-based learning (Larmer & Mergendoller, 2010), standards based learning (Huetinck & Munshin, 2008) the five mathematical proficiency strands (Kilpatrick et al., 2001) and the five process standards (NCTM, 2000). These structures provided a curriculum that gave access to all students. The curriculum was consulted on by another math teacher at the same school to ensure consistency with other curriculum in the building. Common formative assessments were created for district standards and the summative assessment is the final project for the students. After completing this project there are some things that still need to be done to keep furthering the conversation about project-based learning and what is best for students to learn. Chapter four aims to reflect and point in a direction to answer or continue the conversation.

CHAPTER FOUR

Introduction

How can student learning be improved by creating project based curriculum that gives access to all students? I explored this question through creating a project based curriculum for a three dimensional solids unit for a tenth grade geometry course. After completing this project I reflected on its creations and reasoning. I looked at my personal learning and how this contributed to my professional growth and development. I reflected on the research I did and how it impacted my project. Another important part I reflected on was what the implications and limitations this project has. Furthermore, I reflect on how my research question informs me of what needs to be done next. Then finally I share what the benefits to the academic community are. This chapter will be my analysis and reflection of the following six topics; personal learning, literature, project implications, project limitations, future research, and project benefits.

Reflection

Personal Learning. What did I learn by creating this project? My learning can be broken down into three parts. What I learned as a researcher, writer, and a learner. Those three roles are what evolved while creating and writing this project.

As a researcher I learned that there is a lot of different information out there. One of the things that I struggled with was finding articles and sources that worked directly with my topic. It was challenging to find specific articles. I had to change the search terms and find semi related topics to combine into what I was looking for as a researcher. A lot of the research done for project based learning wasn’t for mathematics, but for other subject matters, so I had to connect the mathematical understanding research with the project based learning research. I had to integrate the two strands of research for my paper. This leads to what I learned as a writer.

I am a practitioner not a writer or researcher. I found that out while doing this project. I found it difficult to articulate my findings from my research. I think that when I finally did the project and executed what the research said I had a better understanding of what it was really saying. Writing about it meant nothing until I could practice what it was saying. Once I had put into practice what the research was saying I was able to go back and write about it. That leads into what I learned about myself as a learner.

Like I said above I am a practitioner. I do best with project based learning myself. I needed structure, reflection, and clear goals. I liked the ability to have choice in what I was doing, but I needed deadlines and expectations or I couldn't finish what I was doing. My students and I have that in common.They are self driven, but they sometimes lack focus and structure. The literature suggested that project-based learning was done best with a lot of these traits.

Literature: There are four main pieces of literature that gave focus to my project. They are as follows; the five mathematical proficiency strands (Kilpatrick et al., 2001) and the five process standards (NCTM, 2000), the seven essential skills for project based learning (Larmer & Mergondoller, 2010), and the standards based best practices (Huetinck & Munshin, 2008). Using all four of these researchers will allowed for best practices to come out when planning the curriculum. One main take away from Larmer (2016) was the idea that not all mathematical ideas could be taught with project based learning, but needed to be intermixed with direct teaching of skills and understanding How does using this literature help give access to all students?

Project Implications. Students will learn better given because students are creating their own understanding and therefore develop an understanding that is unique to them with project based learning (Han et al., 2015). What this means about the project is that project based learning should be worked into more curriculum. This project gives teachers a guideline and executed example on how to implement project based learning with the structure that supports all learners. I want teachers to be able to use this as a guide on how to write more units and create more projects that are specific to their students. However this is just one unit done to a specific state and district.

Project Limitations. The project does have some limitations because it is written for one state and district. It is limited in focus but hopefully can be spread to other states standards and district curriculum. It is also limited by the idea that it is only done for one unit and two learning objectives or goals. The reason only one unit was completed was because of time. Also for time sake the project was not implemented and tried on students with data collection. That would be a topic for further research.

Future Research. Implementing the curriculum would be the next step in this process. After implementation three things could be done: data research on student learning, peer editing, and review of curriculum. Also, further units can be created to make an entire course of project based learning. I would do this further research in three steps.

The first step would be to collect and then analyze data through the lens of an improvement in student learning. The literature did say that student learning would improve through project based learning (Larmer & Mergendoller, 2010). Data collection on pre and post assessment and further research into how to assess student learning would need to be done. Then analysis of the data for shortcoming and needed changes in the curriculum.

The second step would would be to conduct the peer review referenced in chapter three. Teachers who are teaching the course have already reviewed the written curriculum. There would need to be reflection and analysis of the data done from step one to offer changes and personal preferences to the curriculum to better meet the needs of the students. Then from there step three could begin.

Step three entails creation of a course based in project based learning. Extending what I have learned and the other teachers have learned to other units within the geometry course. This would allow students to see the benefits of project based learning by repeating the practice. Once this is done there will be a project based learning course to follow. This will allow me to share with others what I am doing.

Sharing and Benefits of the Project. This project will contribute to the community because it is a research based curriculum that is designed to meet student needs through best practices of project-based learning and standards based learning. I will share this project with my school and district community as an example of how best to implement project based learning.

Summary

In summary this project helped answer the following question; How can student learning be improved by creating project based curriculum that gives access to all students? The project did this by using best practices of Larmer and Mergendoller (2010) and Larmer (2014, 2016) for project based learning. It used standards based instruction from Huetinck & Munshin (2008). It intertwined the mathematical teaching principles of Kilpatrick et al. (2001) and NCTM (2000). Creating this curriculum will allow access to all students by using these research based practices for project based learning (Huetinck & Munshin, 2008; Kilpatrick et al., 2001; Larmer & Mergendoller, 2010; NCTM 2000). Sharing this example curriculum will allow teachers and educators access to a plan for project based learning. I hope that this will allow other educators to continue the work and do what helps all students achieve their goals.

BIBLIOGRAPHY

Boaler, J. (2006). Urban success: A multidimensional mathematics approach with equitable outcomes. Phi Delta Kappan*, 87*(5), 364-369. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ773981&site=ehost-live; http://www.pdkintl.org/kappan/k_v87/k0601toc.htm

Boaler, J., 1964. (2000). Multiple perspectives on mathematics teaching and learning. Westport, CT: Ablex Pub.

Bottge, B. A. 1., Ma, X., Gassaway, L., Toland, M. D. 1., Butler, M., & Cho, S. (2014). Effects of blended instructional models on math performance. *Exceptional Children, 80*(4), 423-437. doi:10.1177/0014402914527240

Cogger, S. D. 1., & Miley, D. H. 2. (2012). Model wind turbine design in a project-based middle school engineering curriculum built on state frameworks. *Advances in Engineering Education, 3*(2), 1-23. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eft&AN=89165020&site=ehost-live

Dole, S., Bloom, L., & Kowalske, K. (2016). Transforming pedagogy: Changing perspectives from teacher-centered to learner-centered. *Interdisciplinary Journal of Problem-Based Learning, 10*(1), 45-58. doi:10.7771/1541-5015.1538

Glazer, E., 1971. (2001). *Using internet primary sources to teach critical thinking skills in mathematics*. Westport, Conn: Greenwood Press.

Gordon, S. P. 1. (2016). The flavor of a modeling-based college algebra / precalculus course. *UMAP Journal, 37*(1), 65-82. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eft&AN=115383172&site=ehost-live

Greenes, C. E., & Rubenstein, R. N. (. N., 1947. (2008). *Algebra and algebraic thinking in school mathematics, seventieth yearbook*. Reston, VA: National Council of Teachers of Mathematics.

Grinstein, L. S., & Lipsey, S. I. (. I. (2001). *Encyclopedia of mathematics education*. New York: RoutledgeFalmer.

Han, S., Capraro, R., & Capraro, M. M. (2015). How science, technology, engineering, and mathematics (stem) project-based learning (pbl) affects high, middle, and low achievers differently: The impact of student factors on achievement. *International Journal of Science and Mathematics Education, 13*(5), 1089-1113. doi:10.1007/s10763-014-9526-0

Harris, C. J. 1., Penuel, W. R. 2., D'Angelo, C. M. 1., DeBarger, A. H., Gallagher, L. P. 1., Kennedy, C. A. 4., . . . Krajcik, J. S. 5. (2015). Impact of project-based curriculum materials on student learning in science: Results of a randomized controlled trial. *Journal of Research in Science Teaching, 52*(10), 1362-1385. doi:10.1002/tea.21263

Henderson, K. B. (1969). *Teaching secondary school mathematics*. Washington, D.C.: Association of Classroom Teachers, National Education Association.

Heyl, A. (2008). *Fostering engagement for students from low-socioeconomic status backgrounds using project-based mathematics.* ().Online Submission. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=ED501239&site=ehost-live

Huetinck, L., & Munshin, S. N. (2008). *Teaching mathematics for the 21st century: Methods and activities for grades 6-12* (3rd ed.). Upper Saddle River, N.J: Pearson/Merrill Prentice Hall.

Karaçalli, S., & Korur, F. (2014). The effects of project-based learning on students' academic achievement, attitude, and retention of knowledge: The subject of 'electricity in our lives'. *School Science & Mathematics, 114*(5), 224-235. doi:10.1111/ssm.12071

Kilpatrick, J., Swafford, J., Findell, B., & National Research Council (U.S.). Mathematics Learning Study Committee. (2001). *Adding it up: Helping children learn mathematics*. Washington, DC: National Academy Press.

Larmer, J., & Mergendoller, J. R. (2010). 7 essentials for project-based learning. *Educational Leadership, 68*(2), 34-37. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eft&AN=508181009&site=ehost-live

Larmer, J. (2014). Boosting the POWER of PROJECTS. *Educational Leadership, 72*(1), 42-46.

Larmer, J. (2016). It's a project-based world. *Educational Leadership, 73*(6), 66-70.

Minnesota Department of Education (MDE). (2007). Minnesota academic standards; Mathematics K-12. Retrieved from https://education.mn.gov/MDE/dse/stds/Math/

NCTM. (2000). *Principles and standards for school mathematics*

Schoenfeld, A. H. (2007). *Assessing mathematical proficiency*. Cambridge; New York: Cambridge University Press.

Senk, S. L. (. L., 1943, & Thompson, D. R. (. R., 1954. (2003). *Standards-based school mathematics curricula: What are they? what do students learn?*. Mahwah, N.J: Lawrence Erlbaum Associates.

Tobias, E. S., Campbell, M. R., & Greco, P. (2015). Bringing curriculum to life. *Music Educators Journal, 102*(2), 39-47. doi:10.1177/0027432115607602

APPENDIX A

	Strand	Standard	No.	Benchmark
9, 10, 11	Geometry & Measurement	Calculate measurements of plane and solid geometric figures; know that physical measurements depend on the choice of a unit and that they are approximations.	9.3.1.1	Determine the surface area and volume of pyramids, cones and spheres. Use measuring devices or formulas as appropriate. For example: Measure the height and radius of a cone and then use a formula to find its volume.
			9.3.1.2	Compose and decompose two- and three-dimensional figures; use decomposition to determine the perimeter, area, surface area and volume of various figures. For example: Find the volume of a regular hexagonal prism by decomposing it into six equal triangular prisms.
			9.3.1.3	Understand that quantities associated with physical measurements must be assigned units; apply such units correctly in expressions, equations and problem solutions that involve measurements; and convert between measurement systems. For example: 60 miles/hour = 60 miles/hour × 5280 feet/mile × 1 hour/3600 seconds = 88 feet/second.

(MDE, 2007)

APPENDIX B

Course-at-a-Glance (CAG) --- Mathematics --- Geometry

Note: MN Benchmarks 9.3.2.3 and 9.2.3.4 are included in all units.

First Semester

<u>Unit 1: Lines and Angles</u> (19 lesson days, approximately 5 weeks)
Approximate dates: August 28 – September 29, 2017

1.1 I can solve problems and justify my results using geometric terms, notations, markings, and constructions. (9.3.2.1, 9.3.2.3, 9.3.2.5, 9.3.3.1)
1.2 I can solve problems and justify my results using parallel and perpendicular line properties, including properties of angles. (9.2.3.7, 9.3.2.2, 9.3.3.2)
1.3 I can use coordinate geometry and linear algebra skills to represent and analyze points and lines. (9.3.4.4)

<u>Unit 2: Triangles Part 1</u> (29 lesson days, approximately 7 weeks)
Approximate dates: October 2 – November 17, 2017

2.1 I can solve problems and justify my results using properties of triangles. (9.3.2.1, 9.3.2.2, 9.3.2.3, 9.3.2.4, 9.3.2.5, 9.3.3.3)
2.2 I can solve problems and justify my results using properties of equilateral and isosceles triangles. (9.3.2.1, 9.3.2.2, 9.3.2.3, 9.3.2.4, 9.3.2.5, 9.3.3.3)
2.3 I can solve problems and justify my results using properties of congruent triangles (9.3.2.1, 9.3.2.2, 9.3.2.3, 9.3.2.4, 9.3.2.5, 9.3.3.6).
2.4 I can apply the Pythagorean Theorem and its converse to solve problems and logically justify my results. 9.3.2.2, 9.3.3.4, 9.3.4.7)
2.5 I can apply the properties of special right triangles to solve problems and logically justify my results (9.3.3.5)
2.6 I can use coordinate geometry to translate, reflect and rotate triangles and analyze the results. (9.3.4.4, 9.3.4.6)

<u>Unit 3: Triangles Part 2</u> (21 lesson days, approximately 6 weeks)
Approximate dates: November 20, 2017 – January 12, 2018

3.1 I can solve problems and justify my results using properties of similar triangles. (9.3.3.6, 9.3.4.7)
3.2 I can solve problems and justify my results using the trigonometric ratios sine, cosine, and tangent in right triangles (9.3.4.1, 9.3.4.2, 9.3.4.3).
3.3 I can select and apply the correct triangle relationship (congruency, Pythagorean Theorem, similarity, trigonometric ratios) to find missing sides and angles of triangles. (9.3.1.3, 9.3.1.5, 9.3.3.3, 9.3.3.4, 9.3.3.6, 9.3.4.1, 9.3.4.2, 9.3.4.3)

Second Semester

<u>Unit 4: Quadrilaterals</u> (24 lesson days, approximately 6 weeks)
Approximate dates: January 16 – February 23, 2018

4.1 I can compose and decompose quadrilaterals to solve area and perimeter problems. (9.3.1.2)
4.2 I can describe, compare and contrast properties of quadrilaterals and use that knowledge to solve problems. (9.3.3.7)
4.3 I can solve problems and justify my results using properties of congruent and similar quadrilaterals. (9.3.3.6)
4.4 I can use coordinate geometry to measure and classify quadrilaterals. (9.3.4.4)

<u>Unit 5: Polygons</u> (19 lesson days, approximately 5 weeks)
Approximate dates: February 26 – March 29, 2018

5.1 I can compose and decompose polygons to solve area and perimeter problems. (9.3.1.2)
5.2 I can describe, compare and contrast properties of polygons and use that knowledge to solve problems. (9.3.3.6, 9.3.3.7)
5.3 I can solve problems and justify my results using properties of congruent and similar polygons. (9.3.3.6, 9.3.3.7)
5.4 I can use coordinate geometry to measure and classify polygons. (9.3.4.4)

<u>Unit 6: Circles</u> (20 lesson days, approximately 5 weeks)
Approximate dates: April 9 – May 11, 2018

6.1 I can solve problems and justify my results using angle, arc and segment properties of circles. (9.3.3.8)
6.2 I can solve problems and justify my results using circumference and area of circles. (9.3.3.8)
6.3 I can generate, justify and apply the equation of a circle and analyze the effects of translations on the equation. (9.3.4.5)
6.4 I can measure perimeter and area of complex 2-dimensional figures. (9.3.1.2)

<u>Unit 7: Solids</u> (16 lesson days, approximately 5 weeks)
Approximate dates: May 14 – June 12, 2018

7.1 I can calculate surface area and volume of pyramids, cones and spheres (9.3.1.1)
7.2 I can compose and decompose 3 dimensional figures to determine surface area and volume of various figures. (9.3.1.2)
7.3 I can explain and demonstrate the effect of scale factor on length, area, and volume. (9.3.1.3, 9.3.1.4)

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