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The Best Way to Utilize MakerSpace in a 6th Grade Science Classroom

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by

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Introduction

Research Question

As a teacher, science has always been one of my favorite subject areas to teach. In my teacher training it was my favorite subject to study and learn about. It was hands-on and engaging, there were tactile materials to use and experiment with every week, and even though we were all given the same assignments, such as keeping a science journal, they all looked so different and that was ok. While one student used doodles to connect their ideas to the content, another student could use detailed notes to make the connections, and both were considered correct ways to learn. It was the subject I felt most excited to teach and I was ready to make it the favorite class for all my students.

This was easier said than done. At Hamline University I was able to achieve my Kindergarten through sixth grade license, but what I quickly realized was that most of my training was aimed towards the lower grade levels. I had seen techniques implemented and used successfully, but mostly up until fifth grade. What about the sixth graders? Those students are generally relegated to the secondary level with most sixth graders being placed in the Middle School or Junior High setting. How could these teachings I spent semesters on and invested in be translated to settings and students that are so fundamentally different from the elementary setting?

One technique that really stood out to me in the science and Science, Technology, Engineering and Mathematics (STEAM) classrooms that I visited and learned about was the idea of a MakerSpace - a place where students could explore and build with a plethora of different materials to solve a problem or fulfill a goal presented by the teacher. As a student, and even as an adult, these are my favorite types of projects and problem solving techniques. Getting to build something hands-on with no explicit right or wrong answer. We know that this is a valuable life skill no matter where students eventually end up. We also know that this is a way that allows all levels of learners to access learning and problem solving.

I have seen MakerSpace done successfully numerous times and in various ways with students from Kindergarten to fifth grade, but what about those sixth grade students? As students begin to transition to a more Junior High or Middle school model where they begin to move to their subject-specific classes they tend to gain a science class, but also lose the STEAM specialist classes that are commonly found in Elementary schools. This has been a question and problem that has been plaguing me for the last two years as I have settled into my role as a sixth grade science teacher. For my capstone project I will be looking at *how can the MakerSpace model be implemented in a sixth grade science classroom successfully*?

What is MakerSpace?

Before going any further, we need to define what exactly MakerSpace is. Based on my research, for me, MakerSpace is the concept of providing students with a problem or end goal to fulfill or solve in a way that is as open-ended as possible. Students have access to a variety of supplies, from recycled materials to art supplies, building toys and sometimes even tools and hardware to design a solution (Anderson, 2017, Gilbert 2017). There is no right or wrong way to use or utilize the materials given to students. It is a space where students can explore ideas and concepts either on their own or collaboratively with other students, teachers, or others outside the classroom using the internet to connect them (Anderson, 2017, Gilbert 2017).

For the purpose of my research, I'm working with the idea that MakerSpace is a place for students to make physical products that peak their interest, they are passionate about and that can extend some of their learning done in the classroom. This learning is done both individually and collaboratively in order to grow one's knowledge and skill set. How I developed this working definition can be found in Chapter Two.

Other similar educational concepts to MakerSpace that are commonly used in education might include project-based learning (PBL) or the concept of science fair. While the concepts seem similar on the surface there are some main differences that lead me to use the term MakerSpace over other familiar terms.

With project-based learning there is often the idea that the problem being faced or trying to be solved is one that students are facing in their lives, community or even more largely in the world around them (Capraro, Capraro, Morgan, 2013). While this can be the case for some MakerSpace challenges or problems, this may not always be the case. For example, students may be asked to design a mini-golf course to explore the ideas behind force and motion as a MakerSpace project that ties into their content standards. This project does not correspond to the principles of project-based learning, but would count as a MakerSpace project.

When looking at the concept of science fair we are looking at a more finite term for the project that culminates in a more formal presentation. Just like the project-based learning comparison, there may be times that this would apply, but not always. The use of the word "MakerSpace" seems more inclusive at this time.

Professional Experience

My journey into education was complicated and not always straightforward. I originally wanted to be an architect designing houses and remodeling old buildings. This should come as no surprise, since I love making models and using my hands to complete projects and solve problems. I enrolled at the University of Minnesota to fulfill my dreams of becoming an architect, but it did not meet my expectations and instead I got a degree in management and communications.

While finishing up my degree, I got a part-time job teaching an after-school creative writing program to middle school students in Saint Paul, Minnesota. I immediately felt at home among the students. I was able to flex my creative muscles and show students the wide variety of tools they could use to get their thoughts down on paper including blogs and creating a newspaper for the school I was at. I ended up leaving this position after graduating and securing a full-time job in human resources for various companies in the Twin Cities area.

I quickly missed working with students and creating with them, so I enrolled at Hamline University to get my teaching license. It is at Hamline where I really saw the benefits of hands-on learning experiences, something I never knew I was lacking as a student. I still do not know how I learned science without all the hands-on experiences, labs and open-ended inquiry. Armed with this knowledge and confident it was the best approach, I was ready to hit the schools and teach.

I spent a lot of time at the kindergarten level, both for student teaching and in two separate long-term substitute placements. It was easy to implement hands-on learning for these students. A science lesson was easy to piece together with a short reading, a quick five to ten minute hands-on experiment or project, and then wrap it up nicely with an art project. Students at these schools also had the privilege of having an additional class where they were receiving even more hands-on work with building materials, technology and tools. Anything I could not include in my own room was being included elsewhere. This included access to MakerSpace settings. Students would return to class excited to share about what they were building or what problems they were attempting to solve. They would become elated any day they learned that they were heading back to their class where they could continue to interact with their MakerSpace projects.

When I accepted a position as a sixth grade science teacher after spending two years at the elementary level, I was disappointed to learn that these types of opportunities were not as readily available or utilized. Where were their projects or open-ended exploration? As much as I tried to use the curriculum to drive this, there was a mismatch between the curriculum provided and the more hands-on, exploratory practices I sought to apply with students.

In the 2021-2022 school year, I wanted to make a change. I started collecting old art supplies, old building toys, and recycled materials such as plastic containers, cardboard boxes, and bottles, to make a small MakerSpace cart in my classroom. By spring of that year I presented my students with their first MakerSpace challenge, a force and motion mini-golf hole, that I threw together one Monday morning and presented that same day. It was a slow start with many challenges and hiccups - students were not sure how they were supposed to use the materials, they did not know how to plan or problem solve on their own, and the open-endedness of the challenge was confusing for many who wanted more concrete rules. They worked through these challenges and we celebrated with a mini-golf day.

The light in their eyes was something I saw only on experiment days. I was on to something, but I was not prepared. I was grasping at this light, but was not sure where to go next or how to best implement something like this with students. It was leading me to more questions than answers. It most importantly led me to the question I will be exploring further for my capstone project: *How can the MakerSpace model be implemented in a sixth grade science classroom successfully*?

The Purpose of my Project

Many may be thinking, "Why are you pursuing this question? You seem to have already started something similar to MakerSpace in your classroom?" The answer is simple, I started implementing something similar to MakerSpace on a whim. I know that the concept of MakerSpace can be done successfully in the younger grade levels, but I have not seen it done with diligence in the upper grade levels, and in my case sixth grade specifically.

With what I did with my students, I saw a spark that I want to harness, but I want to do it with fidelity. When I implement a full MakerSpace in my science classroom, I want to know that the research is behind me in a way that I can confidently say that I am doing something that will benefit my students. I want to know the how and why MakerSpace is successful and use that to make a MakerSpace curriculum that can be implemented in sixth grade.

Using my literature review, I will build a curriculum that lines up with the new Minnesota State Science Standards in sixth grade that are being implemented across the state slowly. I want this project I am building to be a stand alone program that can be used with any science curriculum used in the classroom. This will allow it to be used independently of the textbook.

Summary

In conclusion, I am going to be answering the question: *How can the MakerSpace model be implemented in a sixth grade science classroom successfully*? I came to this topic based off of my classroom experience at the younger grade levels and seeing how successful the concept of MakerSpace can be with students. I have had some success implementing a concept like MakerSpace in my classroom already, but have not looked into the research or worked on creating a concrete resource for myself and other teachers to successfully implement this concept.

In Chapter Two I will be conducting a literature review that will look at creating a concrete definition of what MakerSpace is and why it is an important concept to implement in a science classroom. It will look at how MakerSpace can borrow from current science programs that may already exist in the classroom, such as science fair and project based learning, but also how it differs. Chapter Two will look at the research behind MakerSpace and what makes it a positive addition to the classroom and what needs to be done to keep it from running awry. Finally, it will look at what you need in order to run a successful MakerSpace in the science classroom.

Chapter Three will lay out the MakerSpace guide that I made based on my literature review. This will include sections identifying the target audience for this MakerSpace plan, the rationale behind my MakerSpace guide, the goals for my project, an overview of the completed project and my timeline for completing the project.

Chapter Four will be my final conclusion and reflection on my literature review and my completed project. My conclusion will include what I learned as a researcher, write and learner, my biggest learning from my literature review and how it influenced my final product, the limitations and considerations to think through before using the MakerSpace guide, where I hope to continue my research and work in MakerSpace, where I see the future of my current guide going and finally what I think the benefits of my product are.

CHAPTER TWO

Literature Review

Overview of Chapter Two

In the last several years, the Maker Movement has taken the world by storm. You can hardly go on social media or read the paper without seeing signs of this movement in your daily life. This movement is also making a name for itself in schools under the name MakerSpace. While the MakerSpace name itself may be a newer idea, the idea of a space for students to create and have hands-on experiences is not all that new. Theorist John Dewey has long been a proponent of giving students hands-on experiences to make connections between their learning and having a physical component to solidify these ideas (Gilbert, 2017) which is really at the heart of the MakerSpace movement. Connections to Vygotsky's Zone of Proximal Development can also be made when looking at and evaluating the benefits of having a designated MakerSpace for students to interact with in the classroom (Fasso, Knight, 2020). Vygotsky's Zone of Proximal Development highlighted the importance of students building relationships and peers as well as the ability to grow their knowledge and abilities by slowly working towards an end goal at a pace that matches what they need (Kurt, 2020); these ideas and concepts will be highlighted as important concepts in a successful MakerSpace later in this chapter.

This Maker Movement in particular is having a strong presence in the STEAM and science fields when it comes to the education of the youth not only in the United States but across the globe. As a science educator the term "MakerSpace" has become a keyword being thrown around in a lot of the literature I have been reading and in a lot of the sites and professional development I follow. Because of this, I have found myself wondering: *How can the MakerSpace model be implemented in a sixth grade science classroom successfully*?

Chapter two explores the research around the MakerSpace movement. The first part of this chapter will look at what MakerSpace is in the classroom along with a short history of the "Maker Movement" from concept to now. It will also focus on what learning activities and content can be tied into the MakerSpace that is already being done in many science classrooms, such as science fair and project-based learning, but how MakerSpace is also different and is its own concept for in the classroom.

The second section of this chapter is going to focus on the research behind MakerSpace in the classroom. This section will first talk about what are some educational theories or accepted concepts that are linked to the MakerSpace movement, such as the ideas of play, building and individualized learning that have been adopted in many programs and schools already (Gilbert, 2017). This will lead into the second section of what are the positive aspects of the MakerSpace movement and having a dedicated MakerSpace in schools for the students, teachers and possible positive impact on the community at large. This includes working on things that interest students, inventing or making new things that benefit the student/school/community, as well as cementing academic concepts in a way that fits with students' preferred mode of learning (Gilbert, 2017). Finally, the second section of the paper will also look at what some of the negative sides to the MakerSpace are. This includes a closer look at inequities that can become present in MakerSpace and the risk of falling into patterns of traditional teaching (Heredia, Tan, 2021).

The last section of this chapter explores the practical aspects of implementing a MakerSpace in the classroom. It looks at what is needed to be successful as a teacher and to set the students up for their own success. It looks at what is needed in order to have an accessible, productive and well-managed MakerSpace. This includes how such a space may be set up, what it may include and what it needs to be well-managed.

What is MakerSpace?

Like many other educational concepts and programs, MakerSpace can be hard to define. It is not because MakerSpace is a new concept. In fact, much of the research has shown that the ideas that MakerSpace is built upon have been around for a long time and can be linked back to educational theorists like Vygotsky, Piaget and Marie Montessori (Bevan, Petrich and Wilkenson, 2015). While some may argue that the "Maker Movement" - this renaissance of making our own goods - has only been around for the last decade or so (Anderson, 2017, Maietta and Alvierti, 2015), the concepts of making itself have been around for centuries and are where the MakerSpace gets their inspiration. The "Maker Movement" with educators really took off in 2004 when *Make* magazine was first published by Dale Dougherty and Tim O'Reilly (Hatch, 2017). The magazine is still being published quarterly and is referenced in several articles researched as a tool to use when trying to find inspiration for MakerSpace projects.

MakerSpace is hard to define because the concept of MakerSpace is a broad one and often means different things to different people. As Anderson pointed out in his book *Makers,* we are all makers (2017). You can be a kitchen Maker, a garden Maker, anything you can think of can make you a Maker (Anderson, 2017). MakerSpace is not meant to be a place for students to learn specialized skills or discipline-specific skills, but more so a chance to explore many skills and disciplines and apply them to their learning and understanding (Gilbert, 2017).

An important aspect of the MakerSpace is the idea that working within the space can be done both alone, but can also be done in a way that is collaborative. This could mean students working with either other students, educators or even the possibility of those outside the classroom using other tools such as email, the web or other experts (Anderson, 2017). The use of the Web is encouraged, but should not be the only means of working within the MakerSpace (Anderson, 2017). The aspect of working with others and collaboration is a big distinction in MakerSpace versus other projects in the classroom and one that Gilbert (2017) would argue is of the more important differences.

For the purpose of my research, I'm working with the idea that MakerSpace is a place for students to make physical products that peak their interest, they are passionate about and that can extend some of their learning done in the classroom. This learning is done both individually and collaboratively in order to grow one's knowledge and skill set.

MakerSpace vs Other Established Science Programs

There are other science programs that are being implemented in science classrooms that can seem similar to MakerSpace. Two of these programs that seem to be the most popular are science fairs and project-based learning (PBL). These programs share similarities with MakerSpace, but are different enough that it is important that the programs do not become mixed together or mislabeled as another program.

Science Fairs are a common practice in school-based science programs. Science fairs have historically been a way for students to explore specific science topics being learned in class and will often follow a theme or problem that most participants need to adhere to (Dione, Reis, Trudel, Gulliet, Kleine and Hancianu, 2011) . This prescriptive set-up with a theme or constraints works against the ideas behind MakerSpace of autonomy and finding a passion project that links back to science (Kurti, Kurti, Fleming, 2014). There are however Maker Faires that are stemming from the Maker Movement (Dougherty, 2013). These fairs differ from the traditional science fair as they are set up to highlight all products and items made by students and also work to engage the community attending in making as well by providing materials and activities that all can engage in (Harlow and Hanson, 2018). Because there are differences in science fair and Maker Faires, it is important that these names not be used interchangeably when hosting.

Project-based learning (PBL) is quickly becoming a popular addition to many classrooms as a way to engage students in helping their community and to help motivate students to solve problems. With PBL there is often the idea that the problem being faced or trying to be solved is one that students are facing in their lives, community or even more largely in the world around them (Capraro, Capraro, Morgan, 2013). While this can be the case for some MakerSpace challenges or problems, this may not always be the case. For example, students may be asked to design a mini-golf course to explore the ideas behind force and motion as a MakerSpace project that ties into their content standards. This project does not correspond to the principles of project-based learning, but would count as a MakerSpace project. With MakerSpace we want students to be engaged in a project that they find meaningful and have a connection to, and while this may be something that is a community problem they are trying to solve, it is not always the case. By giving them the constraint that their project must help the community/school/others around them, we are taking away a lot of their autonomy and may limit their creativity or engagement in the project (Kurti, Kurti, Fleming, 2014).

Research Behind MakerSpace

The ideas behind MakerSpace are not new to the field of education and are often built upon concepts already widely accepted and used in schools today. A lot of the ideas that are utilized in a MakerSpace setting can trace themselves back to the ideas presented by theorists such as Lev Vygotsky and Jean Piaget, Maria Montessori and Seymour Papert.

Lev Vygotsky and Jean Piaget both have argued that play is a central component in the process of learning (Bevan, Petrich and Wilkenson, 2015). Maria Montessori has promoted play as a central part of learning as well, so much so that whole centers are being built on the idea of play for young learners (Bevan, Petrich and Wilkenson, 2015). MakerSpace may not be completely play-based, but a lot of what students are doing while engaging in the MakerSpace mirrors play and what they have been doing since a very young age. Many MakerSpaces include toys such as LEGOS as part of their tools available for students, linking back to the idea that play is central to the learning process for students.

On top of play being a large portion of the MakerSpace, model making and making physical products is also a big highlight of using such a space. Seymour Papert's ideas come to play in this aspect. Papert was a big believer that actually making an object can help students develop a deeper understanding of concepts and these objects can be used to show their understanding as well (Bevan, Petrich and Wilkenson, 2015). More specifically, Papert believed that activities involved with making an object or model could be beneficial to learning when it is used to be the vehicle driving the learning and retention of key concepts and skills (Gilbert, 2017). This is the core of MakerSpace - taking ideas and concepts students know or want to explore more and making a physical object or model to carry out those ideas. The MakerSpace is a great way to allow learners of various learning types the chance to show what they have learned or to expand on ideas they already know.

MakerSpace is an idea being explored not just on a classroom-by-classroom basis, but is actively being funded because it is believed to be a beneficial concept for students. In 2012, the Obama administration worked to launch the MakerSpace concept into schools across the country; this push included funding for some of the high tech tools, such as 3D printers, that I will later highlight (Anderson, 2017). Hatch (2017) went as far as to speculate that MakerSpaces are so important to education that most schools will have a MakerSpace in them in the next several years.

Benefits of the MakerSpace

MakerSpace in the educational setting has not been thoroughly studied as well as in more public settings, such as after-school programs or in libraries, but the benefits of such a concept are still numerous. The ability for students to explore, be creative and “tinker” can be used to guide and support students to a better understanding of classroom concepts (Bevan, Petrich and Wilkenson, 2015). We can use the MakerSpace to pose questions or to create challenges that allow students to explore key concepts in ways that work for their learning by allowing them this open time to explore. Narrowing down the focus to science in particular, the ability to use MakerSpaces has allowed students to not only want to actively engage in science, but it makes them more interested and feel more capable of being a scientist and working within science concepts (Krishnamurthi, Bevan, Rinehart and Coulon, 2013).

If MakerSpace is implemented correctly and with a lens that is focused on equity, it is argued that MakerSpace could be a catalyst in opening the STEM field to groups that are normally underrepresented in these positions (Bevan, Petrich and Wilkenson, 2015). In a field that is predominantly male and white centered, opening the door to other less represented groups could lead to opportunities for students down the road and keep them from writing off the STEM field as one they cannot participate in. A study of a Maker Club outside of school found that fourteen of the students participating were male and only three were female (Martin and Dixon, 2015). This is not the normal makeup of a classroom population and would mean that the educator implementing the MakerSpace program needs to be aware of who will be in the space and allow for those students to come in as their authentic selves and explore the MakerSpace in a way that makes sense for them at that particular moment in time. What works for one MakerSpace may not work for another because of who is present and participating in the space. We need to be sure to honor and include other cultures, contributors to science, and ideas outside of those traditionally present in science curriculums.

Bevan, Petrich and Wilkenson (2015) highlighted some examples from a school in Oakland, California where students were allowed access to a MakerSpace to explore and build on ideas that came up in class. Their projects varied from trying to create a gill for swimmers, making different spray nozzles for a graffiti project, and exploring why rain drops do not kill people when they fall. Students were engaged in the scientific process of coming up with a question, figuring out problems, testing solutions and recording data as well as using feedback and creating new iterations of their project until they were satisfied with their solution (Bevan, Petrich and Wilkenson, 2015). All of these skills are important to becoming a strong scientist and skills needed to get through formal schooling, and students are engaging in the process themselves not just reading about it.

Jarrett (2016), a STEAM (science, technology, engineering, the arts and math) teacher who worked on implementing a MakerSpace in his school, highlighted the benefits of their space and students' ideas to the community. He noted that projects that were generated in his classes involved figuring out how to help a student's brother with hearing aids better participate in sports and how to help a teacher with a physical disability haul their belongings into school everyday. Projects like those highlighted previously show how MakerSpace can reach beyond the classroom when students are creating projects that peak their interest or impact their daily lives and can then be duplicated to benefit others in the school community or greater community.

On top of benefiting communities around the school, MakerSpaces can be a great way to incorporate the public in student's accomplishments and designs. In a study conducted by Stornaiulo and Nichols (2018), looking at how a first year MakerSpace was implemented and ran, they discovered that many students found that the most motivating part of working in the MakerSpace was producing things to share with an audience. These audiences varied in importance to the students, some found their teacher more motivating than parents while some were motivated to share their designs with the more general public, but most students found an audience that resonated with them. This motivation can open the door to running Maker Fairs or inviting guests into the classroom to see what students are working on. Other opportunities highlighted in the study included sharing student work online, finding contests to enter student work in, and encouraging students to find their own outlets for sharing. When working within the MakerSpace the educator may have to make some observations into what audience the student is trying to reach and plan from there as to how they are going to get the students work shared (Stornaiulo and Nichols, 2018).

All of these benefits - more access to science for all students, following passion projects, and engaging with the community - not only keep STEM as a focus for students, it can open up job opportunities for them in the present and in the future (Maietta and Aliverti, 2015). Hatch wrote that one MakerSpace for students out East trained students and allowed them access to laser cutters and design programs. This particular program also has a relationship with a local cardmaking company. Students are sometimes asked to help come up with new designs or help with local orders (Hatch, 2017) These students are seeing how their skills and expertise can be directly related to future careers and job opportunities, or current job opportunities, using skills they learn in the MakerSpace. As Martin and Dixon (2015) pointed out, allowing students to see and live these relationships, MakerSpaces are building a context in which students can apply these skills outside the classroom. One suggestion from Dougherty (2013) to allow students to benefit from their time in MakerSpaces is to document their work in a way that can be used to present to others down the road, like a portfolio, to achieve admission into post-secondary schools and trade schools or in job applications.

The Next Generation Science Standards (NGSS) that are being implemented in over two dozen states and are adopted in some senses in several others can be supported by implementing a MakerSpace in the science classroom. NGSS strived to put together new standards and practices that will enable students to think on their own, problem solve, and collaborate with a focus on hands-on work that engages students with the concepts and phenomena we are trying to teach them (Next Generation Science Standards, n.d.). Utilizing a MakerSpace in the classroom allows educators to do these things with students in a way that gives them the opportunity to learn and explore in a way that makes sense to them. MakerSpaces give students the chance to access science in new ways that they cannot always do in the traditional classroom and gives them the chance to truly engage with STEM concepts and practices that are essential to becoming learners (Krishnamurthi, Bevan, Rinehart and Coulon, 2013).

Pitfalls of the MakerSpace

While there are many positive aspects of MakerSpace, there are things that educators need to be aware of in order to make a successful MakerSpace in their classroom. There were several things that came up in my research that need to be considered when implementing a MakerSpace.

One thing that needs to be addressed is the fact that oftentimes in school settings educators are quick to give detailed instructions to students to get through an activity or in science class, to get through lab experience. Students are used to this structure and many students crave this structure. This does not work in a MakerSpace. There is a big risk of running MakerSpace activities in this way that takes away from the exploring and play aspect that makes a MakerSpace so great. Bevan, Petrich and Wilkenson (2015) highlighted an example of students learning how to use the laser cutter in their MakerSpace; they were given an example project, a keychain, to learn how to use the new tools, but then that was all students wanted to make and they were not openly exploring the new tools. This is the opposite of what educators want in a MakerSpace. Educators need to set up the space for exploring and experimenting and not giving out cookie-cutter projects to be completed. While there is room for some set activities, such as when learning a new tool, there also needs to be the expectation that students are free to explore and are encouraged to do so. This is not always a straightforward process and may change from activity to activity, but so long as you are aware of this pitfall when setting up your MakerSpace you are already closer to being successful in doing so.

Schools are a place where students are expected to learn and show their knowledge often through standardized testing and other formal assessments throughout the year. A MakerSpace is not always going to be a place of learning or a place where students are able to showcase that they have completely mastered a skill (Rosenfield Halverson and Sheriden, 2014). A student may fail at creating the product they wanted to make or they may not fully understand the concept and therefore cannot see through their ideas completely. Educators need to be aware and be alright knowing that it may not always go as planned and pass this onto their students who are often striving for success. This does not fit the “normal” school model that educators and students are used to, so there needs to be a shift in thinking of MakerSpaces being educational. As Dougherty (2013) pointed out, we need to teach students to have a growth mindset when it comes to MakerSpace and schooling; without the growth mindset students will stop trying or engaging with the space when things do not go as planned .

Kumpulainen and Kajamaa (2020) studied how students worked in a MakerSpace and noted how some students were focused on doing things correctly to the point that they were growing frustrated with their projects when they were not sure how to proceed. These students may benefit from learning more about having a growth mindset and ability to accept failure as a learning tool.

With the ability to tie MakerSpace ideas to those of past researchers, such as Papert or Vygotsky above, it would be easy to just say “the experts agree” and move on with implementing the MakerSpace. There are strong links with the ideas of play and building things with learning, but we also have to remember that a large part of learning is focusing on ideas and linking these ideas to our learning and the physical thing that we are trying to make (Gilbet, 2017). It is not enough to allow students to make and hope they learn the concepts we are trying to instill in them. Educators need to make sure students understand the concepts they are engaging in. We need to explore these ideas with students while in the process of making, otherwise they are not actually learning these concepts at all according to Whitehead (Gilbert, 2017). This could be done with the additional step of recording their ideas in a science notebook, talking about their object and ideas with other classmates or teachers, or creating a presentation about their object to share with others. All of these ideas will help the teacher using the MakerSpace know that students not only understand the concept, but can explain them and utilize the concept to make a successful physical product.

Another pitfall of MakerSpace is the focus on technology as the driver in having a successful space and program. Two of the three things Anderson (2017) stated are needed to support the “Maker Movement” are the use of digital desktop tools and using the internet to collaborate with other Makers. This narrow view of a MakerSpace and the “Maker Movement” can alienate other students and educators who are not familiar with technologies, do not have access to technologies or do not consider themselves to be "tech-savvy". Technology, or lack thereof, should not be the deciding factor into whether educators start implementing a MakerSpace (Kurti, Kurti, Fleming, 2014). Any materials can be used to make and should be used to create a MakerSpace (Hira and Hynes, 2018). This thought process opens the door to anyone to start a MakerSpace with limited resources. The focus of a successful MakerSpace should be on the ideas, collaboration and products and less on the tools and materials used in the process (Rosenfield Halverson and Sheriden, 2014; Kurti, Kurti, Fleming, 2014).

What a Successful MakerSpace Needs

A question many educators ask themselves once they are ready to implement a MakerSpace in their classroom is, "What do I need to have a successful MakerSpace?" The answer to this question is not a simple one. The research behind what a successful MakerSpace has greatly varies based on several factors, such as the amount of funding that is being utilized to create and run the space as well as where the space is located. While as educators we will be integrating MakerSpace into our schools, either as a standalone class or in our own classrooms, there is a lot of research about MakerSpaces in the public settings as well, such as community centers and libraries. I have pulled together research from all areas, as I feel that all suggestions should be taken into consideration when trying to figure out what is best for our learners.

Engaging Students

Before addressing the tangible things that educators need to have a successful MakerSpace, we need to address the most important aspect of the MakerSpace: the Makers. Without student buy-in, a MakerSpace will not be successful. Simply allow students to be in the space provided with the notion that there are no expectations, especially at the beginning stages, can be enough to engage students and keep them coming back to class and interacting with the materials being presented (de Leon, Saorin, Torre-Cantero, Meier, Garica Marrero, 2019).

The end goal for the MakerSpace should always be to have engaged learners. In order to do that, Fan (2022) suggests that we want to tap into students' intrinsic motivations and the idea that we as humans have the desire to make things with our hands and make things that mean something to us. Because this space is going to be used primarily by your students, it is important that materials being brought in mean something to them. This may be the right time to implement using choice and student voice to figure out what to bring into the MakerSpace that would make sense to the people actually using it. Students can make a MakerSpace wishlist, bring in materials from home for their own use or to share, or at least make you as the educator aware of what is out there that is engaging students and what you can find that is similar (Dougherty, 2013). Dougherty (2013), who is often seen as the leader of the current “Maker Movement”, also highlighted the importance of identifying and providing materials and projects that link to students interests (2013).

A group of teachers participating in a semester-long course on making in K-12 education were required to participate in the making process and reflect on their experiences. A theme that was common in the reflection process was the importance of collaboration and being part of a community of makers throughout the semester (Heredia and Tan, 2021). If the educators benefited from the ability to collaborate and work with their colleagues in a safe community, students would also benefit. Allowing the space for students to work together and have freedom to collaborate and talk through their designs and thinking can keep students engaged in the MakerSpace. Some projects lend themselves better to collaboration, such as building or making models, while other MakerSpace projects involving technology may be a more individual endeavor, students will often gravitate towards students doing like minded projects and work in parallel as they progress on their projects (Kumpulainen and Kajamaa, 2020).

Because of the iterative nature of working and designing in a MakerSpace, the ability to collaborate allows for students to receive feedback and take in suggestions from peers and educators (Heredia and Tan, 2021). This ability to collaborate and work in a Maker community also can help position students in a role of teacher as they share their knowledge and expertise with other Makers within the MakerSpace, a common theme seen in Hira and Hynes' study of different MakerSpaces (2018). There are often only one or two educators in a room with students, so allowing students to be experts and share their expertise opens the door to more students receiving help at any given time then a traditional setting where only the educator is doing the teaching (Kurti, Kurti, Fleming, 2014). These students can then pass on their passion for making and creating in the MakerSpace to students that may not have the opportunity to engage in your MakerSpace encouraging them to seek out more opportunities in school and outside of school to become creative (Dougherty, 2013).

Space for Making

In order to have a MakerSpace, educators need to start by identifying a space to hold not only their materials, but a space for students to work and keep and display their designs. While some schools have access to an entirely separate classroom that can be utilized solely for a MakerSpace, that is not always going to be the case. In my question of how to implement a MakerSpace into a 6th grade science classroom, I was thinking specifically about how to work a MakerSpace into my classroom space so that it coincides in the same four walls as my everyday science classes. The research shows that there are similarities that can be established for MakerSpaces in both contexts that are important for establishing a successful MakerSpace.

Schools are set up often with the thoughts of routine and learning at the forefront, specifically traditional learning and MakerSpaces are run in a way that often contradicts what a traditional classroom is set up to do. The goal of learning in the classroom is often shown as being successful through performing well on tests, assessments and other assignments throughout the school year, while work achieved in the MakerSpace is shown as successful when a student is proud of a design or has created something that meets a goal that was set by the student and not the educator (Heredia and Tan, 2021). Because these two versions of success are measured differently and sometimes do not go together, it is important that the space set aside for making is a dedicated spot where students are not expected to conform to the mold they try to fit in the regular classroom. This space could be a corner of the classroom with their materials and workspace that are different from what they use during their regular class time. The space itself should also remain adaptable and able to change to meet the needs of the students that are utilizing the space at any given time (Hira, Hynes, 2018).

While the physical space was something that came up in the research, Heredia and Tan (2021) also found that the consideration of time as a space may be something to keep in mind when implementing a MakerSpace. The educators that participated in their professional workshop on making pointed out the importance of making sure that the time allotted for making allowed as many students as possible to participate, meaning that MakerSpace time should fall into parts of the day when students are not receiving other services, such as English Learner support or Special Services support, in order to allow space for all levels of learners (Heredia and Tan, 2021).

Materials for Success

The physical materials needed in order to have a successful MakerSpace vary depending on the research you read. Some articles are focused on MakerSpaces that have been given generous grants to either start or upkeep their space and some focus on classrooms that are just getting started and are being minimally funded or barely funded at all. This will be a comprehensive look at all options that can be utilized with the understanding that every MakerSpace is going to be different.

Technology has become synonymous with the MakerSpace movement. While a lot of research has pointed to it not being completely necessary, there are benefits to having access to modern tools. A report released by Education Week on May 17, 2022 found that in secondary schools almost 90% of district leaders say that students are 1:1 with technology, meaning most students have uninterrupted access to technology throughout that school day (Bushweller, 2022). This same study found that elementary schools have a lower percentage of 1:1 with technology coming in at 40% (Bushweller, 2022). With these numbers, it’s safe to say that technology is being integrated into every day classes on a regular basis and can be a great starting point for introducing technology to the MakerSpace. Many school districts allow students to retrieve approved applications for their devices at little or no cost to the district.

Starting with lower costs of acquiring new technology, de Leon (2019) points out that cutting plotters, a small printer that can be used with computer programming to cut out items such as vinyl, paper and thin wood, can be a great first option in newer or smaller MakerSpaces. They have many of the same benefits as a 3D printer with a smaller price tag and a potentially smaller footprint; this could allow the cutting plotter to fit in an already established classroom looking to add in a MakerSpace. There are some drawbacks to the cutting plotter as well, such as louder mechanisms, dust, and a learning curve that needs to be addressed before being used in the classroom (de Leon, Saorin, Torre-Cantero, Meier, Garica Marrero, 2019). This would add in the extra cost, either time-wise or money-wise, of the educator implementing the cutting plotter technology to also become trained and certified to use the device in the classroom. Looking on the higher end of the spending spectrum with technology, a MakerSpace could utilize a 3D printer in the classroom. On top of cost being a potential barrier, 3D printers have a slower output that could exceed time allotted in class for MakerSpace work time and they cannot create multiple projects in a short period of time (de Leon, Saorin, Torre-Cantero, Meier, Garica Marrero, 2019). Add this to the added cost again of training, both monetarily and with time, and it may again not be feasible for every classroom MakerSpace. Other technology highlighted in my research included SmartBoards, projectors, and robotics materials (Hira and Hynes, 2018). Kurti, Kurti, and Fleming (2014) advised that before making any large purchases or investments in technology, the educator that is creating the MakerSpace should first study the students that will be using the space to determine what is actually needed and appropriate before spending the money.

Besides technology, students will need access to other materials as well for their building and making. These materials can range from vinyls, plastics and papers to be used in the cutting plotter (de Leon, Saorin, Torre-Cantero, Meier, Garica Marrero, 2019), tinkering toys such as LEGOS or other building toys, to crafting supplies that can range from new items to recycled materials. Hira and Hynes (2018) went as far as to say that any materials that can be used to make things in a MakerSpace are materials that should be included in the MakerSpace . This approach can allow the space to be easily adapted to different projects or students making the space more flexible and accessible to more ideas. Some projects made in the research I read included pop-up cards made with a cutting plotter (de Leon, Saorin, Torre-Cantero, Meier, Garica Marrero, 2019), embroidery projects made from educators in a training (Heredia and Tan, 2021), and wind tubes and circuits were highlighted in Bevan, Pietrch and Wilkensons' work (2015).

An important note to make is that an essential part of the MakerSpace is the ability to engage in the entire engineering and design process, which has a focus on the iterative process of design (Heredia and Tan, 2021). This means anything you are providing should be provided in an ample supply so students have access to enough material to build prototypes and create redesigns until they are happy with their end product.

While less flexible than open-ended materials such as LEGOS, printers and crafting supplies, the growing popularity of making has provided the opportunity for educators to purchase products marketed as Maker kits, such as LittleBits, MaKey MaKey, Cubelets and Spheros (Hira and Hynes, 2018). These kits can be adapted to the projects that students want to explore or can be a gateway to getting students to engage in the MakerSpace. Because they can come with prescribed projects or more detailed instructions, they can also be used when there is not sufficient time to accomplish a larger MakerSpace project.

An item not brought up in a lot of research was the access to knowledge. Hatch (2017) points out that this can be in a variety of forms - online, books, community members - but it is an important material to have. The access to knowledge can lead to a question, can show students and educators how to use new tools or materials being introduced to a space, or can show an item that students want to make or improve on. This access to knowledge might not always be free, but with the growing number of Makers and access to technology, everything you need should at least be generally easy to find and access (Hatch, 2017). As one student learns a new skill, concept or method for making something, they can then in turn show another student or even educator in the classroom which keeps the collaboration going, another goal of the MakerSpace model.

While the research on the materials needed for a MakerSpace can seem too broad or not specific enough, it has shown that the materials that can be used in the MakerSpace do not necessarily matter as much as one may think. This allows educators to adapt the space to fit their learners, their physical space and their current budget.

Conclusion

This chapter took a look at what a MakerSpace space is in order to help better answer my research question: *How can the MakerSpace model be implemented in a sixth grade science classroom successfully*? To do this, I conducted a literature review to look at several aspects of the MakerSpace to get a better understanding of how to implement one myself. I first looked at and defined what a MakerSpace was to have a working definition that was more concise. Next, I looked at the research and educational theories that can be tied to and used to support implementing a MakerSpace in the classroom. This led to finding some benefits and pitfalls of this program that educators need to consider when designing their MakerSpace. Finally, using the research as a guide the last section of this chapter laid out what things are needed in order to start a MakerSpace in the classroom.

This research looked at a variety of studies, books and articles that all looked at what is going on with the "Maker Movement" in schools and the public around the world to paint a better picture of what a MakerSpace might look like. Many of the studies reviewed highlighted a lot of benefits of using MakerSpaces in the classroom, such as making students feel more engaged with the content, opening the field of science to a larger audience and often underrepresented audiences, creating a link between students and the community, as well as opening up the classroom to a wider variety of learning styles. The research also pointed out that there are some downsides to MakerSpaces that need to be addressed as they are being implemented. Educators will need to start practicing with students that failure is alright and that students need the ability to explore without limits, that technology is not the only way to be successful in creating a MakerSpace and that we still need to help students make some connections to the content when engaging in the MakerSpace.

The final part of the research aimed to outline what an educator would need in order to effectively implement a MakerSpace in the classroom. There were some gaps in this portion of the research and many authors and researchers did not want to lay out a list of precise materials needed to be successful. Instead the research highlighted a variety of available technologies, premade kits, as well as a push to accept that anything that can be used to make can be incorporated into a MakerSpace.

Preview

Chapter Three will map out a MakerSpace plan for educators teaching sixth grade science in Minnesota under the new standards using the literature review I conducted to help guide me in how the MakerSpace model could be implemented in a sixth grade science classroom successfully. It is aimed at educators who are new to the MakerSpace movement and are planning to implement one in their classroom along with their normal teaching of science using their district provided curriculum.

CHAPTER THREE

Project Description

The core question at the center of this research project was: *How can the MakerSpace model be implemented in a sixth grade science classroom successfully*? Chapter Three is going to describe the project that the research has led to. Using the research as a guide, I created a plan for a first-year MakerSpace in a sixth grade science program in Minnesota. The goal of this plan is to equip educators that are new to the MakerSpace concept or new to implementing one so they feel successful in their first year and provide students a place where they can feel successful as well. The following sections will identify the target audience for this MakerSpace plan, the rationale behind my MakerSpace guide, the goals for my project, an overview of the completed project and my timeline for completing the project.

Target Audience

The target audience for the MakerSpace plan is sixth grade science students in Minnesota specifically. The MakerSpace plan is a plan that can be implemented by a sixth grade science teacher in their regular science classroom. The educator utilizing the MakerSpace plan will generally be an educator with no MakerSpace background. They are interested in starting a MakerSpace in their science classroom, but may not be sure where to start. The plan is not a stand alone curriculum and should be used alongside the science teacher's everyday science curriculum. The MakerSpace plan is designed with the sixth grade Minnesota science standards and topics in mind, but can be used in various states or grades.

The MakerSpace plan is designed to allow for one overarching theme or project per quarter for students to engage in outside of their regular school work. Because there is a longer timeline for each overarching theme or project, this plan can be adapted to fit classes that are of various lengths or in schools that use different schedules outside of the standard daily interaction with students, such as an alternating block schedule.

Rationale Behind the MakerSpace Plan

After examining the research and studies done around the MakerSpace model, it could be noted that there were a lot of positive outcomes associated with implementing a MakerSpace in the classroom. Most notably, Krishnamurthi, Bevan, Rinehart and Coulon (2013) found that MakerSpaces allowed students to not only want to engage in science but it made them more interested in science and feel more capable of being a scientist and working with science concepts. This finding is what many educators want to hear about how their students feel in the classroom – capable, interested, engaged.

The research however did not conclusively come up with a prescription on how to get these results in implementing a MakerSpace in the classroom. An educator would need to piece together several articles, studies and books to come up with potential benefits of implementing a MakerSpace program, things to look out for that could derail their attempts at creating a beneficial space for students, and a list of items that may help their MakerSpace work in the way that they had hoped. Educators would need to know that Anderson (2017) recommends that all MakerSpaces are centered around technology while Hira and Hynes (2018) speculate that anything that can be used to make something would be a good material to include in a MakerSpace. The MakerSpace plan provides educators and students with a starting point for their MakerSpace that will benefit all involved and help them identify things to look out for that could cause issues in reaping the benefits of such a space.

Goals, Overview and Timeline

The goal of the capstone project was to develop a MakerSpace plan for educators that work in science classrooms, more specifically with sixth grade students in Minnesota. The MakerSpace plan is intended to help educators implement a MakerSpace in their science classrooms for the first time with little to no knowledge or training on the MakerSpace concept. In the MakerSpace plan there are guiding documents for educators on the benefits of implementing a MakerSpace that can be shared with administration, parents or other classroom stakeholders and a list of recommended starting guidelines for their space and materials that would be beneficial to have when they start their MakerSpace.

The curriculum portion of the MakerSpace plan focuses on students completing a MakerSpace project once per quarter or once per overarching topic being taught. The plan follows the Minnesota State Science Standards that were adopted in 2019 and focus on Earth sciences. The quarterly projects can be implemented in any order after students have been taught the design process explicitly in class so they are aware of the process they should be implementing when they are working on their project. The four overarching topics included are: Earth systems and weather; minerals and rocks, plate tectonics and surface systems; distribution of natural resources, human impact on the environment, energy, and climate; and Earth-Sun-Moon systems and the solar system.

For each quarterly project there are resources in the MakerSpace plan that will help guide students as they start to come up with ideas and questions that will lead them to their project. To start there will be a list of questions or ideas that can be hung up in the MakerSpace area that are related to the topic being covered in that quarter that students can either completely adopt for their projects or use as a starting place to develop their own ideas. Because some of the questions or ideas might be relating to topics that are not going to be covered until further into the quarter, there is also a list of resources for students to use as they begin their design journey.

Design of each quarterly project was informed by backward design (Wiggins, McTighe, 2011), including a list of essential questions that students should be able to answer and understand by the end of the topics being taught. This backwards approach allows students to see what their end goal for the quarter should be as well as what their projects should be able to show as a result (Wiggins, McTighe, 2011).

To help students with their design process, the MakerSpace plan comes with notebook inserts for science notebooks to help students keep track of ideas, designs, questions, and resources. These inserts are generic so they can be used with all projects throughout the year and so students will become familiar with the process. The inserts can also be used for other projects throughout the year to keep students using a familiar worksheet and process.

Finally, the MakerSpace plan includes a generic assessment tool for teachers to use as they are evaluating students' work. It is adaptable for any standard the student is working on mastering. It is also adaptable for evaluating students who may not have completed or finished a MakerSpace project in the time allotted but have shown improvement or growth in their mastery. This can be hung up in the MakerSpace as well for the year so students can self-evaluate as they work.

The timeline of the Capstone project started with a careful literature review on MakerSpaces in Summer 2022, followed by project development in the Fall of 2022. I spent the fall consolidating all that the literature review uncovered to create the year-long MakerSpace plan. As the plan was developed, it was being implemented in a sixth grade classroom to work out the best way to make the materials in the MakerSpace plan usable for both students and educators. There was no data collected from the implementation.

It is my hope that the MakerSpace plan is an effective and easy to implement guide for educators interested in starting a MakerSpace in their own science classrooms. It is ideally a great starting point that will inspire educators to make bigger and more exciting MakerSpaces and MakerSpace projects for students across all subject areas.

Chapter four will look at the writing process that led to the MakerSpace plan and curriculum. The full unit plan will be submitted separately and include all the setup guides for educators, the four projects and assessment tools.

CHAPTER FOUR

Conclusion

Over the last several months, I have been looking into *how can the MakerSpace model be implemented in a sixth grade science classroom successfully*? This has been an important question to me over the last several years as I have been starting my teaching career and spending more time in the science field. My conclusion will include what I learned as a researcher, writer and learner; important learning from my literature review and how it influenced my final product; the limitations and considerations to think through before using the MakerSpace guide; where I hope to continue my research and work in MakerSpace and where I see the future of my current guide going;and finally, what I think the benefits of my product are.

My Role as a Researcher, Writer and Learner

The process of completing this research and creating a MakerSpace guide for other educators has been a significant learning experience for me. As a researcher, I have learned the importance of going into research with an open-mind and without expectations in what I think I will find in the process. My best research days were days where I went into the process without preconceived ideas of what I was going to find or what I wanted to find. It kept me more open to using various sources, authors and publications in my research process and allowed me to really lean into the process of finding, reading and evaluating research with a more open mind. Because the topic I was researching has not been as heavily researched in classrooms, I had to open myself up to looking at studies from other countries and in less conventional learning spaces, like public spaces, libraries, and in other grade-levels. This was something that I was not originally open to, and I had to make adjustments to my approach as I learned more.

This was my first experience with extended academic writing, so I had to take the time to find my voice in an academic setting. The research I conducted not only helped me with finding the answers to my question on MakerSpace, but also helped me find my writing voice. I found as I continued on with my writing and became more passionate about my topic and findings, my writing became stronger and more focused as well as became more confident in what I was saying.

It took me a while to find my space as a learner in this process. I went into the research with an idea of what I wanted my end product to look like and feel like, and I found it hard to come across research that supported what I wanted. I had to open myself up to accepting that what I had thought or been taught in the last several years was not always best-practice or backed by research. After I got over the initial fear of being wrong, I found it easier to learn more and enjoy the process of research and finding studies that successfully looked at MakerSpace through a supported and research-backed lens.

Reflection on the Literature Review

As I dove into the literature review and wrapped up my research, I found a few particularly interesting changes in my understanding of MakerSpace and the learning process. I think one of the largest and most influential findings was that there are parts of MakerSpace that actually do not work well or that can derail a successful MakerSpace implementation, such as not planning out the work space, creating a separate space for working or even limiting the materials available in the space.. I went into my review originally thinking that finding pitfalls of MakerSpace would be bad and detrimental to my project, but I later found this part of my literature review to be helpful in developing a stronger MakerSpace guide for teachers.

Another significant finding that I found to be helpful in creating a MakerSpace guide was that one of the biggest pitfalls of MakerSpace is having too many constraints and too much structures that take away from the exploration and open-ended aspect that is at the heart of MakerSpace (Bevan, Petrich and Wilkenson, 2015). Because of this finding, which came up over several articles, the guide I created did not include an actual project for students to complete but instead provided questions, vocabulary and some potential projects that can be explored based off of the topics being covered in sixth grade science classes in Minnesota. My initial foray into MakerSpace in my classroom before my research was a lot more prescriptive in practice, but that was the first thing I took out of my product after completing my literature review.

Limitations and Considerations

While my MakerSpace guide is a great starting point for educators looking to implement a MakerSpace in their classroom, there are some limitations and things to consider before implementation. The largest limitation to the MakerSpace guide is that it was made to fit the sixth grade science standards in Minnesota because that is the classroom I am currently teaching in and plan on using my MakerSpace in. This guide was made to fit the new standards for 2019 and will not match any sixth grade classrooms that are still using the older standards based around the physical sciences; this would work in eighth-grade classrooms that are still using the older standards though since there was a flip between the grades. My guide was also influenced by the curriculum that I use in my classroom, Savvas Elevate Physical Science for Minnesota. While my guide can be used with any curriculum because it is a stand-alone guide, it does match up the closest to this curriculum and the pacing guide used by Savvas.

Other considerations to take into account from educators looking to implement the MakerSpace is that there is going to be a small upfront cost to get started because you need to provide items for your students to build with and experiment with. You can keep costs low by asking for donations or old materials students have at home, if that is something your administration allows, but you will still have to buy art supplies, building toys, and other items to keep your space stocked. I have found that I can utilize a lot of items that come in my curriculum boxes for experiments and activities, but I know that my administration is alright with me using these items this way and they will replace these items as I need them, even if it is used in my MakerSpace and not in my traditional classroom space.

The Future of my Current Guide and Future Endeavors

In the future I would like to expand my current MakerSpace guide for sixth grade to include some sample projects from the four main unit projects I outlined. I think that providing example projects that have been completed by other sixth grade students can help provide inspiration for students who are trying to come up with an idea of their own. I would want these projects to come in a wide variety of modes – models, posters, multimedia projects, and more art influence projects – so students do not feel like they have to stick to projects that have a model or a heavy science-influence.

I hope to expand my MakerSpace guides to include the other grades at my current teaching location so students can continue exploring MakerSpaces throughout their time at our school. It will also make science and the topics we cover more attainable to all students, not just those in my classroom. I feel because I have a format for the sixth-grade MakerSpace guide that is easily adaptable, making guides for the other grades would not be as time intensive as this first one and require little to no new research because our students are all similar in age and learning abilities.

I would be curious to expand research in how to implement MakerSpace concepts into other content areas, like Language Arts and Math. I know that this will require additional research into the best practices in how to do this as well as looking at schools that have already done something similar to this to see how it worked and what pitfalls may be.

I am currently using my guide in my sixth-grade science classroom to find out where I can make improvements in my product and to see how each portion works in an actual classroom. I am also hoping to have my counterpart in the other sixth-grade classroom start to use my MakerSpace guide in their classroom as well at some point during the 2022-2023 school year after I complete my first unit project in the winter of 2022. My initial finding is that students are excited about having a space to explore and experiment with little boundaries and guidance from me.

As I make changes and adjustments to my MakerSpace guide, I hope to update the guide as it is a living document in Google Drive. Eventually, I would like to make a website to make updates more readily available to people that are interested in implementing their own MakerSpace. This would be an easier way for me to add in projects that have been completed in my classroom and can be used as examples for future students. It would also be an easier way to share updated research coming out on MakerSpace and best practices.

Contribution to the Teaching Profession

I believe that my MakerSpace guide is a great way for educators to get a start in MakerSpace that will take little effort on their part as I have all the items needed to hang up in the classroom and easy to use checklists that they can use to make sure that they have what they need to get started. In my research there was nothing like this out there that is so straightforward and available at no cost to educators. My guide is backed by research and is something that is being used in my classroom and I feel confident that it will be beneficial to students. It was made with students and educators in mind and at the forefront of my research.

I also think that by providing a starting point for exploration and experimentation in the classroom, we are going to make science more accessible and enjoyable for all students. The guide is built on the idea that it is ok to fail and try again or that it is ok for an idea to not work out the way we originally planned or envisioned it working and that is a healthy process to go through. It makes our students less afraid to fail or start over, which will carry over to other areas in their learning and carry over to other classrooms and their futures once they leave our classrooms.

Conclusion

My journey with MakerSpace all started with the burning question of: *How can the MakerSpace model be implemented in a sixth grade science classroom successfully*? This all came about because I worked in various schools and in collaboration with many educators through my short career that showed me that inquiry and the ability to make something can engage even the toughest learner. With my own sixth grade science classroom, I was ready and interested in making time and space for students to make and create, but I was not quite sure where to begin.

I started my journey with a clear picture of what I wanted to create, a guide for teachers interested in creating their own classroom MakerSpace, but the picture changed as I learned more about MakerSpaces and the MakerSpace movement. My literature review uncovered many positive outcomes of MakerSpaces, but also showed me that there are some drawbacks and pitfalls to look out for when implementing in the classroom. I read about what is needed to make a successful classroom MakerSpace, including the physical space and some suggestions for materials. Most importantly, I learned more about how to engage students in the space.

Using all the knowledge I picked up in my literature review, I made a MakerSpace guide for teachers new to the MakerSpace movement. My guide was made more specifically for sixth grade science teachers to use in Minnesota. Included in my guide were materials to get teachers started on their first year of utilizing MakerSpace. There were teacher materials, like letters to send out to administrators and families, a list of suggested materials, and suggestions for how to set up the MakerSpace. My guide also included items to be hung up in the MakerSpace for students to use each quarter and a MakerSpace design journal for students to use as they work.

Everything in my guide was inspired by my literature review and backed by research and other's ideas. While I have not utilized everything myself as of this writing, I have started to use my own MakerSpace guide with my students and in my own classroom in the last few weeks with success. As the year continues, I plan on updating my MakerSpace guide to reflect my own findings and make changes as I learn what works well and what needs to be fixed and adding more components as the years continue.

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