

Making in the Science Classroom: Inspiring and Empowering Underprivileged Minority Students

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ABSTRACT

In this educator's submission, we describe a grant program funded by the National Science Foundation that has brought Maker-space technology into the formal classroom environment. Through this program, we as teachers have been able to see first-hand how our students can grow when given the opportunity to learn Making and engineering concepts alongside with their science curriculum. Over the four years of this project, our students' worlds have been enlarged as they have the opportunity see themselves as future workers in fields involving Science, Technology, Engineering, and Math (STEM). Students who once only saw themselves as Wal-Mart employees now want to be engineers, teachers, or computer programmers. Additionally, this program has given teachers and parents a chance to learn how to encourage young students to dream big, and has turned the teachers in to Makers themselves.

1. INTRODUCTION

As you enter Roberts Elementary*¹, you immediately feel a part of our Regal Eagle family. It does not take long to be consumed by the love, commitment, determination and family culture. Roberts Elementary is a neighborhood Title 1 school with 96% of our students identified as economically disadvantaged. While we are developing our school culture, we still respect, honor and celebrate our students' individual cultures. Our diverse population is reflected not only in our students, but in our staff as well.

Failure is not an option at Roberts Elementary, and our teachers instill a sense of self-efficacy in our students. We believe that every student CAN succeed, and we communicate this belief daily through our words and actions. We believe that education is the means for our students to attain upward mobility. So when they come, we don't make excuses, we make a difference.

Because of our commitment to develop lifelong learners, we continuously strive to seek opportunities to help our students develop skills that will ensure their success in a world that is technology driven. It is because of this commitment that we agreed to partner with a group from a large research university who was interested in how classroom-based Making can impact students' self-efficacy and attitudes towards their STEM future selves. Below we describe what has been an ongoing four year project funded through the National Science Foundation titled [*This has been deleted for reviewing purposes*] (known henceforth as Makers). Through this project, we have seen a phenomenal change in not only our students, but in ourselves, our administrators, and our community. We believe that it is important to share what we have seen and learned through this invaluable project with the larger Maker-centered and digital fabrication learning communities.

2. DESCRIPTION

2.1 Description of Setting

Roberts Elementary has a large population of English Language Learners. However, because the majority of our students are economically disadvantaged, we view all of our students as linguistically disadvantaged. This positively affects our English Language Learners because the strategies we utilize are school wide. We focus on developing academic language in order to prepare our students to not only meet state expectations but also set the stage for them to become lifelong learners. As a result of that, the Makers program allows students that lack interests and confidence in science to shine and do well in science when implementing this innovative science program.

Roberts Elementary School is located in a small urbanized city in the Southeastern United States. It is also located 7 miles from a predominantly White institution and it is part of an Independent School District (ISD). Currently, the school district has 16,000 students. It

¹ *The elementary school name has been changed to ensure anonymity for review purposes

comprises 15 elementary schools, 2 intermediate schools, 2 middle schools, and 4 high schools. The percentage of students in the school district classified by the state as Economically Disadvantaged is 73.2%. In addition, 65% are considered At-Risk students because of educational, family or socioeconomic difficulties. Also, the student mobility rate is 20.4%. The student demography in the district is as follows: 20.1% African American, 52.4.0% Hispanic, 25.8% Caucasian, 1.1% two or more races, and 0.6% other.. The district was chosen as part of the study because of its high numbers of ELLs and its vision to provide positive educational experiences to all students.

Currently, we have a total of 362 students at Roberts Elementary. 54 students are in kindergarten, 82 students are in grade one, 70 students are in grade two, 88 students are in grade three, and 68 students are in grade four. The ethnic distribution for Roberts Elementary stands as follows: 21.5% African American, 74.5% Hispanic, 3.0 % Caucasian, and 1.0 % other. From the 362 enrolled at the school, 96.6% are classified as Economically Disadvantaged, 79% are At-Risk, 21.1% is the Mobility Rate, and 48.3% are English Language Learners.

2.2. Program Description

In 2015, Roberts Elementary partnered up with a large university to establish an innovative and hands on Science program for its 3rd, 4th, and 5th grade classes which would allow students to experience real-life problem-solving situations with the use of technology and engineering principles. Roberts Elementary was selected as a partner in this STEM program because of the gap of diversity of students of color, English Language Learners, girls, and low socio economic background in STEM career fields, all of which are represented at Roberts Elementary. Our school year is divided into 6 six-week periods in which the curriculum required to teach by the state is divided. Once every six-week period, the Makers group from the university comes in for a period of five days (known henceforth as the implementation week). The university team works with two of the classes in each grade level, leaving two control classes for comparison.

Prior to the first Maker week, a pre-survey is administered which asks students questions about how they see their future selves (for example, *'list 3 jobs you might have when you grow up'*). Quantitative questions about STEM self-efficacy are also asked. A shorter version of this survey is also administered after each Maker week so that the measures are tracked over the course of the program and the changes in student responses are recorded. Planning for the implementation week begins several weeks prior and starts with matching the curriculum standards with engineering and Making principles.

Working with researchers and experts in fields such as Computer Science, Education, Mechanical and Electrical Engineering, and Psychology, a Design team creates Making activities centered around the science concepts being taught in the classroom that week. While it would be fun to incorporate Makers into after school activities, or other electives, infusing the Making into the science lessons ensures that every single student has access to the program, instead of only the students who can stay after school or come on the weekends. The team plans for four days of Maker activities and one day of surveys for data collection purposes. At the beginning of the year, time is also given to teach students about the characteristics of Makers. Students are supported through the to teacher to be curious, to ask questions, to tinker or explore when faced with a problem, and are encouraged to bring prior knowledge or knowledge learned from home into the activity. Students are also encouraged to help each other and share new knowledge that is learned with their classmates.

For the first three years of the project, the Maker team from the university was in charge of both the planning and implementation of the Maker activities. A postdoctoral researcher with a background in education taught all Maker lessons during implementation weeks. As classroom teachers, we were not instructed on what type of a role to engage in, but for the most part we acted as helpers to the researcher, assisting where needed. However, this year, we as teachers were asked to take a more active role, and have begun developing our own Maker lessons and taking over the instruction of the implementation weeks. The researchers are there only as observers, and assist when needed if the students ask during the Making time.

2.2.1 Sample Makers Week

During the week where our students were learning about the properties of soil, the students used coffee filters, graduated cylinders, 4 different soil samples, salt water, and circuits to test the water retention in each type of soil (Figure 1). This concept is difficult for students and is often low scoring when tested in statewide and district assessments. Each student group made water collection containers that had 3 conductive sensors attached. When the water drained from the soil, the sensors would light up an LED bulb showing the amount of water that was not retained in the soil. This activity was divided up into 3 days. On the fourth day, students created a quiz board and lit up correct answers to multiple choice questions provided by the teacher using an LED (Figure 2).

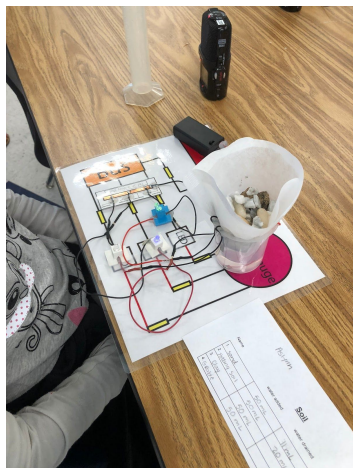


Figure 1

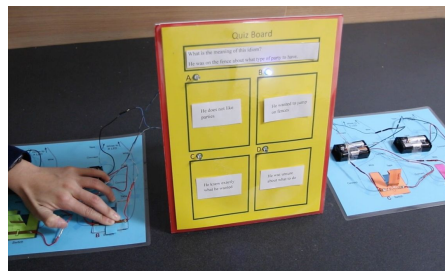


Figure 2

Figure 2

Another example was a third grade unit on the Solar System. The students were assigned a planet to research. Students were given a foam board, a laptop, paper, a rotating motor and stand, and an arm. They colored a piece of paper to represent their planet and also made a sun. They colored a diorama of the solar system but left their planet off. They then created a circuit including a rotating motor to make their planet orbit around the sun. Students also get practice with public speaking when they have to present their diorama to the class. This was done with the purpose of having students research about the planet assigned and actually see a planet orbiting the sun, as it happens in our Solar System.

Solar System Project [Video](#)

2.3 Benefits for Students

Science is a subject where hands-on activities are a must. Experimenting, failing, correcting, designing, changing, perfecting, using common sense and creativity is what scientists do. They are innovators; they need this innovation and creativity to solve problems or overcome issues and to find answers based on scientific knowledge and experience. The Makers program allows students to do just that. They develop their creativity based on engineering and scientific principles, previous knowledge and going beyond what meets the eye. Everything is aligned to the curriculum in their learning. In other words, they become a real scientist. In Makers, students use devices such as circuits, electric motors with simple machines attached to them, arduinos, and even 3D printers, most of which are not available to them outside the program. Makers also teaches them to follow the Scientific Method and come up with valuable conclusions to share which is how every session ends.

It also has broadened the spectrum of opportunities for their future. Now they see there is a wider range of possibilities, such as becoming a doctor, an engineer, a scientist, an architect, or a teacher. These are now options to pursue with a tangible feasibility of making it materialize. This program empowers and motivates. Kids truly own their learning and knowledge. It has also helped in the development of social skills such as respect for other people's opinions, tolerance, kindness, and responsibility of individual tasks within a group project. Students learn to get along and learn from each other. Additionally, their self esteem and confidence has grown tremendously, and they now know that achievement limits are set only by themselves.

For example, a student from last year was having many discipline issues. His attitude towards authority and the classroom was always negative, and he was constantly interrupting, distracting other students, and not working at all. Since he was included in the Makers program everything changed. He never wanted to miss a class, he became part of a working team, and his participation in class went from practically zero to wanting to be involved in everything that was going on. He even cooperated with the teacher in keeping the class focused, and when asked questions about the activity or the science content, his questions and participations were not limited to simple one word answers or comments. He went even further, predicting outcomes, stating the scientific reason behind the outcome. Although this started in originally in Makers, it soon was part of every class he attended. He went from apathetic to proactive.

After spending only a few short weeks with the Maker activities, students quickly learn how to work as innovators. They learn to have a positive attitude when they are working, which allows the Makers group to make the best of the time they have. The best thing about this program is that students have embraced it so well that it permeates to their everyday life., My students now talk to their families about Science and other subjects, they explain scientific principles and continue being Makers at home using whatever is at hand to explain and demonstrate what they have learned. Now, they are also able to explain Physics principles and how things work such as lights or electric appliances being turned on or off, how motors work and how they can switch from moving clockwise to counter clockwise. Makers gives our students a chance to think, believe in themselves, create, and act, and once they get involved we believe that they will have the foundation to be Makers for the rest of their life.

Getting students interested in STEM based careers and in turn getting them excited about and taking ownership of their education gives us a chance to break generational poverty and find solution for their environment of origin. Making the Makers also teaches students to reduce, reduce and recycle by using the same material and adapting it to different needs, and making them aware that the environmental challenges we face can be solved if we change from a waste culture to a conservation society.

2.4 Benefits for Teachers

As a teacher, one of the biggest problems that we face is time. We always want more time to teach the content to the children, especially those children that do not have a complete understanding of the concept. Since we cannot have more time, the next best thing is to make the most of the time we have. Makers allows us to do exactly that. It allows us to add as much academic content as we can into a small amount of time. As a bonus, this time is primarily hands-on and learning levels are at their highest when students are thinking and working as researchers and problem solvers.

Another benefit for teachers is that our teachers are learning just as much as the students. Teachers are continually getting significant professional development and firsthand training by experts in STEM research so that we can properly instruct the children. We have created a group of teacher researchers who think critically, outside the box, to problem solve. We are empowering ourselves and students as we are giving them freedom to develop new concepts and ideas using this innovative program. In this final year of the project, we have been empowered to start developing our own Maker lesson plans and to take a more active role in the classroom while the Maker team is here. At first this was quite daunting, and nerve-wrecking. We felt as if we were being evaluated similar to when we undergo our yearly teacher evaluations. However, as we took time to practice the teaching portion, and as we became more familiar with the Making

technology, this task became easier. Teaching the lessons ourselves has actually helped us to learn the engineering and Making principles quicker, and is enabling us to apply these concepts to our own lives.

Lastly, Makers allows Roberts Elementary teachers to share knowledge gained with students, coworkers, administrators, and the community since the implementation of this unique program. Educators from around the district often seek our advice and expertise. Not only are we leading the district in Science, we are actively helping the district become better prepared to educate all learners in a creative and exciting way.

2.5 Benefits for the School and Community

The Making the Makers program has opened many opportunities for Roberts Elementary. Every six weeks there are weeks when we have several college students walking the halls to help with the Makers program. They bring with them their experiences and their smiles and compassion. The students connect with them through the course of the year and become just as attached to the helpers as they are to their teachers. The students in our classes also have conversations about what the college helpers are studying, giving our students another opportunity to be exposed to various career options for the future.

Another way that the Making the Makers program has benefited the community of Roberts Elementary is by providing a 3D printer for use by the teachers and students. Providing this type of technology not only exposes the students to the technology of 3D printing, but also allows parents and community members to see, touch, and explore 3D printed objects that they would normally not have access to.

In addition, Makers has opened the eyes of our school and community to many new career fields and opportunities. The students are able to visit the nearby University. They live just a few miles away, but many don't step foot on the campus unless taken by the school. With the impact that the university plays in our community, the fact that most of our students do not go to the campus is alarming. Makers gives our students an opportunity that they may not get otherwise to visit a campus where hopefully they will see themselves as future students. They have also been able to lead presentations about the Makers to the superintendent of an ISD, students and research faculty at the University, and the local news stations. Allowing our students to experience these opportunities has also shown parents that it is possible for their child to attend a university, graduate, and have a successful career in a STEM field, regardless of their gender or socio economic background.

One parent noted that they saw a change in their child's attitude toward school after starting the Making the Maker's Program. They stated that before the program began it was difficult to get the student up and ready for school because they simply did not want to go. However, once starting the program, the student was ready and excited to go to school. As you can see, the Makers program has positively impacted the Roberts Elementary and its surrounding community.

6. CONCLUSIONS

The Makers program has been positively impacting the lives of students of Roberts Elementary in many ways. It is both inspiring and also empowering the students to have ownership in their work and to be responsible for their learning process. The Makers program is innovative and untraditional in its teachings but is grasped by students of all ages. It allows students to create, collaborate, and experience learning pertaining to STEM lessons, which produces higher level thinking and learning. Moreover, this program has also had a major impact on the teachers and our community, empowering us to continue training and educating ourselves so that we can in turn encourage our students to dream big and truly believe that they have a future in fields involving science, technology, engineering, and math.

Although this is the last year of funding for this project, we hope to continue this work and generate discussions with other school administrators who might be interested in bringing this innovative program to their schools. To make this project sustainable, the teachers are being trained in Maker technology so that they can continue to use the tools with their classrooms. To gain a better grasp on the entire process, the teachers designed their own unit from start to finish this school year and have taught all of the Maker units this year. The idea behind this is to give teachers more control, while only receiving minimal support from the research team. We are also giving input on how to make these activities available to a wider audience. For example, this project can be replicated by producing and selling Science Making Kits. These kits would include everything needed for a Making the Makers unit for a specific grade level. The teachers could then use the lesson plans and materials to recreate the unit that we have successfully implemented in our school. Future work will focus on expanding the program in a meaningful way so that all students can access this innovative program.

7. BIOS

Rachael Murphy is a 4th grade Math and Science teacher at Neal Elementary School. She has been a Bryan ISD employee for 10 years and has been a Math and Science teacher at Neal Elementary School for 5 years. In her 5 years of teaching, Rachael has developed a fun and engaging way to educate her students, has served as Lead Teacher, and has been an integral part of the Texas A&M Making the Maker program. She is the school representative for the Positive Behavioral Intervention and Supports, a program created and implemented by Neal Elementary school teachers for the district. She is also a 2 year member of the districts Teacher Retention Task Force. Rachael is a graduate of Bryan ISD and Ashford University and holds a Bachelor's Degree in Education. She prides herself in maintaining relationships with both students and faculty and loves that she has the opportunity to teach in the same school district where she was taught. Rachael and her husband are residents of Bryan and have 3 children who are all students/graduates of Bryan ISD.

Mandi Weathers is a 3rd grade Math and Science teacher at Neal Elementary School. In her 11 years teaching, she has developed many creative, hands-on ways of communicating the curriculum to her students, served as a leader in her school and implemented strategies to help her students perform to the best of their abilities in class and in life. She holds a Bachelors in Academic Studies from Sam Houston

State University. She lives in Bryan, Texas with her husband, David and son, Clayton. She is active in her church, enjoys reading, playing board games, and doing crafts in her spare time.

Hector Perez is a 3rd grade Science and Social Studies teacher at Neal Elementary School. In his 26 years teaching, 2 of those at Neal, he has come to believe that being a teacher is a great responsibility, a challenge, but also the best opportunity to make a difference and have a positive impact in today's youth. He holds a Bachelor's Degree in Education as well as a Master's. He has studied Civil Engineering as well at Universidad Iberoamericana in Mexico City. He loves what he does and where he does it. The Maker program has opened doors that were previously nonexistent to broaden the students knowledge and expectations of learning and their future. He is married, has a 15 year old boy, loves sports, meditates and practices Yoga. He also loves music.

Agustin Lara is a 4th grade bilingual teacher at Neal Elementary in Bryan, Texas. He has been employed by the Bryan Independent School District for 21 years. He has a passion for teaching underprivileged English language learners because they share many of the same experiences. Mr. Lara migrated to the United States at the age of 15. He is the first member of his family to obtain a college degree. He holds a bachelor degree in agricultural development from Texas A&M University and a masters degree in education administration from Sam Houston State University. He is currently pursuing his doctorate degree in bilingual education from Texas A&M University. During his free time he teaches Mexican traditional dances to 45 underprivileged children and organizes annually a Mother's Day Program, a Father's Day Program, and a Fourth Grade Bilingual Graduation. Mr. Lara loves traveling around the world to do volunteer work or to conduct research. He has traveled to more than 20 countries. Thanks to those overseas experiences he has been able to expand his appreciation and knowledge of cultures from around the world. He likes to share knowledge gained from those international travels with students, teachers, school administrators and his community.