8-2018

Introducing STEM Education Through A 3D Printing Demonstration

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Abstract

This research project investigates the impact of a science, technology, engineering, and mathematics (STEM) 3D printing presentation on a selected population and evaluates the need for further research on 3D printing as an introduction to STEM education. Participants completed a pre-survey measuring knowledge and interest in STEM education and 3D printing. A PowerPoint presentation demonstrated the viability of STEM education and careers and showed the variety of careers that utilize 3D printing. After the presentation, a demonstration of 3D printed small objects showed a sample of what is possible with the A5 3D printer. Each participant received a 3D printed item as a "takeaway." Finally, a post survey to reevaluate knowledge and interest in 3D printing and STEM education was conducted. After the presentations, researchers analyzed the data from the pre-surveys and post-surveys to examine the change in knowledge of STEM and 3D printing. The results showed students awareness of basic STEM knowledge and exposure to 3D printing. However, there was a deficit in knowledge of STEM careers and a lack of interest in technology found in the research.

Introduction

Technology is evolving around the world today and is constantly changing the way clothing is manufactured and produced. There are numerous impacts of technology in the world; however, one of the main impacts is its influence on the fashion industry. Using technology, the fashion industry has opened an abundance of outlets for new, creative ideas, including the implementation of 3D printing with science, technology, engineering, and mathematics or STEM.

In the 1990's, the term used for the combined areas of science, technology, engineering, and mathematics, STEM, was created at the National Science Foundation. Since then, it has been used as a generic label by programs through policies and practices that involve one or several of the STEM disciplines. A study conducted by Quinn (2012), examined Fashion Futures and how clothing is made and processed using 3D printers, software, and computer hardware (Quinn, 2012). Additionally, individuals have international and domestic opportunities in well-paying jobs such as architecture and textile design within the STEM fields. Just over 4% of the workforce focuses on STEM occupations; however, it is critical to economic productivity and technological innovation (Hill, 2010).

One of the rapidly emerging technologies, 3D printing, has revolutionized the way products are produced and has provided opportunities for STEM students to create new technological skills as they print their own creations (Sabantina, Kinzel, Ehrmann, and Finsterbusch, 2015). Three-dimensional printing has surfaced in many STEM fields including archeology, engineering, education, health and many others: 3D printers are making practical impacts around the globe (Canessa, Fonda, Zennaro, 2013). With the rising use of 3D printing in several career fields, increasing prior education and general knowledge of the subject could

inspire students, specifically high school students, to utilize STEM, 3D printing, and other technological skills to participate in STEM careers.

This research focused on two specific objectives: objective one involved introducing 3D printing as an interesting way to present STEM topics to high school students and objective two determined if the introduction to STEM provided a change in knowledge of STEM topics and 3D printing. From these objectives, four hypotheses were constructed, which are listed below.

- H_1 - Participants are more likely to report an increased awareness of STEM careers after exposure to a 3D printer presentation.
- H_2 - Participants are more likely to report interest in technology after exposure to a 3D printer presentation.
- H_3 - Participants are more likely to report interest in pursuing a technology-based career after exposure to a 3D printer presentation.
- H_4 - Participants are more likely to report increased intention to attend college after exposure to a 3D printer presentation.

This thesis paper was a group research project written to complete honors requirements. Without the group aspect, it would not have been possible to complete all necessary elements needed to research the two objectives. Kennedy Rickard focused on objective one, which included the responsibilities of obtaining funding, purchasing materials, and securing the sample population. Emily Vrbas focused on objective two, which included creating the 3D object, analyzing the data, and presenting the research to Gamma Sigma Delta Honors Society at the annual poster competition. Together, they completed the presentation and demonstration in the classroom, collected data, input the data into Excel, and completed this research paper. This research project was supported by funding from a University of Arkansas Honors College

Research Grant, which was used for materials, traveling, and other expenses. We would like to thank our committee, Ms. Stephanie Hubert, Dr. Kathleen Smith, and Dr. Mahendran Balasubramanian, for their help throughout this research project, as well as a special note of appreciation to NWA 3D for consultation and design assistance.

Literature Review

Individuals around the world are entering lucrative jobs utilizing STEM education. The STEM field has grown by reaching out and educating younger generations before they reach college or their future careers. Making 3D printing more financially achievable and attainable for younger generations is in development and holds a promising future (Canessa et al., 2013).

Just over 4% of the workforce focuses on STEM fields, which are critical to economic productivity and innovation (Hill, 2010). The decreasing number of individuals focused on STEM could lead to a decrease in the production of new technologies and become a problem in the future. This possibility might affect the future for those going into STEM related fields and create barriers for entry into STEM related careers.

Interest in STEM careers comes from hands on activity within STEM technology and applying what is learned to further individual success in the STEM field (Hill, 2010). This helps within the 3D printing process and with the creation of an object. Because 3D printing is a rapidly emerging technology, it has revolutionized the way products are produced (Sabantina et al., 2015). Futuristic designs produced using 3D printers are often inspired by science, climate change, space suits, artificial intelligence, genetic engineering, or even nanotechnology (Quinn, 2012). These new types of inspiration are changing the fashion industry and influencing the target market, reaching a wide range of people who may not have been interested before (Campbell & Parsons, 2005).

The 3D printing industry started in the late 1980's with a limited number of initial experiments and a limited number of expensive machines, which could only be used by professionals (Canessa et. al, 2013). Three-dimensional printing has evolved over time into a technology that can be used by the masses for a variety of needs. The fast-moving, 3D printing revolution is spreading on a global scale and benefiting industries and educational programs around the world (Canessa et. al, 2013).

To ensure students are interested in entering STEM programs in college and pursuing STEM jobs, they must be educated in high school or before about the basics of STEM and the viability of its related careers. Companies such as Stratasys are establishing modules that can be implemented into curriculums at the middle and high school levels, although programs like these are still very rare (Stratasys, 2016). A challenge that the school systems face is the lack of general guidelines for teachers to follow regarding how to teach using STEM integration approaches in the classroom (Wang, Moore, Roehrig, and Park, 2011).

One of the schools, which has implemented 3D technology programs into their curriculum, is Bishop McLaughlin Catholic High School located in Florida. They began applying 3D printing to real world problems within their community (3D Printing, 2017). Although this school was successful and had the resources, the majority of schools do not have the funds to educate their students on STEM or 3D printing. Even if the school does have the funding, there may not be upper level courses for those interested to pursue further education. Companies have noticed this and some have funded or supplied schools with 3D printers (Molitch-Hou, 2014).

Also in Florida, the "Race to the Top" grant has been reaching out to smaller, rural schools, pairing students with engineers and allowing them to explore different areas of STEM

by working on high demand projects (Progress, 2013). State officials believe that the funds of the grant will prepare students for future STEM related college majors and careers. In Florida, there has been a 12% increase in enrollment in STEM programs (Progress, 2013). If Arkansas schools applied similar mindsets and gained funding for schools, we could potentially see similar trends in STEM enrollment and interest. By increasing access and education to STEM classes and increasing awareness and interest in 3D printing, the United States could begin leading these fields.

In Arkansas, strides have been made to introduce STEM education. Recently in 2016, Microsoft and Governor Hutchison came to an understanding that Microsoft would partner with state programs to introduce STEM into education (Lyon, 2016). There are a variety of initiatives that the state and Microsoft are collaborating on, including: YouthSpark, DigiGirlz Camp, and Microsoft Classroom. Arkansas is the first state to partner with Microsoft, which supports Hutchison's goal of "keeping up momentum" and having computer science taught in all Arkansas public high schools (Lyon, 2016).

A branch of the University of Arkansas, the University of Arkansas at Little Rock (UALR), has a STEM Education Center to connect those interested in STEM in Arkansas schools. The STEM Education Center pairs those who are interested in STEM both inside and outside of the college (STEM Education Center, n.d.). The Center also provides curriculum and other education opportunities for educators to pass on to their students (STEM Education Center, n.d.).

Along with the previous initiatives, programs, and opportunities, there is the Arkansas STEM Coalition. This coalition is a statewide partnership for the education system and corporations to work in STEM focused areas. The coalition hopes that, by increasing the access,

knowledge, and use of STEM throughout Arkansas, it will expand our economy (About the Arkansas STEM Coalition, n.d.). The Arkansas STEM Coalition has several programs to achieve these goals including the Computer Science Initiative and Girls in STEM to increase girls' involvement in science programs. To access the female students, conferences are held throughout the state, with a total of 3,600 girls in grades 7-12 attending over the past three years (About the Arkansas STEM Coalition, n.d.). There is also a Laptop Loan Program for high schools to receive loaned laptops from the state to enhance students' computer skills. Pea Ridge School District, where this research was conducted, benefits from this program. Finally, a unique program offered by the coalition allows for the purchase of education themed license plates and a portion of the income goes towards providing science education and supplies to both educators and students across the state (About the Arkansas STEM Coalition, n.d.). There are a variety of science centers throughout the state, including the University of Arkansas, that obtain funding and partner with the STEM Coalition.

Also in Arkansas, there is the Arkansas School for Mathematics, Science, and the Arts. This school is a residential program similar to college where students take college level courses focused on STEM related areas in small classroom settings (ASMSA, n.d.). While this specialty school is available to all students in Arkansas, it still may not be feasible for all students to attend. Many courses at this school focus heavily on introducing students to the areas of STEM in different classes with hands on projects and activities (ASMSA, n.d.).

However, even with the introduction of specialty high schools, programs, and initiatives throughout the state, there is a decrease in overall STEM interest (The Condition of STEM, 2016). This is seen in the Arkansas STEM Report, where between 2014 and 2016 there was a 1% decrease in interest. While slight, if the trend continues, we could lose our momentum and

funding. This finding was not only seen in Arkansas, but across the United States in those who took the ACT (The Condition of STEM, 2016).

It is vital that states realize the viability, potential, and growth of STEM based careers and introduce students to these concepts so that there will not be gaps in the workforce in these important areas. Careers utilizing STEM topics are not just engineering and computer programming, but can include the medical field, STEM education, and architecture. According to the Bureau of Labor Statistics, in 2015 there were approximately 8.6 million jobs based in STEM in the United States. Computer related careers are the most common, making up approximately 45% of all STEM careers (Fayer, Lacey, & Watson, 2017). Computer focused jobs also have the most potential growth in the future. These career areas typically have wages above national averages, which can act as an incentive to pursue a career in STEM (Fayer et al., 2017). However, it is recognized by the Bureau of Labor Statistics that STEM occupations demand a higher education requirement, typically requiring a bachelor's degree at a minimum. Even with the increasing demand of STEM jobs, Arkansas was among the states that added the fewest number of STEM careers since 2009 compared to states such as California and Texas that added more than 24,650 (Fayer et al., 2017). While most careers in STEM require a form of post-secondary education to be successful, many students are losing interest before college. This illustrates why partnerships with companies are important to provide opportunities for students to participate in unique, stimulating activities furthering their education and leading to potential careers in STEM.

Although most of the aforementioned programs are for high school curricula, it can be argued that it is never too early to introduce STEM to children, as seen in the Mand Labs article, "Why STEM Education Should be Introduced Early on for Children." This article explains that

you do not need expensive technologies to introduce these concepts because simple activities can explain STEM ideas (Why STEM Education, n.d.). Activities such as simple water pressure activities or utilizing building blocks can be a stepping-stone into STEM.

Three-dimensional printing is a stimulating activity in the STEM world. Although, 3D printing takes time and consistency to learn the process from design to creation, students can learn and become faster with practice and hands-on experience (Canessa et. al, 2013). The cost and efficiency of 3D printers is a continuing limitation. Portable 3D printers are now customizable and assembled for those who are concerned with accessibility. The three-dimensional component encourages a creative and experimental process that can lead to a more intricate design. The integration of 3D technology, in many forms, allows for visualization of new creative possibilities that the STEM field has to offer (Campbell & Parsons, 2005).

Some Arkansas high schools made strides in 3D printing. For example, at Hot Springs World Class High School, students printed a brain tumor for a patient after surgery (Saunders, 2018). The students who worked on this project intend to take it further by creating 3D copies of tumors before surgery for both the patient and surgeon. By providing a copy for the surgeon, they may have a better understanding of what they are working against and what is the best way to approach the surgical procedure. At Little Rock Christian Academy, a student also began 3D printing for the medical field by printing a prosthetic hand for a younger student at the same school (Mershon, 2018). Another student created a prosthetic leg for an injured duck using 3D printing technology (Ramsey, 2018).

According to Bertram and McDonald (2013), “For the next generation of scientists, engineers and technologists to succeed, they must develop a basic understanding of engineering

design and have hands-on experience creating, building and refining new ideas, inventions and innovations." (para. 4).

Materials and Methods

Purpose Statement

With the rising use of 3D printing in several career fields, increasing prior education and general knowledge of the subject could inspire students, specifically high school students, to utilize STEM, 3D printing, and technological skills to participate in STEM careers. Objective one of this project was to introduce 3D printing as an interesting way to present STEM topics to high school students and objective two was to determine if the introduction to STEM provided a change in knowledge of STEM topics and 3D printing.

Sampling Method

For this research, a sample of high school students ages 15-18+ were obtained (See Chart 1). This sample came from a population at Pea Ridge High School located in northern Benton County, Arkansas. The 3D printing demonstration and STEM presentation was conducted during one school day of scheduled class periods. The Family and Consumer Sciences classes that were surveyed included 9^{th}-12^{th} grades (See Chart 2). In total, there were 95 participants. The selection process involved separating students into groups based on those who had signed parental consent forms and those who did not. The participants were pre-divided into groups based on the time period of their class. Overall, a cluster sample was utilized. The sample was restricted because of the limitation to one class type in the entire school. Surveys of other classes were not allowed, which if surveyed could have resulted in a more diverse sample and different responses.

In total, the participants were mostly white females. Parent consent forms were obtained from all 95 participants surveyed. The study consisted of 67 female and 26 male high school students; 2 students preferred not to disclose their gender. Over 70% of students sampled were female students and only 26% were male (See Chart 3). Of the 95, 38 of the participants were 14-15 years old, 53 students were 16-17 years, and 4 students were 18+ years (See Chart 1). The results were also categorized into grades 9^{th} – 12^{th} resulting in 24 students in 9^{th} grade, 42 students in 10^{th} grade, 19 students in 11^{th} grade, and 10 students in 12^{th} grade (See Chart 2). The students' ethnicities consisted of five American Indians, one Asian, seventy-nine Caucasians, four Hispanics, one Native Hawaiian, and four students preferred not to disclose ethnicity (See Chart 4). The participants in our survey took part as an extra credit assignment in their class and received a 3D printed Arkansas keychain in return (See Figure 1).

Materials

A computer and TV screen displayed a PowerPoint presentation about 3D printing. The PowerPoint presentation consisted of multiple text slides, pictures, and a 3D printing video. The video explained how 3D printers can be used at home and displayed different uses of 3D printed clothing. The presentation was followed by a 3D printer demonstration using an A5 3D printer.

On display during the presentation was a 3D printed Arkansas keychain. To construct the 3D printed keychain, several different types of software were used to produce the design and a visit to NWA3D helped develop multiple figures. By using a free, computer aided design software, 123Design, an object was created to demonstrate printing for the class. The object was saved as a stereolithography (.STL) file and uploaded into Cura software, a software that converts the .STL file to a printable (g-code) file. To fund this research, a grant was obtained

from the University of Arkansas Honors College. This research grant assisted in buying filament, funding travel cost, and paying other expenses.

Data Collection

In each class period, the project began with the pre-survey consisting of 15 multiple-choice questions to evaluate the student's knowledge of STEM (See Appendix for the pre-survey questions). Each student received a slip with a four-digit code. The student was responsible for writing the code on their pre and post survey so that the pre and post responses could be matched while maintaining the anonymity of the respondents. Next, a 10 minute STEM presentation with short video clips was shown, followed by a 3D printer demonstration using an A5 3D printer (See Figure 2). The 3D printer was preheated and was preloaded with the filament and the 3D (g-code) file so that it was ready to print before the presentation began. Students then observed a 3D printed Arkansas keychain in the printing process. The object was created out of polylactic acid, PLA, a low cost hard filament. Each print required about 13 minutes to complete. To conclude the class period, students completed the post survey consisting of 20 multiple-choice questions and Likert type questions to evaluate any change in knowledge or interest in STEM and 3D printing (See Appendix for post-survey questions). The experiment lasted 45 minutes total.

The surveys were created to measure students' responses to our STEM presentation and 3D printer demonstration. Data was entered into a MS Excel spreadsheet for evaluation and classified as pre-survey, post-survey, and scale data with responses under each individual code. Once the data from the pre and post survey questions were entered into a MS Excel spreadsheet the data was transferred into IBM SPSS Statistics where a McNemar test was run to analyze any noticeable difference in pre and post responses. The McNemar's test was used to determine if

the four hypotheses were proven to be true. The data was also categorized by gender, ethnicity, age, and grade level. This data was imported into IBM SPSS and was analyzed by converting the variables into frequency tables.

Results

The four hypotheses listed below are based on the four variables.

H_1 - Participants are more likely to report an increased awareness of STEM careers after exposure to a 3D printer presentation.

H_2 - Participants are more likely to report interest in technology after exposure to a 3D printer presentation.

H_3 - Participants are more likely to report interest in pursuing a technology-based career after exposure to a 3D printer presentation.

H_4 - Participants are more likely to report increased intention to attend college after exposure to a 3D printer presentation.

A McNemar test was used to develop the pre and post survey data in the form of contingency tables. The variable was asked, "Are you aware of any STEM Careers?" on the pre and post survey (See Graph 1). Results from the McNemar Test showed an exact value of .000 which proves there was a significant change in knowledge of STEM careers. Statistical significance is indicated when the p-value is less than .05, supporting acceptance of hypothesis one. Although there was not a statistical significance in the other three variables, there was a slight change from pre to post survey data.

The second variable was "Are you interested in technology?" with a P-value of .508 showing a slight change with the frequency of "Yes" answers increasing by three participants

(See Graph 2). The third variable asked, "Are you interested in a technology based career?" Based on the results from the McNemar test the P-value was .180 (See Graph 3). The fourth question, "Do you intend to go to college?" provided a P-value of 1.00 (See Graph 4). We found that there was no substantial change in the second, third, and fourth variables. After analyzing data this could be due to missing information within the initial STEM and 3D presentation, therefore, further modifications need to be considered.

The scale from the post survey ranging from "Strongly Agree" to "Strongly Disagree" was made up of Likert type questions (See Graphs 5, 6, 7, and 8). When asked to rate their response to the statement, "I have learned additional information about STEM education," more than 80% answered that they agree and less than 4% said that they did not learn any new information about STEM (Graph 9). This indicates that 77 students agree that they have learned new information about STEM education and only 4 students disagree; signifying significant value in our first hypothesis "Participants are more likely to report an increased awareness of STEM careers after exposure to a 3D printer presentation." More Likert type questions were asked in order to rate the students response to the presentation and demonstration (See Graphs 10, 11, 12, and 13).

Discussion

For a more accurate analysis of the impact of this research, the study needs to be repeated in a larger population to further validate generalizations. For example, the study would benefit from being completed at both public and private schools, in rural and urban areas and, potentially, in both domestic and international areas. Data that are more extensive could then allow further comparison between the differences between public and private education, rural and urban areas and how these different populations influence entry into STEM education and

STEM careers. Extending this research internationally would help to predict how the United States of America compares to the other areas of the world. The data results from this research indicated a significant impact from the 3D printer demonstration, leading to this conclusion. Given that there was an increase in knowing what STEM stood for, 99% in total, demonstrates that introduction of STEM education provided prior to this research was not substantial enough. There is a need to educate students more completely on the breadth of STEM uses and careers and the viability of 3D printing.

Further study is also recommended to provide a complete picture of how Arkansas compares to other states. The data reported in the literature review stated that California and Texas added more STEM jobs than Arkansas. This statistic was reported as a number of jobs, which would be expected in the largest states in the country. Further investigation into the number of jobs added as a percentage of the state population could show that Arkansas is more successful than it appears.

Unlike literature referenced above, no local businesses funded STEM courses or provided 3D printers to Pea Ridge High School. Rather, like the literature, they do offer a single STEM course that teaches students how to use a 3D printer and how this technology is utilized to help change real world solutions. The results of this research show that one class is not enough. More in-class opportunities need to be available for students working towards STEM related career goals.

The primary objective of this research project was to provide a basic 3D printing demonstration as a way to increase knowledge of STEM and 3D printing and to increase student interest in STEM careers. The demonstration and surveys are simple enough to be easily

duplicated at other schools. Translations and adaptation of the presentation might be necessary to increase the impact in specific classes.

College degrees and careers regarding STEM need to increase exponentially. If students are not prepared prior to college, there could be a significant gap in both knowledge and interest in these areas that might severely affect STEM growth in the United States. By introducing these concepts at an earlier education level such as high school, school systems can develop upper level curricula for students to further their STEM education before college. This could increase exposure and general knowledge about the variety of uses of STEM in most, if not all, careers. Research indicates it is necessary to reach students before they get through college in order to encourage them to obtain degrees and develop skills necessary to succeed in areas related to science, technology, engineering, and mathematics.

References

3D printing: Service to our community. (2017, June). Bishop McLaughlin Catholic high school, Spring Hill, Florida. *District Administration*. Retrieved from https://www.districtadministration.com/techx/awards/bishop-mclaughlin-catholic-high-school-spring-hill-florida

About The Arkansas STEM Coalition. (n.d.). Retrieved from https://arkansasstemcoalition.com/about/

ASMSA. (n.d). Retrieved from http://www.asmsa.org/

Bertram, V., McDonald, J.W. (2013, November 11). Bringing Real-World Science to The Classroom. Retrieved from www.usnews.com/opinionarticles/2013/11/11/how-to-get-middle-and-high-school-students-interested-in-stem

Campbell, J. R. & Parsons, J. (2005). Taking advantage of the design potential of digital printing technology for apparel. *Journal of Textile and Apparel, Technology and Management, 4*(3), 1-10. Retrieved from https://textiles.ncsu.edu/tatm/wp-content/uploads/sites/4/2017/11/Campbell_full_133_05.pdf

Canessa, E., Fonda, C., Zennaro M. (Eds.). (2013). Open book on "*Low-cost 3D printing for science, education and sustainable development.*" Retrieved from http://sdu.ictp.it/3D/book.html

The Condition of STEM. (2016). Retrieved from http://www.act.org/content/dam/act/unsecured/documents/STEM2016_52_National.pdf

Fayer, S., Lacey, A., Watson, A. (2017, January). STEM occupations: past, present, future. Retrieved from https://www.bls.gov/spotlight/2017/science-technology-engineering-and-mathematics- stem-occupations-past-present-and-future/home.htm

Hill, C. (2010). Why so few? Women in science, technology, engineering, and mathematics. Retrieved from http://www.aauw.org/research/why-so-few/

Lyon, J., & Arkansas News Bureau. (2016, December 12). Microsoft to partner with Arkansas to promote STEM education. Retrieved from http://www.arkansasnews.com/news/20161212/microsoft-to-partner-with-arkansas-to-promote-stem-education

Mershon, M. (2018, May 10). Little Rock high school student uses 3-D printer to create prosthetic for a fellow student. Retrieved from http://katv.com/news/local/little-rock-high-school-student-uses-3-d-printer-to-create-prosthetic-for-a-fellow-student

Molitch-Hou, M. (2014, October 6). NVBots goes to fundable to bring 3D printing to low-income schools. *3D Printing Industry*. Retrieved from 3dprintingindustry.com/news/nvbots-goes-fundable-bring-3d-printing-low-income-schools-34139/

Progress: Teachers, leaders and students transforming education. (2013). Retrieved from https://sites.ed.gov/progress/2013/12/bringing-stem-to-rural-scholars-in-florida/

Quinn, B. (2012). *Fashion futures*. London: Merrell.

Ramsey, D. (2018, January 8). Eighth grade students in northeast Arkansas build prosthetic foot for duck with 3D printer. Retrieved from https://www.arktimes.com/ArkansasBlog/archives/2018/01/08/eighth-grade-students-in-northeast-arkansas-build-prosthetic-foot-for-duck-with-3d-printer

Sabantina, L., Kinzel, F., Ehrmann, A., & Finsterbusch, K. (2015). Combining 3D printed forms with textile structures-mechanical and geometrical properties of multi-material systems. In *IOP Conference Series: Materials Science and Engineering* (Vol. 87, No. 1, p. 012005). IOP Publishing.

Saunders, S. (2018, January 31). High school students first people in Arkansas to successfully 3D print a brain tumor. Retrieved from https://3dprint.com/202105/3d-print-brain-tumor-arkansas/

STEM Education Center. (n.d.) Retrieved from https://ualr.edu/stemcenter/

Stratasys launches 3D printing education modules. (2016). *CAD/CAM Update*, *28*(2), 2-4.

Wang, H.H.; Moore, T.J.; Roehrig, G.H.; and Park, M.S. (2011). "STEM Integration: Teacher Perceptions and Practice," *Journal of Pre-College Engineering Education Research* (J-PEER): Vol. 1: Iss. 2, Article 2. https://doi.org/10.5703/1288284314636

Why STEM education should be introduced early on for children. (n.d.) Retrieved from https://mandlabs.com/blog/why-stem-education-should-be-introduced-early-on-for-children/

Figures

Figure 1. 3D Printed Arkansas Keychain

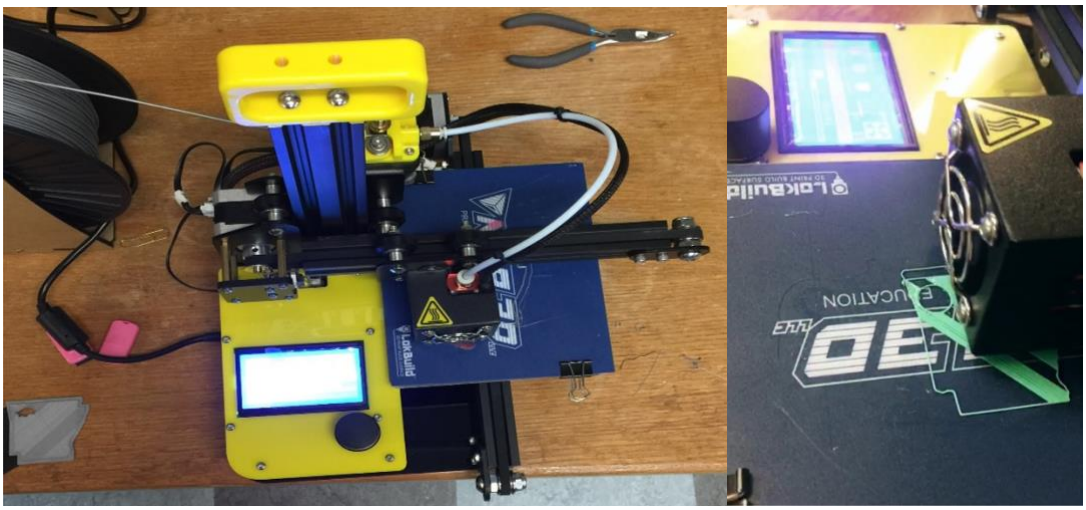


Figure 2. A5 3D Printer

Charts

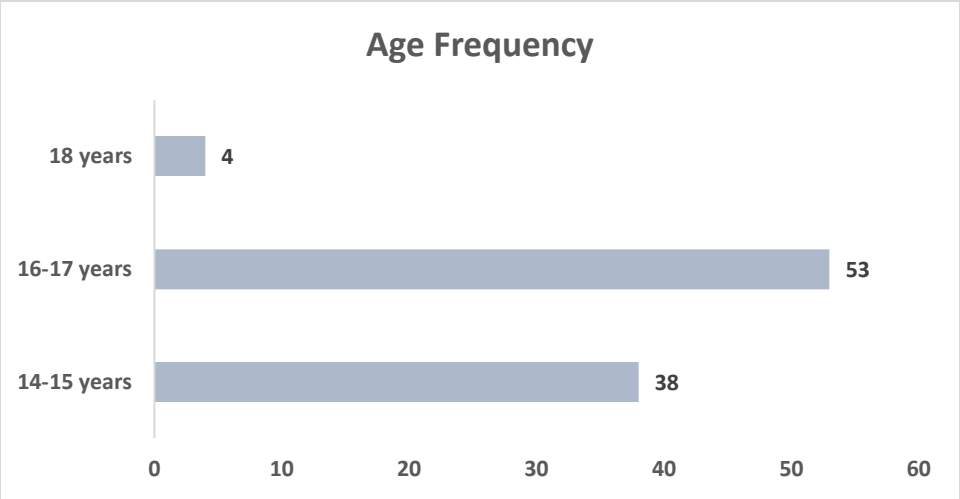


Chart 1. Age frequency chart

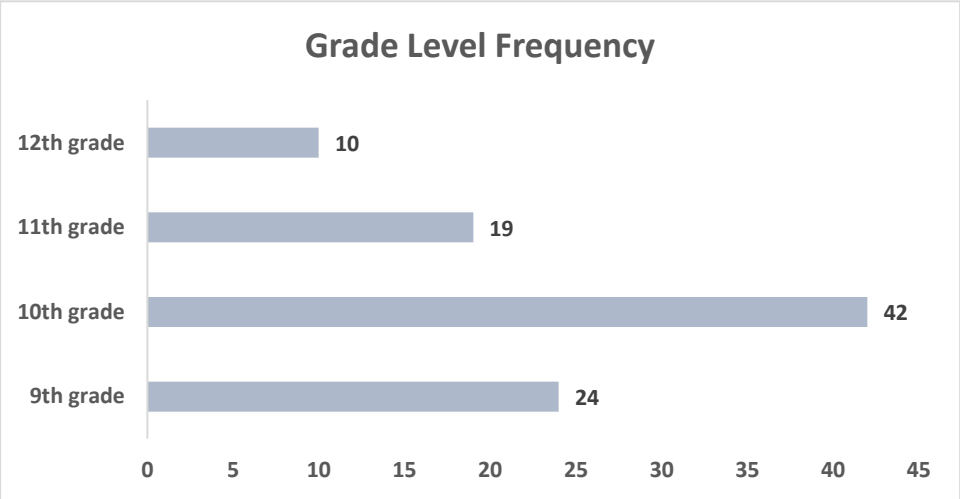


Chart 2. Grade level frequency chart

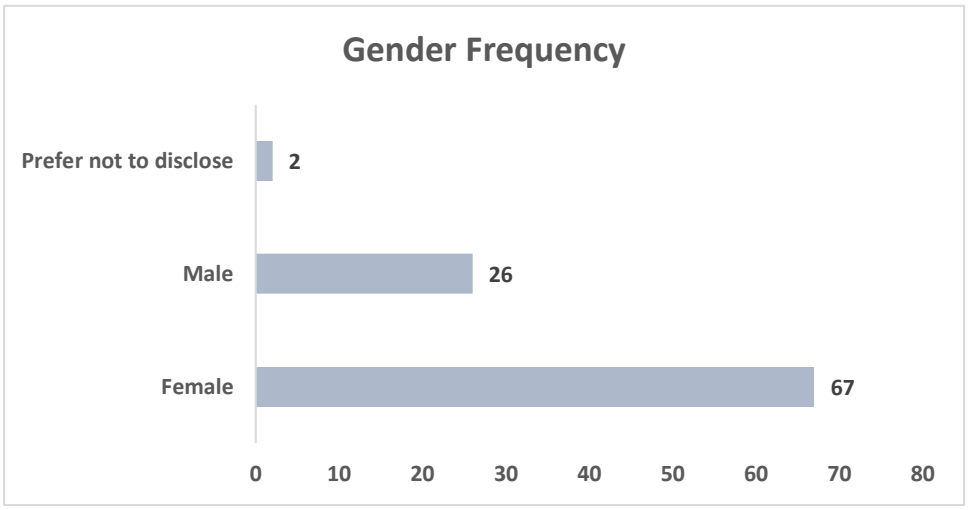


Chart 3. Gender frequency chart

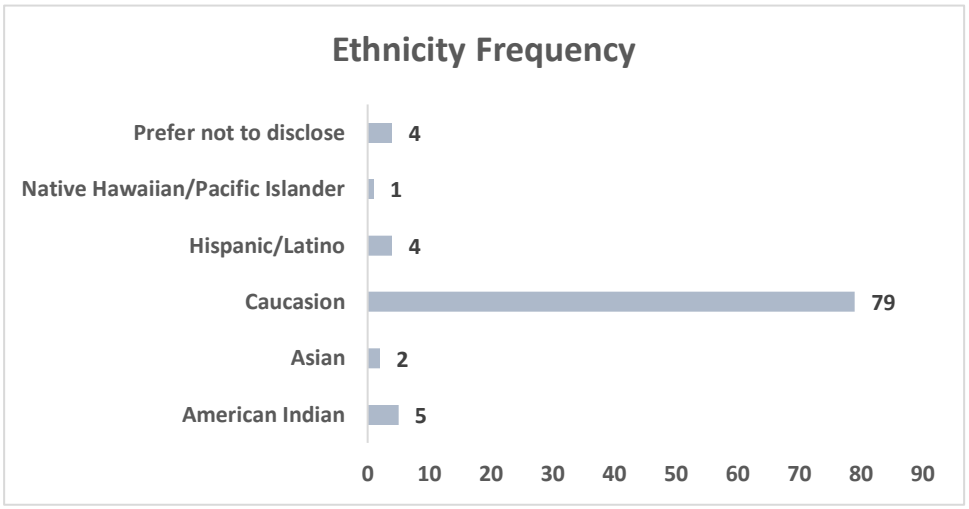
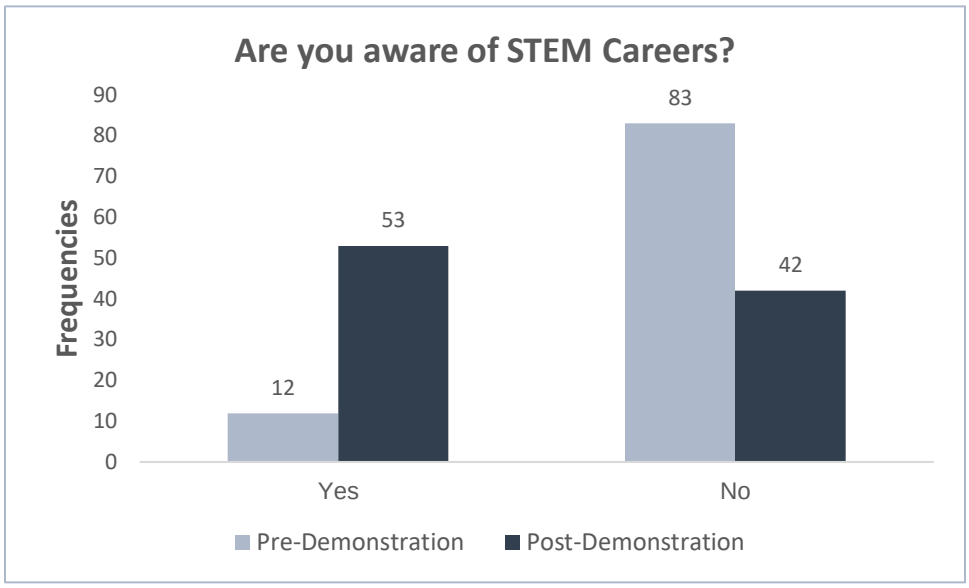
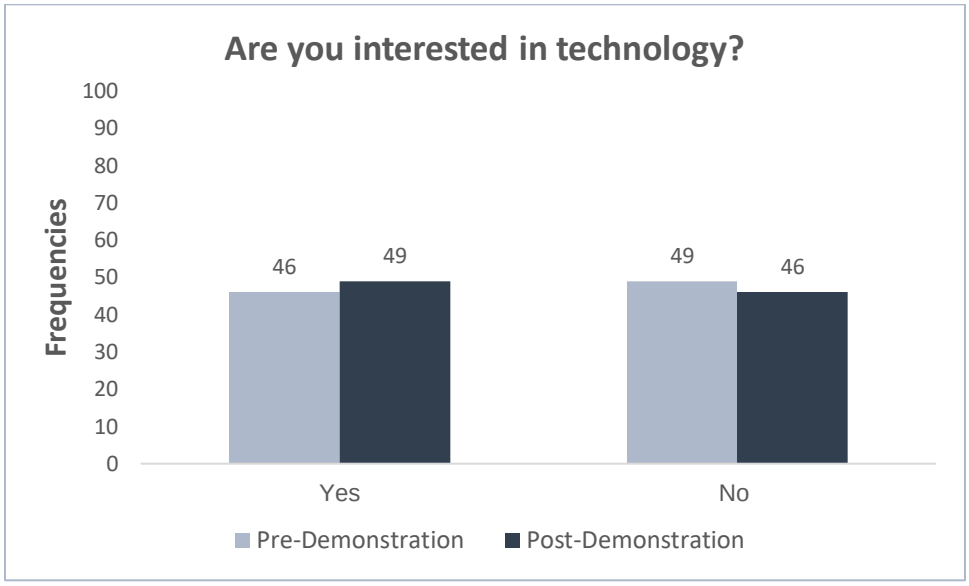


Chart 4. Ethnicity frequency chart

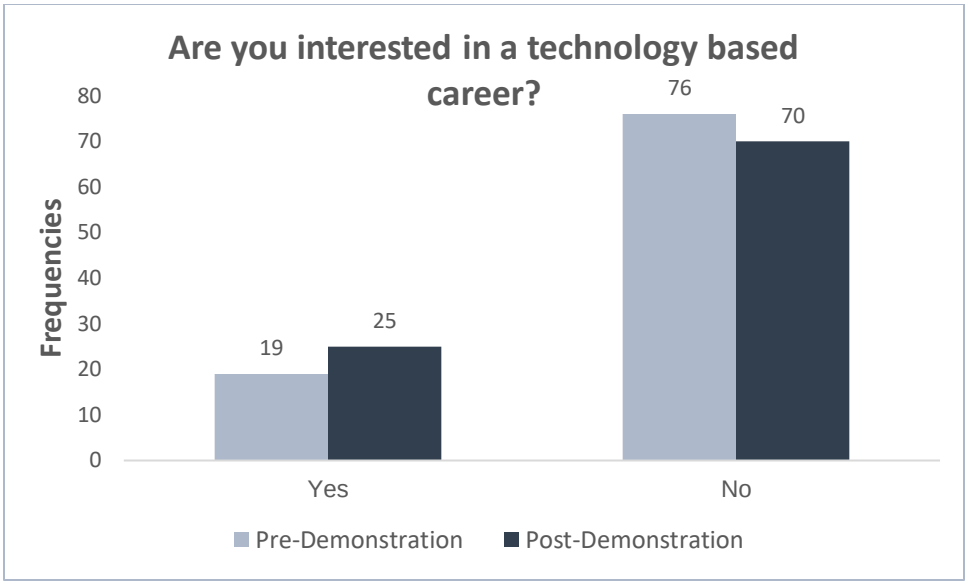
Graphs



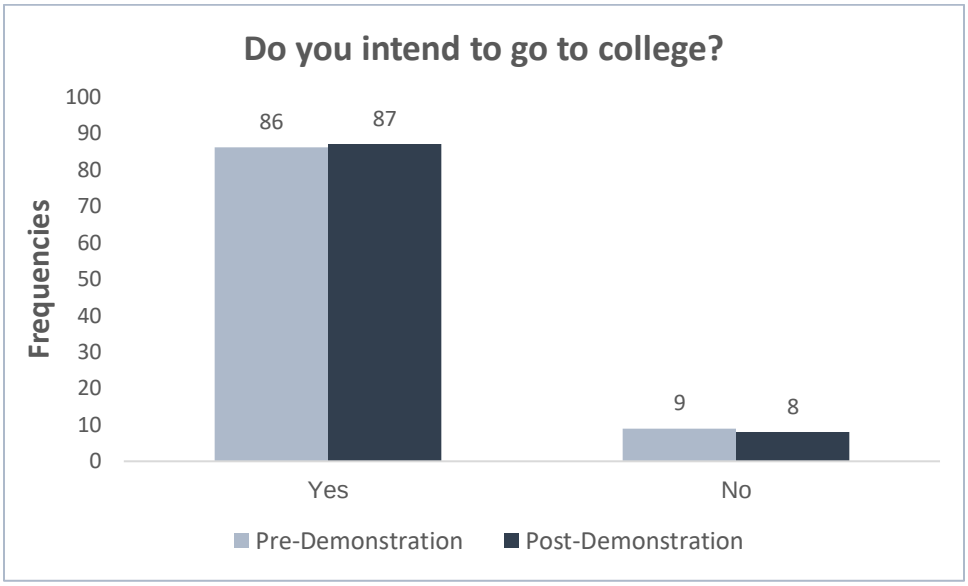
Graph 1. This graph represents student's awareness of STEM Careers pre-demonstration and post-demonstration.



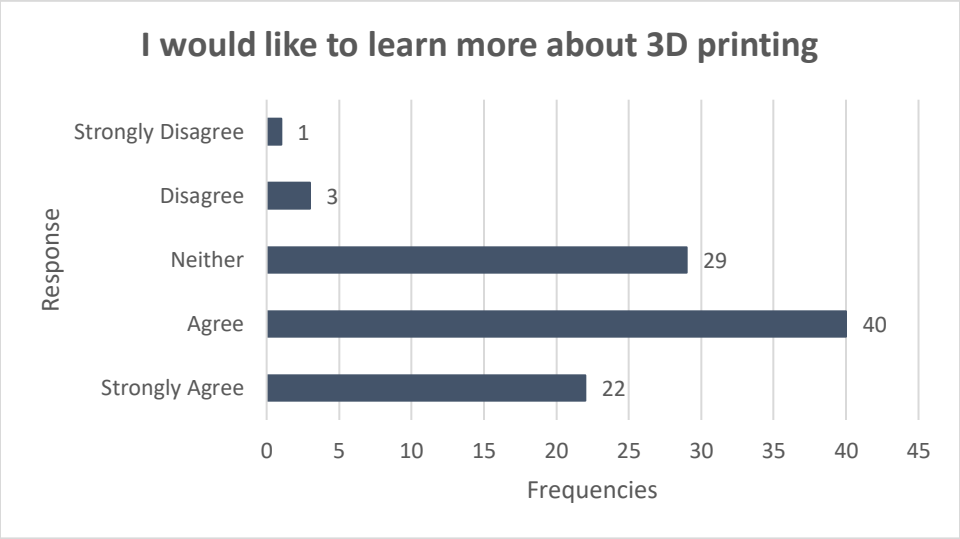
Graph 2. This graph represents the frequencies of students responses interested in technology.



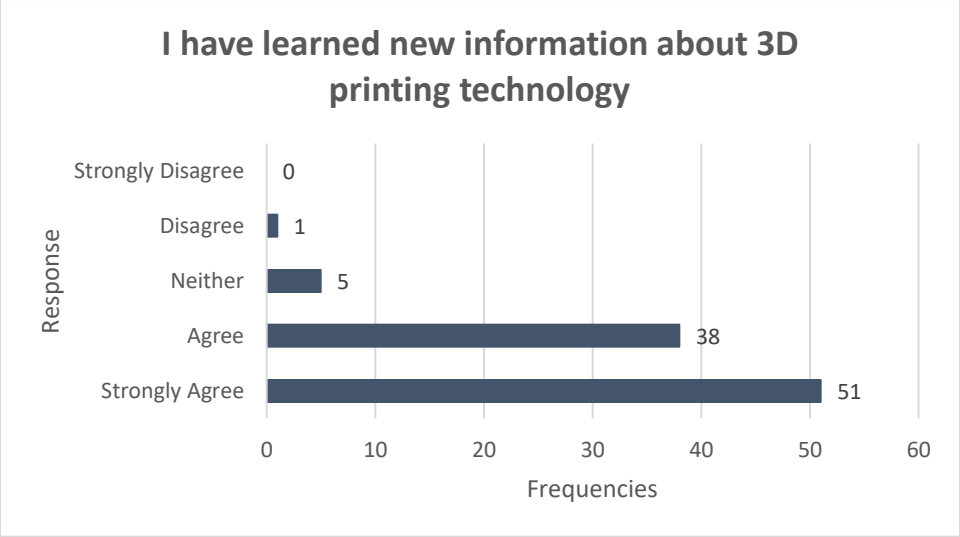
Graph 3. This graph represents the frequencies of students responses interested in technology based careers.



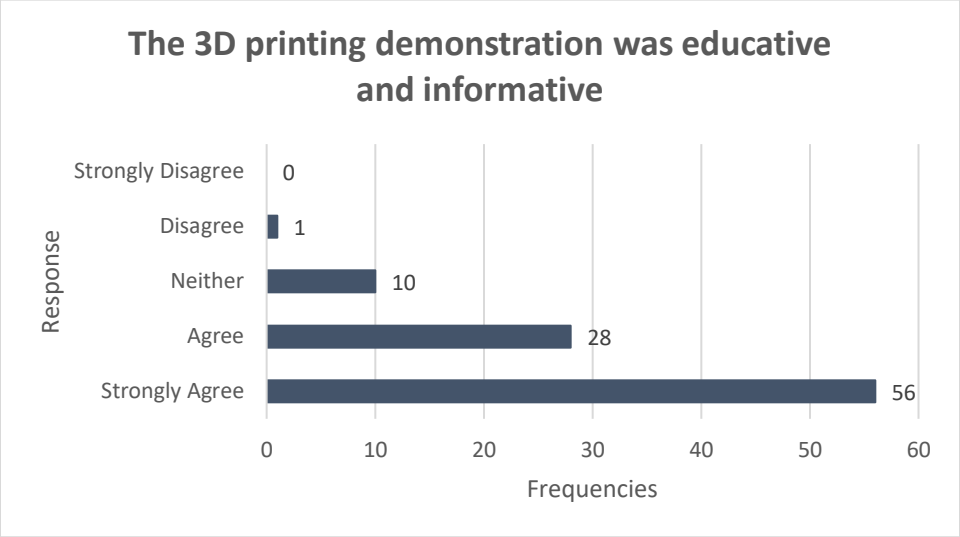
Graph 4. This graph represents the frequencies of student's responses intending to go to college.



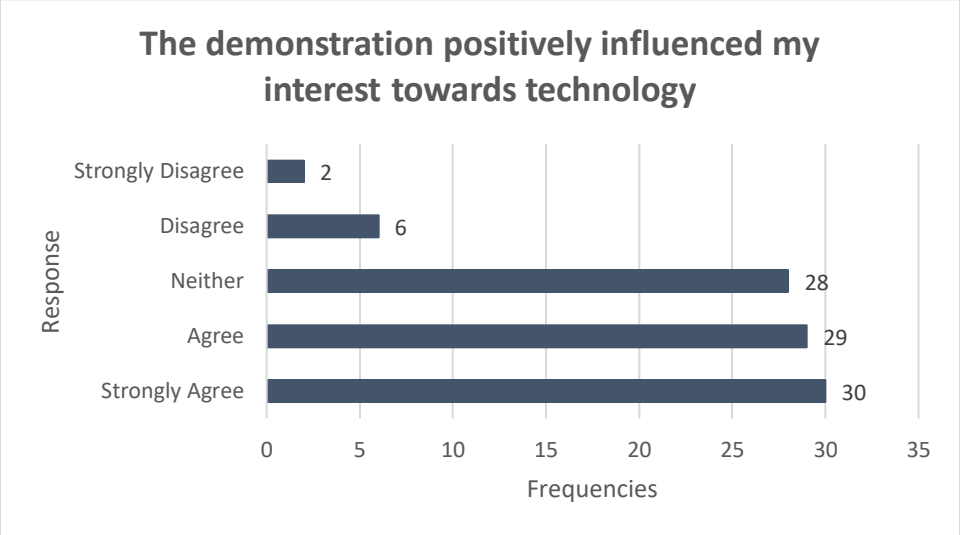
Graph 5. The Likert type question "I would like to learn more about 3D printing?" was asked on a scale ranging from strongly agree to strongly disagree.



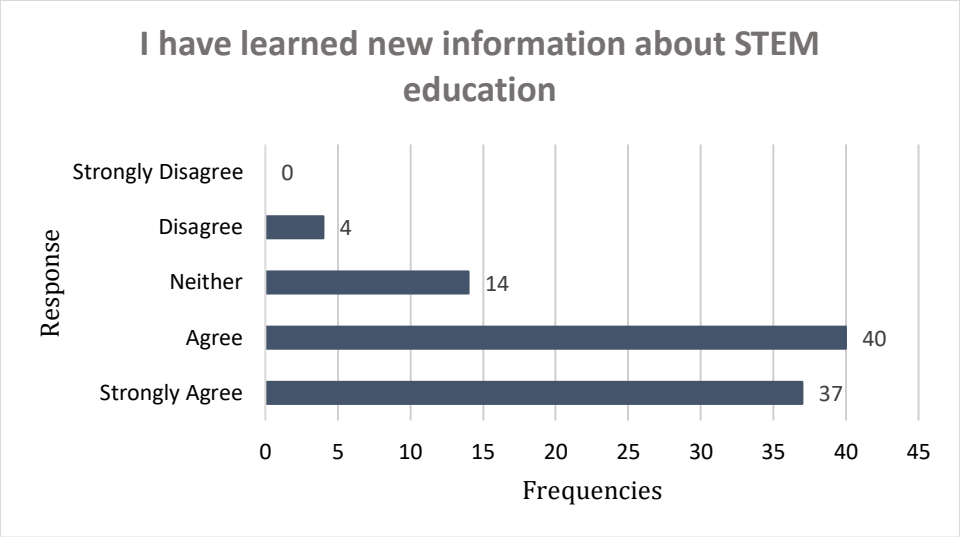
Graph 6. The Likert type question "I have learned new information about 3D printing technology" was asked on a scale ranging from strongly agree to strongly disagree.



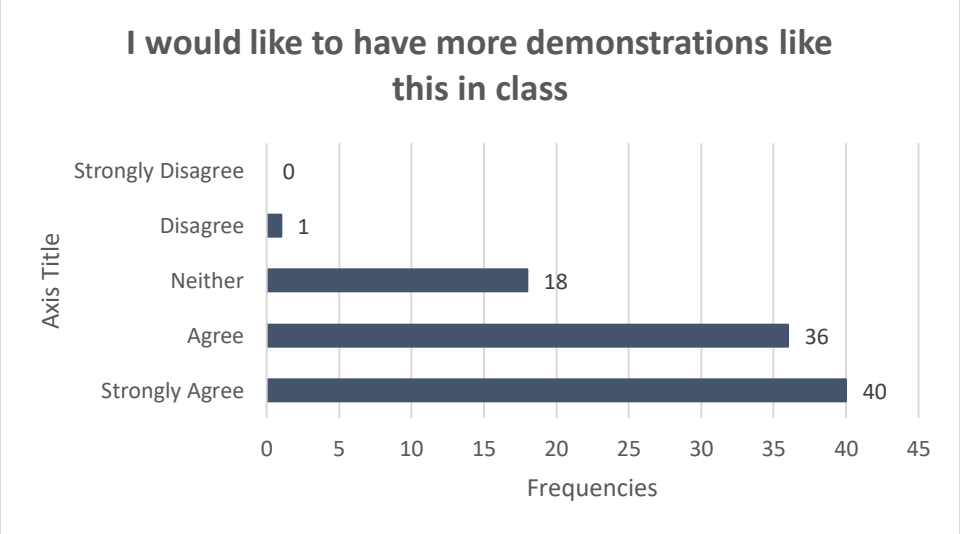
Graph 7. The Likert type question "The 3D printing demonstration was educative and informative" was asked on a scale ranging from strongly agree to strongly disagree.



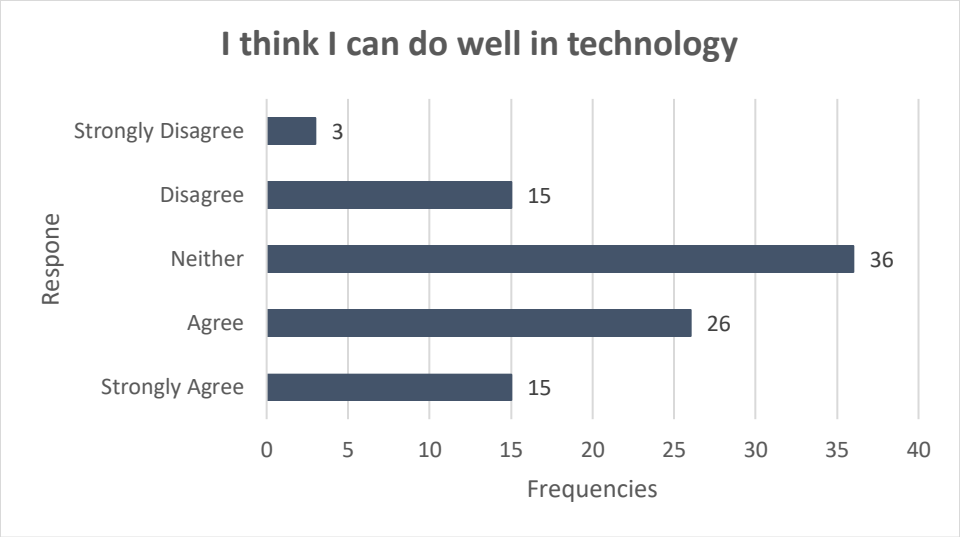
Graph 8. The Likert type question "The demonstration positively influenced my interest towards technology" was asked on a scale ranging from strongly agree to strongly disagree.



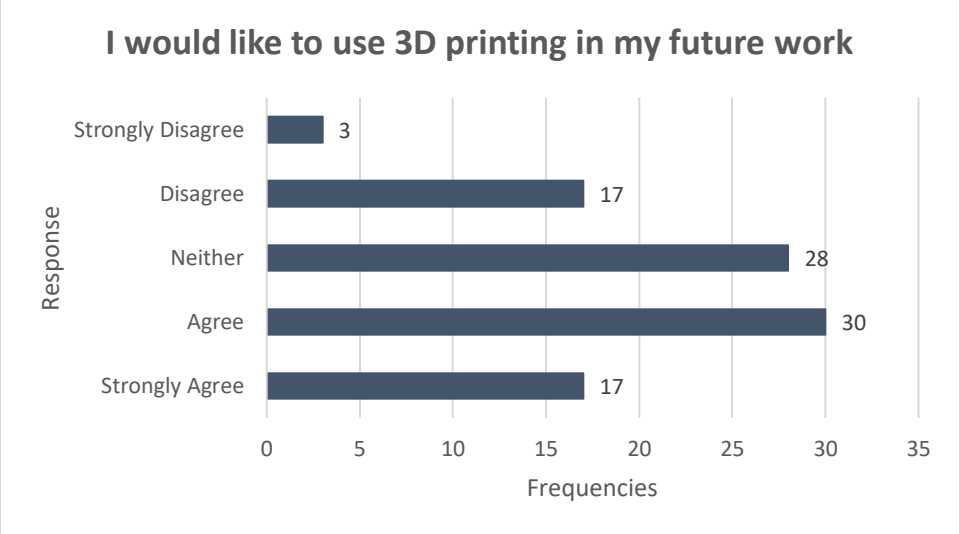
Graph 9. The Likert type question "I have learned new information about STEM education" was asked on a scale ranging from strongly agree to strongly disagree.



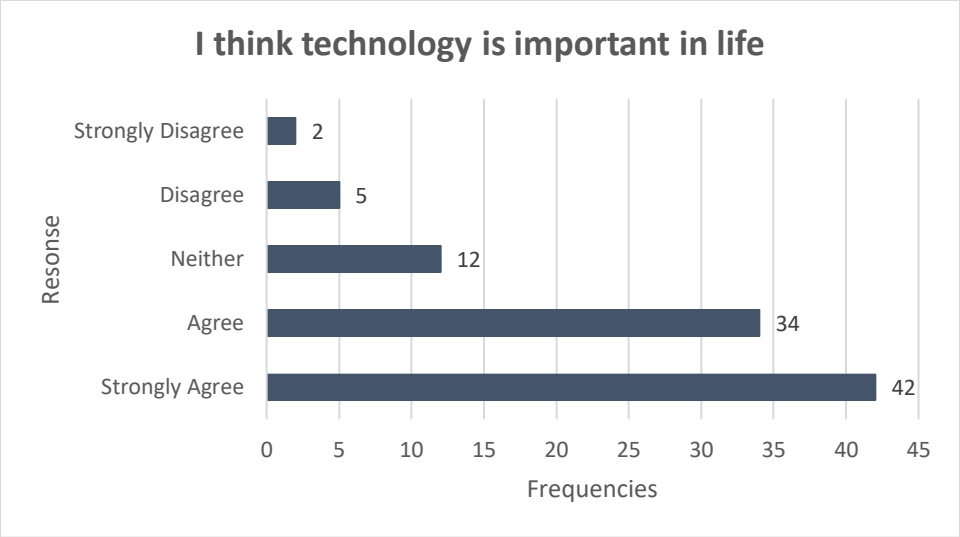
Graph 10. The Likert type question "I would like to have more demonstrations like this in class" was asked on a scale ranging from strongly agree to strongly disagree.



Graph 11. The Likert type question "I think I can do well in technology" was asked on a scale ranging from strongly agree to strongly disagree.



Graph 12. The Likert type question "I would like to use 3D printing in my future work" was asked on a scale ranging from strongly agree to strongly disagree.



Graph 13. The Likert type question "I think technology is important in life" was asked on a scale ranging from strongly agree to strongly disagree.

Appendixes

PRE SURVEY

1. Gender
    a. Male
    b. Female
    c. Prefer not to disclose.
2. Age
    a. Below 14
    b. 14-15
    c. 16-17
    d. 18
    e. 19 or above
3. Ethnicity
   Select all that apply
    a. American Indian
    b. Asian
    c. Black/African American
    d. Caucasian
    e. Hispanic/Latino
    f. Native Hawaiian/Pacific Islander
4. What is your grade level?
    a. 9th
    b. 10th
    c. 11th
    d. 12th
5. Do you know what STEM stands for?
    a. Yes
    b. No
6. If you answered YES for question #5, please answer question #6.
    a. Science, Technology, Electronics, Mathematics
    b. Science, Technology, Engineering, Mathematics
    c. Science, Technology, Electronics, Mechanics
7. Are you aware of any STEM career fields?
    a. Yes
    b. No
8. If YES, please list.

_____

9. Have you heard of a 3D printer?
    a. Yes
    b. No
10. Have you seen a 3D printer work?
    a. Yes
    b. No

11. If YES, where?
    a. TV
    b. Home
    c. School
    d. Store Location
    e. Other _____
12. Are you interested in technology?
    a. Yes
    b. No
13. Have you thought about a technology based career?
    a. Yes
    b. No
14. Do you intend to go to college?
    a. Yes
    b. No
15. What career field will you choose upon graduation?

_____

POST SURVERY

1. Do you know what STEM stands for?
    a. Yes
    b. No
2. If you answered YES for question #1, please answer question #2.
    a. Science, Technology, Electronics, Mathematics
    b. Science, Technology, Engineering, Mathematics
    c. Science, Technology, Electronics, Mechanics
3. Are you aware of any STEM career fields?
    a. Yes
    b. No
4. If YES, please list.

_____

5. Have you heard of a 3D printer?
    a. Yes
    b. No
6. Have you seen a 3D printer work?
    a. Yes
    b. No

7. If YES, where?
    a. TV
    b. Home
    c. School
    d. Store Location
    e. Other _____
8. Are you interested in technology?
    a. Yes
    b. No
9. Have you thought about a technology based career?
    a. Yes
    b. No
10. Do you intend to go to college?
    a. Yes
    b. No
11. What career field will you choose upon graduation?

_____

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I would like to learn more about 3d printing					
I have learned new information about 3d printing technology					
The 3d printing demonstration was educative and informative					
The demonstration positively influenced my interest towards technology					
I have learned new information about STEM education					
I would like to have more demonstrations like this in class					
I think I can do well in technology					
I would like to use 3d printing in my future work					
I think technology is important in life					

Introducing STEM Education Through a 3D Printer Demonstration
Consent to Participate in Research

INVITATION TO PARTICIPATE

You are invited to participate in research regarding the impact of STEM education through a 3D printer demonstration. You are being asked to enroll in this study because you are enrolled in high school grades 9 through 12.

WHAT YOU SHOULD KNOW ABOUT THIS RESEARCH STUDY

Who are the principal researchers?

Kennedy Rickard, Honors Student
kerickar@uark.edu
Emily Vrbas, Honors Student
eavrbas@uark.edu

Who is the Faculty Advisor?

Stephanie Hubert
skhopper@uark.edu

What is the purpose of this research study?

The purpose of this study is to evaluate students' knowledge of STEM education and their opinions on 3D printing and its viability in different career fields.

Who will participate in this study?

Male and female students enrolled in high school grades 9 through 12.

What am I being asked to do?

You will be answering two short surveys and viewing a STEM presentation and 3D printing demonstration.

<u>Your participation will require the following:</u>

1. Each participant will be required to answer a short pre-survey regarding their knowledge and interest of STEM education and 3D printing.
2. The survey will include an ID code to identify each participant's survey. All data will be confidential and accessed only by the researchers.
3. All participants will view a short presentation over STEM and 3D printing in the workforce. This will be followed by a 3D printing demonstration.
4. Some participants may be allowed to print 3D objects themselves with assistance from the researchers.
5. Participants will then complete a post-survey to assess any change of interest and knowledge of STEM education and 3D printing.

What are the possible risks or discomforts?
There are no possible risks from participating in this research.

What are the possible benefits of this study?
The research may identify a need for increased STEM exposure to students before college to potentially affect collegiate and career choices.

How long will the study last?
The study will last approximately the length of one 50-minute class period; the pre-survey at five minutes, presentations 35-40 minutes, and post survey at 5 minutes.

Will I receive compensation for my time if I participate in this study?
Yes, students who participate in the study will be given a 3D printed object.

Will I have to pay for anything?
No, there is no cost for participation in this study.

What are the options if I do not want to participate in the study?
If you do not want to be in this study, you may refuse to participate. Also, you may refuse to participate at any time during the study. Your job, your grade, your relationship with the University, etc. will not be affected in any way if you refuse to participate.

How will my confidentiality be protected?
All information will be kept confidential to the extent to allowed by State and Federal law. All surveys will be coded and stored in a secure area separate from parental permission slips.

Will I know the results of the study?
At the conclusion of the study, you will have the right to request feedback about the results. You will receive a copy of this form for your files.

Stephanie Hubert, skhopper@uark.edu
Kennedy Rickard, kerickar@uark.edu
Emily Vrbas, eavrbas@uark.edu

What do I do if I have questions about the research study?
You have the right to contact the principal researchers or the faculty advisor for any concerns you may have. You may also contact the University of Arkansas Research Compliance office listed below if you have any questions about your rights as a participant, or to discuss any concerns about, or problems with the research.

Ro Windwalker
Research Compliance Coordinator
479-575-2208
iwindwal@uark.edu

TITLE: Introducing STEM Education Through a 3D Printer Demonstration

The intended research will evaluate high school student's grades 9 through 12 and their knowledge and interest of STEM education and 3D printing. It will involve the completion of pre and post surveys and viewing a presentation and demonstration. Students who participate will receive a 3D printed object. Your child's participation is entirely voluntary and only group data will be published. Your child maintains the right to withdraw from the study at any time.

I have read the above statement and understand the purpose of the study as well as the potential risks and benefits involved. I understand that participation is voluntary. I understand that no rights have been waived by signing the consent form.

If you have any questions, please contact Kennedy Rickard, Emily Vrbas, or Stephanie Hubert.

Student Printed Name _____

Student Signature _____

Parent Printed Name _____

Parent Signature _____

UNIVERSITY OF ARKANSAS

To: Emily A. Vrbas

From: Douglas James Adams, Chair IRB Committee

Date: 02/28/2018

Action: **Exemption Granted**

Action Date: 02/28/2018

Protocol #: 1802102099

Study Title: Introducing STEM Education Through a 3D Printer Demonstration

The above-referenced protocol has been determined to be exempt.

If you wish to make any modifications in the approved protocol that may affect the level of risk to your participants, you must seek approval prior to implementing those changes. All modifications must provide sufficient detail to assess the impact of the change.

If you have any questions or need any assistance from the IRB, please contact the IRB Coordinator at 109 MLKG Building, 5-2208, or irb@uark.edu.

cc: Stephanie Kay Hubert, Investigator Kennedy E. Rickard, Investigator
Kathleen R Smith, Investigator
Mahendran Balasubramanian, Investigator

PEA RIDGE PUBLIC SCHOOLS

979 Weston Street Pea Ridge, AR 72751

Administration
Rick Neal, Superintendent, 800-451-0032
Keith Martin, Asst. Superintendent, 800-451-0032
Charley Clark, High School Principal 800-451-1343
Barrett Robinson, Asst. High School Principal
Bonnie Fullmer, Testing Coordinator 800-451-3583
Sue Stacey, Special Education Director 800-451-6675

Board of Education
Sandy Button, President
John Dye, Vice-President
Jeff Neil, Secretary
Ryan Heckman, Member
Jenny Wood, Member

Permission to Conduct Research

I have granted permission for the following proposed studies to be conducted at Pea Ridge High School:

"Introducing STEM Education Through a 3D Printer Demonstration" by Kennedy Rickard and Emily Vrbas

I understand the Kennedy Rickard and Emily Vrbas will obtain signed parental permission forms prior to any data being collected. Participation by students is entirely voluntary and may be terminated at any time during the study. For their participation, students will receive a 3D printed object.

I understand that all data will be collected during a specified class period time. Any data collected will be coded and kept confidential. Only pooled results will be published.

A copy of University of Arkansas IRB approval will be provided to our school prior to the study. Any questions about this approval should be sent directly to my office.

Sincerely,

Charley Clark, Pea Ridge High School Principal
781 W Pickens Road
Pea Ridge, AR