

Delving Deeper into Makersmithy : A Case for Curriculum Integration of 3D Printing in Upper Elementary Classrooms

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Figure 1: Miramar Ranch Elementary School Students Attending Workshop

ABSTRACT

3D printers are becoming easily accessible in elementary schools, through the wide availability of makerspaces, STEM grants, and decreasing cost of the equipment. However, the lack of faculty training and relevant curriculum leads to the under utilization of the 3D printers. In this paper, we present a case for exclusive 3D printing workshops for upper elementary students (4th and 5th grade) that align with their curriculum. We conducted a one-hour workshop for 200 elementary school students at Miramar Ranch Elementary, in the San Diego Unified School District, to gauge interest in 3D printing and assess the accessibility of similar

workshops in the area. The data collected clearly demonstrates the necessity for comprehensive curricula and faculty training.

CCS CONCEPTS

• **Social and Professional Topics**; • **Computing Education**; •
→ K-12 Education ; Informal Education;

KEYWORDS

3D Printing, Tinkercad™, Elementary, Curriculum, Accessibility, Outreach

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1 INTRODUCTION

The first commercial 3D printer was released in 2006, and less than a decade later conversation began about a technological revolution in home computing leading to the introduction of more sophisticated

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fabrication equipment to children and to the world of possibilities of creations[12]. Michael Eisenberg compared the advent of commercial 3D printers to the growth of home computing in the 70's and mentioned various challenges to accommodate the abilities and activities of young children[8].

"Makersmithy" is defined as play-based learning through hands-on STEAM activities focused on making creative objects. These maker spaces cater to kids of all ages and has opened up opportunities to study the perspectives of young children and their attitudes towards readily available advanced systems. The results suggest that children are highly welcoming towards 3D printing in a myriad of ways [11].

The informal education provided the students a sneak peek into a world of possibilities[3]. Copious research also exists to prove that 3D printing improves spatial skills in students encouraging them to pursue more STEM careers[2, 14]. Over the years, 3D printers have continued to become cheaper and more accessible and programs have been launched to introduce children to various facets of Computer Science like Robotics and Electro-mechanical Engineering[10].

Even though the fabrication technology is cheap, the how-to become locked behind a paywall. The activities surrounding 3D printing have become repetitive and there are some communities that have access to the printers, thanks to STEM grants, but no access to people or budget to run the programs or to maintain the equipment.

This paper showcases the data from a particular community of one of the highly rated schools in San Diego Unified School district, Miramar Ranch Elementary. It demonstrates through extensive data that 1) Children are not aware of or priced out of 3D printing related camps in the area 2) Children would like to learn 3D printing relevant to school curriculum.

2 MOTIVATION

Miramar Ranch Elementary School was chosen as the place for this study as it fits the initial criterion. The school had received a Makerbot 3D Printer and a Dremel Digilab 3D Printer through a donation and a STEM grant respectively. Due to the lack of dedicated faculty and budget issues, they remained unused for many years.

The workshop was designed to achieve two purposes: 1) to kick start the usage of the 3D printers, 2) to showcase the various ways they could be used in tandem with the school curriculum, based on previous research and qualitative analysis which revealed eight different ways in which elementary students found relevance in curriculum-aligned making activities[6]. This opened up a myriad of opportunities from studying the students' responses to gauging the teacher interest in training.

3 METHODOLOGY

To gain better insight into the level of the student understanding and to comprehensively measure their interest, a workshop was designed to take the students through the A-Z of 3D printing.

3.1 Setup

The demographic for the workshop were 4th and 5th grade students of the school. The team was assigned two classes of 30 students a



Figure 2: Students watching a 3D Print

day and they were engaged in a hands-on activity involving the design of a 3D key chain.

Basics of 3D modeling were covered in a short lecture which included an interactive discussion on :

- What is 3D modeling?
- What careers use 3D modeling? Like Game Designer, Architects, Product Designers, Engineers etc.
- What would you like to design in the future?

The students were then guided to create their custom designs, which were printed over the course of the week.

3.2 Tool and Constraints

Various technologies exist to teach 3D modeling and the most popular of all for programming and 3D graphics alike has been Turtle [13]. Since all student in the San Diego Unified School District have access to chromebooks, the team chose the web-based application Tinkercad™ as the modeling tool. Classroom accounts were created for each class and students logged in using their SDUSD IDs. Based on the research in Bolier et al.[4], which states that drawing in a virtual 3D space improves spatial skills in elementary children, we adopted Tinkercad™ which mimics drawing motions with the finger on the touch pads, rather than clicking on the mouse.

The time allotted was 1 hour per class, hence the following constraints were placed on the students :

- Students must choose between two existing key chain designs
- Size of the key chains may not be modified
- All Text and pictures must be inset into the key chain

These constraints also helped in keeping the printing time for each student the same and overall minimal. The completed projects of each student were saved under their respective names and then converted to ".stl" files ready to be printed on the school's 3D printers.



Figure 3: Sample Printed Key chains

3.3 Printing

The printing was done over the course of the week. In addition to the design constraints above, the output was also restricted to the following:

- All prints were a single solid color
- Colors were Blue/Gold (school colors) and one was picked arbitrarily

This allowed the team to successfully complete the workshop and assess the students within the time frame allotted.

4 STUDENT LEARNING OBJECTIVES

To level the playing field among the students for accurate results, the team set out to achieve the following:

- An understanding of real life applications of 3D modeling
- An understanding of 3D shapes and dimensions
- Basic proficiency in 3D modeling software (TinkerCAD™)
- Understanding how to edit, create and manipulate 3D models
- Understanding the process required to have a 3D printed object created
- Foster creativity, by allowing students to freely design their own 3D models
- Develop an understanding of the design process

5 SURVEY

There is some debate on the best way to measure how to assess the outcomes[9]. The team decided post-surveys were the best and the quickest evaluation tools to measure the effectiveness of the outreach program and collect feedback. A modified version of the NCWIT Grade 4-12 Computing Program Participant Post-Survey evaluation tool[1] was added to collect the set of data, from the students using the Likert scale, shown in Table: 1

Participation post-surveys were administered to the students after all the key chains were delivered. Student names were kept anonymous but their grade information, what they liked and disliked about the program were requested. The team also requested to know what technologies the students knew before hand, and information about computer programs / camps in the geographical area.

The purpose of the survey was two fold: 1) To gain feedback about the workshop conducted so that the team may be able to make modifications to the study and survey, and administer it in another setting, 2) to reflect on the initial motivation, i.e. the need for fresh activities that are related to the curriculum in school to make use of the 3D printers.

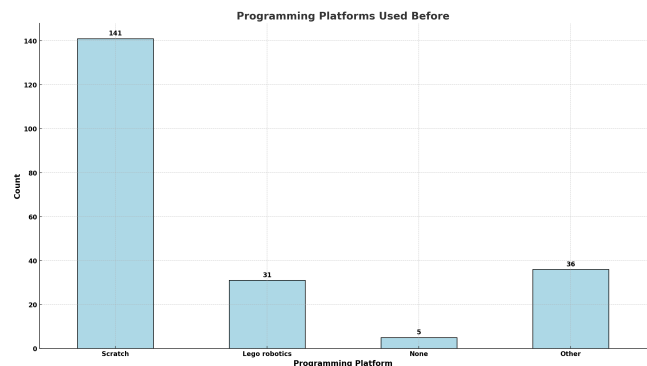


Figure 4: Previous Experience of Students

6 RESULTS

The results from the survey are tabulated in figures. Below are the detailed observations , highlights and feedback interpreted from the charts.

6.1 Observations

The following statements are observed from the graph results :

- Most kids do not know of camps / computer programs that they can attend. (Figure: 12)
- Irrespective of whether they have programming experience or not, the students know Scratch or have interacted with Scratch. (Figure : 4)
- Lego Robotics is the second most popular program among the students, because it uses block coding, similar to Scratch.
- Majority of the students want to attend a more detailed 3D printing workshop in school which is related to school topics. (Figure: 9)
- Skills learned from the 3D printing workshop:
 - Thinking in a 3D space. (Figure : 6)
 - Creative thinking. (Figure : 5)

6.2 What Worked

The students had the following opinions on what worked about the workshop:

Table 1: Likert Scale Post-Survey Statements

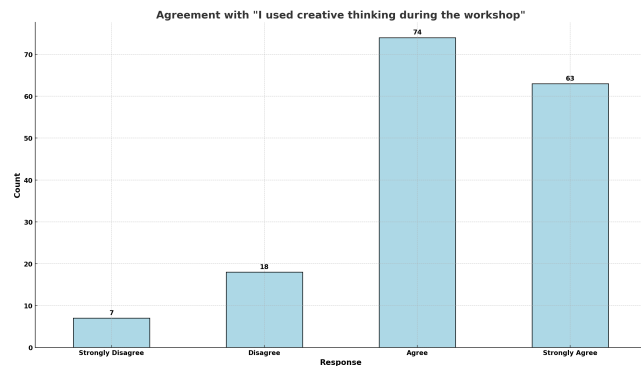
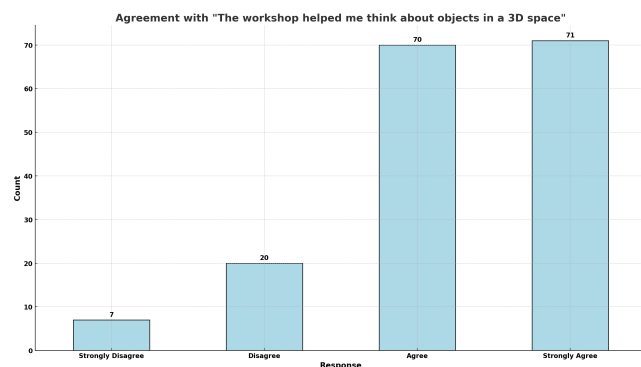
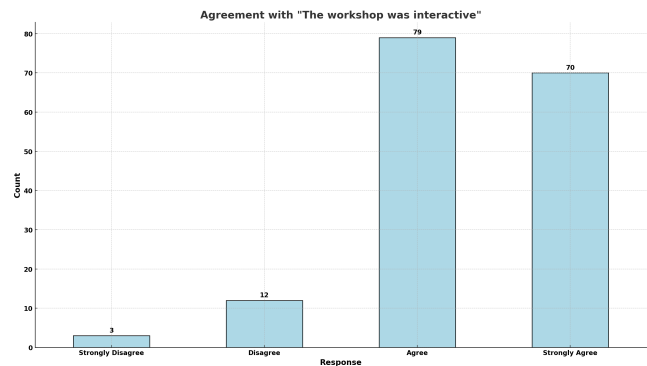
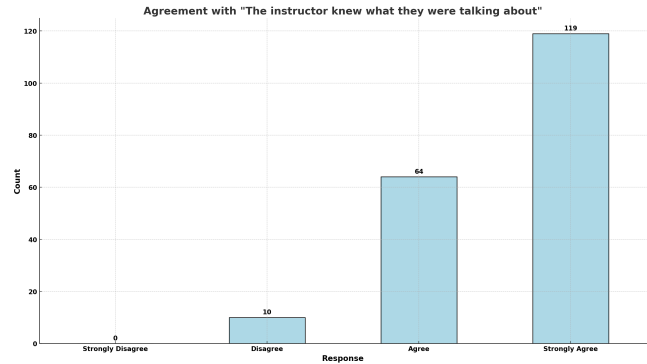
No.	Questions
1	The workshop was interesting
2	The workshop was interactive
3	The instructor knew what they were talking about
4	I would attend workshop again to learn about 3D modeling
5	I used creative thinking during the workshop
6	I used problem solving skills during the workshop
7	The workshop helped me think about objects in a 3D space

- Instructor was very well versed, making a case for a dedicated faculty or teacher training. (Figure: 8)
- Workshop was interactive, encouraging the idea of tandem informal education in the school environment. (Figure: 7)
- Each student was able to create something personalized and the end product was tangible. (Figure: 3)

6.3 What did not Work

Students had the following opinions on what did not work with the workshop: (Figure: 10)

- Lack of color options with filament
- Restrictive creativity due to time constraints

**Figure 5: Creative Thinking Usage****Figure 6: Thinking in 3D Space****Figure 7: Workshop Interactivity****Figure 8: Instructor Effectiveness**

- High wait time to get the key chains back
- Confusion regarding what would and what would not show up on the key chain and how it would look.

7 CONCLUSION AND LOOKING AHEAD

The data collected clearly reflects our premise. There is a need to delve beyond makersmithy and dependency on tools and resources hidden behind a paywall. Faculty need to be trained and school curriculum must be integrated with creative 3D printing activities to make effective use of available technologies. It is very clear from the data, there the interest among the student population is high

for side by side informal and formal education, which is the way of the future.

The outreach effort not only managed to generate data to make a case for integrated curriculum, but also generated interest to go back and propose a modified version of the workshop. From the feedback collected and assessment of the student performance, the following changes will be taken into consideration for the future outreach :

- Extending the workshop from a one-time activity to a series

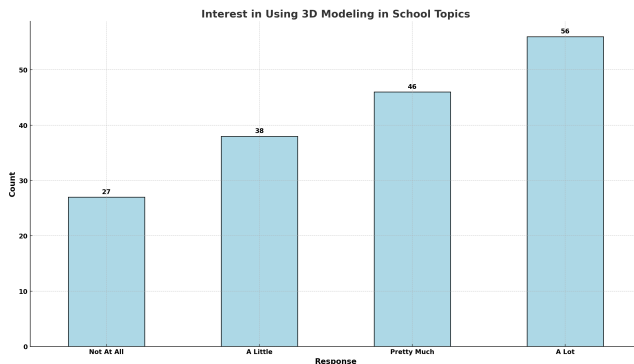


Figure 9: 3D Printing and School topics

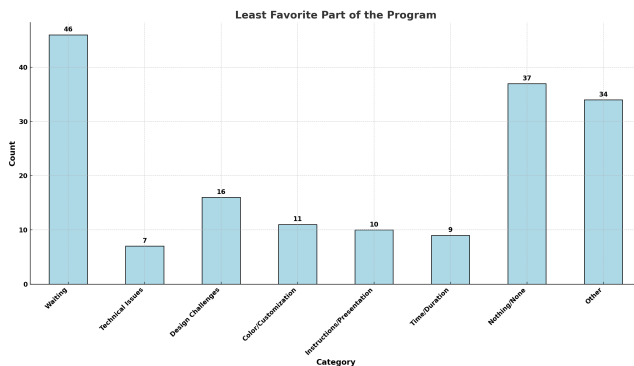


Figure 10: What did not work

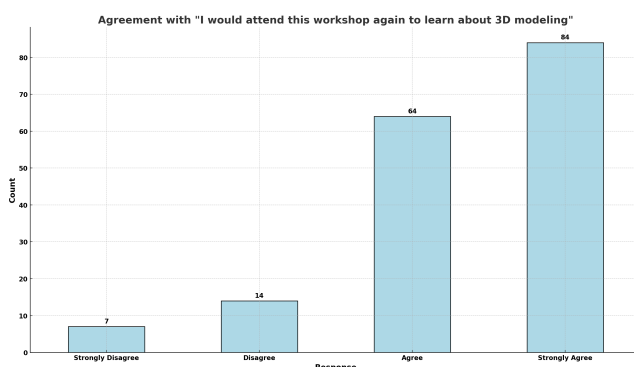


Figure 11: Student Interest

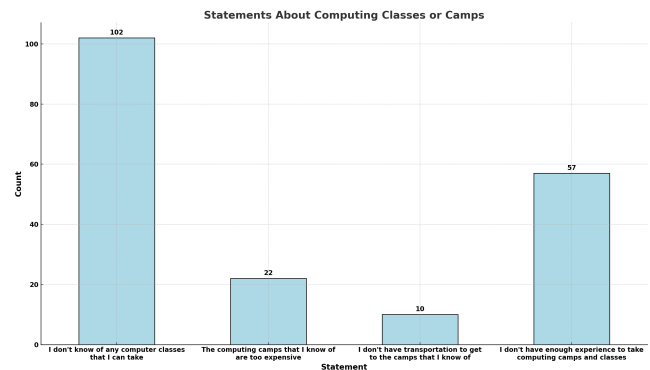


Figure 12: Camp Accessibility

- Using Physical manipulatives like play dough and building blocks to visually understand objects in a 3D space
- Choosing a curriculum relevant topic and hosting a design challenge to boost participation.
- Adding a coding based activity to add an additional layer of challenge and evaluate an additional aspect of coding producing tangible results. Premise based on C.Chytas et al.[7]
- Opt for a volume based design vs a flat design
- Give students an option to pick filament color and more control over the output.
- Make the workshop more inclusive to include the Special education students and work with educators on evaluating specific software based on E. Buehler et al.[5]

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