Chapter

Bridging the Digital Divide in Design and Mathematics through an Immersive Maker Program for Underrepresented Students

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Abstract

Maker spaces engage students in learning by empowering them to explore ideas and problem-solving in a hands-on environment using digital and/or physical modalities. Design-based programs like this can increase learning by fostering student autonomy and promoting problem-solving and sensemaking. Our interdisciplinary team of researchers at this Midwest university, in conjunction with community partners, offered a program targeted at underrepresented and minority students in a school zone with an exceptionally high educational achievement gap, one of the worst in the nation. Our state ranks 48th and 50th in the high school graduation rates for African American and Hispanic students, respectively. Our work focused on design and mathematics learning and on using maker spaces to bridge the digital divide to create opportunities for underrepresented students. This chapter describes how we developed a culturally responsive pedagogy for underrepresented K-12 students to learn about design and mathematics. We share some short-term outcomes of providing equal access to immersive curricula to underrepresented students, and describe how we bridged learning losses due to the impact of the COVID-19 pandemic.

Keywords: maker spaces, design, mathematics, STEM/STEAM, K-12

1. Introduction

Maker spaces engage students in learning by empowering them to explore ideas and problem-solving in a hands-on environment using digital and/or physical modalities. Design-based programs like these can increase learning fostering student autonomy and promoting problem-solving and sensemaking [1]. Our interdisciplinary team of researchers at a Midwest university, in conjunction with community partners, offered a program targeted at underrepresented and minority students in a school zone with an exceptionally high educational achievement gap, one of the worst in the nation. Minnesota, US ranks 48th and 50th in the high school graduation rates for African American and Hispanic students, respectively [2]. Our work focused on design and mathematics learning. Using maker spaces to bridge the digital divide creates opportunities for underrepresented students. This chapter highlights how we developed a culturally responsive pedagogy and implemented it with underrepresented K-12 students to help them learn about design and mathematics. We discuss short-term outcomes of providing equal access to immersive curricula to underrepresented students and bridging learning losses due to the impact of the COVID-19 pandemic. Long-term outcomes include increased diversity in design and mathematics and the development of a scalable model that can be replicated in other communities.

2. Literature review

2.1 Underrepresentation in STEM

Severe underrepresentation of certain groups in science, technology, engineering, and mathematics (STEM) continues to be a serious problem in ensuring that the nation will have a well-trained and skillful workforce in tomorrow's high-tech sector [3]. Today, 30–40% of the workforce in critical areas such as aerospace engineering, next-generation computing, 2-D materials, therapeutics, and drug design is of international origin [4]. The University of Minnesota (UMN) has been successfully broadening participation in STEM for women, but so far not for Black, Indigenous and People of Color (BIPOC) students. Students enrolled in UMN are majority white female (35.5%). While the percentage of women undergraduate students in the College of Science and Engineering has risen from about 18 to 33% over the past decade, the percentage of African American students has remained around 1.6%. Demographic data on UMN enrollment show 4.04% Black or African American, 3.82% Hispanic or Latino, 3.3% two or more races, 0.309% American Indian or Alaska Native, and 0.0791% Native Hawaiian or Other Pacific Islanders. In 2020, however, BIPOC students comprised approximately 25% of the graduating classes in high schools in the Minneapolis/St. Paul area in Minnesota. The growing percentage

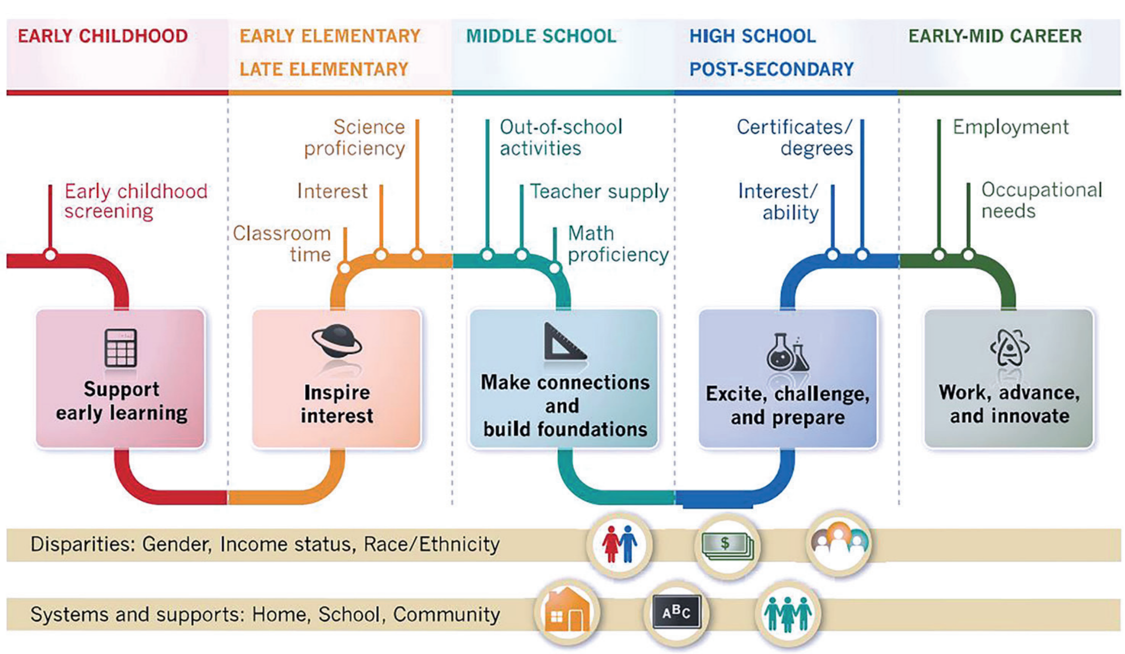

Figure 1.
STEM Cradle to Career Continuum [5].

of BIPOC students in the Twin Cities area, and in greater Minnesota, makes it an opportune time to develop programs that provide exposure to STEM, particularly in informal maker settings. MINNESOTA COMPASS, a STEM education advocacy group composed of educators and private-sector leaders from companies such as Boston Scientific and Ecolab, has championed what it refers to as the "STEM Cradle to Career Continuum." Their logic model (**Figure 1**) divides the continuum into early childhood, early to late elementary school, middle school, high school and postsecondary education, and early to mid-career. Disparities are recognized to be greatest in middle and high school, with wealthy communities having the means to provide many enriching after-school activities while under-resourced communities do not [6, 7].

2.2 Maker spaces and STEM

Exposing students to STEM using maker spaces is of great interest among educational institutions across the United States because of demonstrated outcomes [8–11]. The maker space movement was originally developed outside of the school environment and mostly involved adults. Recently, however, there has been interest in integrating it into education, specifically to create opportunities that engage students in science, technology, engineering, and mathematics [12]. Investment by funding agencies, increased coverage in the popular press, and investment in maker spaces by museums are all signs of the growing interest in and validation of this type of engaged, informal, hands-on STEM learning. Tinkering Studio at the Exploratorium in San Francisco, Ingenuity Lab at the Lawrence Hall of Science in Berkeley, Maker Space at the New York Hall of Science, and MAKEShop at the Children's Museum of Pittsburgh [13, 14] are all high-profile examples of maker space exhibits. The US government has made substantial investment in maker spaces through funding agencies and other initiatives. The White House declared June 18, 2014, a "National Day of Making," and in 2015 expanded these activities to a Week of Making from June 12 to June 18 in Washington, DC. The initiative was an overall call to action for companies, colleges, and communities to promote invention, creativity, and resourcefulness and to celebrate the maker movement. While there are many types of "making," Bevan and Ryoo [15] identified three specific types of programs: those focused on entrepreneurship (i.e., making products for market), those focused on workforce development, and those focused on educational programs.

Researchers have discussed three types of educational making—assembly, creative construction, and open-ended inquiry [15–17]. In assembly, learners are given a step-by-step process of how to make an object that results in an identical object. Creative construction involves providing learners with a challenge to address, and the resulting design/object is personalized. Open-ended inquiry involves a learner developing an individual idea and figuring how to accomplish it. This method is often called "tinkering," since it emphasizes creativity [15]. "When Making is organized to leverage students' ideas and interests, it can create powerful conditions for learning to occur particularly for students who may not already affiliate as STEM learners" (p. 3). Maker spaces support a combination of creating, craft making, and experimentation. Evidence shows that these are attributes of top-performing scientist and that these skills are highly valued by STEM educators, professionals, and industry [18].

2.3 Underrepresented students and maker spaces

The Maker Movement is "traditionally viewed as grounded in gendered, white, middle-class cultural practices" [19, 20], and researchers have argued for making it more inclusive [21, 22]. Researchers at the November 2015 NSF Maker Summit in Washington, DC, funded by the National Science Foundation (NSF), discussed four key issues crucial to advancing the Maker Movement: (1) the relationship between informal and formal learning; (2) teaching, assessment, and evaluation; (3) diversity, accessibility, and inclusion; and (4) new technologies and innovation [12]. The summit participants highlighted the importance of diversity, accessibility, and inclusion in the maker movement to foster industry growth and economic and global workforce advancement. Summit participants also noted the need for the "emergence of strong leaders from underrepresented communities and advocates for diversity" [12]. Marsh et al. [22], in *Makerspaces in the Early Years: A Literature Review*, discuss the importance of inclusion because of limited literature on underrepresented groups and maker spaces. Kafai et al. [23] discuss "ethnocomputing" in their study, which links traditional indigenous sewing methods and the evolution of e-textiles in their culturally sensitive work to broaden participation in STEM among American Indian youth. Their making process highlights how combining traditional artifacts and recent technological developments can help participants acknowledge and learn about their cultural roots. Eglash [24] describes the synergetic connection in this making process as "design agency," a notion that not only does the maker influence the design but the design influences the maker.

Barton and Tan [21] note that makerspaces that explore communities and cultural traditions are an exception, and discuss community-centered making programs as a way to foster equity, learning, and making. Schwartz and Gutiérrez [25] contend that "[i]nventing, making, tinkering, designing, are indigenous practices, that is, practices that originate and occur naturally in particular ecologies" (p. 577). They argue for a "more culturally-responsive approach," where the making experience benefits both cultures and does not privilege the dominant perspective. Vossoughi et al. [20] also advocate for an equitably framed maker process rather than a situation where "working-class communities of color are once again positioned as targets of intervention rather than sources of deep knowledge and skill, and dominant communities are reinscribed as being ahead, with something to teach or offer rather than something to learn" (p. 212).

3. Supporting programs

3.1 Building bridges to design program

The Building Bridges to Design Careers programs, conducted annually by author one, created a dialog on diversity and design between grade K-12 students, college of design students, scholars, and practitioners. Annual panels, workshops, and summer camps led by design faculty and practitioners engaged participants in creative problem-solving and prototyping exercises focused on cultural expressions in design. Since 2013, annual panels, workshops, and summer camps have engaged diverse participants in design problem-solving exercises focused on cultural expressions in the built environment. The program is structured to include after-school programs, summer design camps, lectures, and panel discussions. In the design camps, K-12 students are guided through ideation, concept sketching, and modeling exercises. The week-long summer design camp focuses on daily hands-on activities in design, three-dimensional modeling, and fabrication, and includes field trips (**Figures 2** and **3**). Lectures and

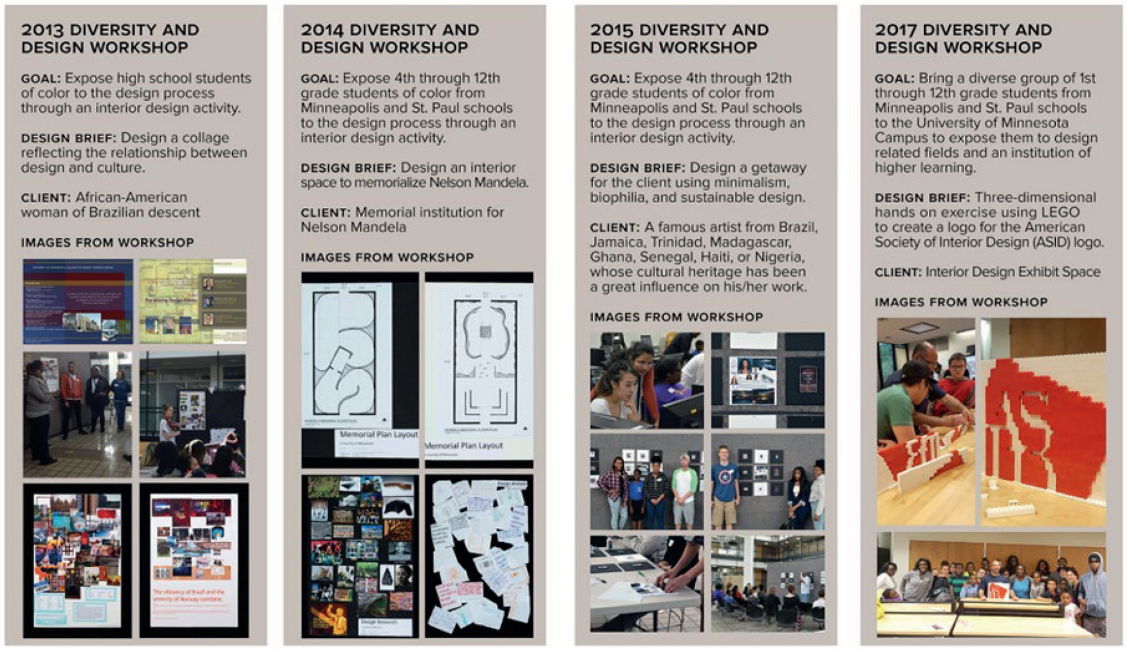

Figure 2.
Building Bridges to Design program, 2013–2017.

Figure 3.
Building Bridges to Design program, 2018–2019.

panel discussion for K-12 students focus on global design history, multicultural design perspectives, and diverse contributions to the built environment. Woodworking, laser cutting, and LEGO modeling experiences are used to guide K-12 students through the hands-on activities. A systematic instructional design process that engaged the learners, and included objectives, methods, and evaluation, was used in the development and execution of the program. During the programs, feedback was obtained through pre- and post-surveys from student participants to learn about their experiences and improve the programs.

3.2 Woodworking and laser design experiences

Design experiences such as woodworking and laser cutting are found to nurture STEM-related skills such as problem-solving, creativity, and innovation in K-12 students [8, 26, 27]. Using digital and physical tools in woodworking and laser cutting, K-12 students experienced the making of objects from scratch. The Product Realization Lab in RMIT used woodworking and laser cutting as components of design courses to provide students with equipment access and manufacturing training [28]. Similarly, underrepresented K-12 students designed their name tags on the laser cutter. They also participated in open-ended experimentation in the wood shop by building imaginative objects from recycled wood.

3.3 LEGO design experiences

In a recent study, participants ages 8–10 reported profound accessibility, curiosity, enjoyment, and collaboration with peers through experiences using LEGO [26]. At the University of Westminster, Gauntlett [29] found LEGO a powerful tool to facilitate creative thinking [29]. It is compact in size yet flexible, affordable, and applicable for a wide range of age and gender. Building on this literature, we engaged K-12 underrepresented students in different LEGO experiences, from small to large scale. For the small-scale projects, K-12 underrepresented students created the logos of the American Society of Interior Designers (ASID), the International Interior Design Association (IIDA), and the American Institute of Architects (AIA) in one-day after-school programs. For the large-scale project, they recreated the Sugar Hill Building designed by Black Architect Sir David Adjaye, the Architect of the African American Museum in Washington DC.

3.4 Prepare2Nspire

Prepare2Nspire (P2N) is a multi-grade, multi-ethnic, near-peer mathematics tutoring and mentoring program that was developed and implemented in an urban community. Higher than average unemployment and crime rates plague the residents of the community and cause social, economic and cultural challenges [30]. P2N provides more than just support in doing mathematics homework; it is a supportive, safe space that students describe "as friendly and alive. I feel accepted. I feel like I belong…" (field notes, October, 11, 2017).

3.5 Rationale

The mission of Prepare2Nspire is to prepare marginalized students to succeed on grade-level and high-stakes mathematics exams and to inspire them to continue their study of mathematics. This mission is accomplished by developing mathematics confidence, content knowledge, connections, communication skills, and community through its cascading tutoring and mentoring model. P2N also works to create a STEM pipeline for urban underrepresented students to post-secondary education and opportunities.

Prepare2Nspire uses the terms *mentutor* and *mentutee* to signal the combination of the mentoring and tutoring roles. Recognizing that mentoring is a function of building relationships and that tutoring entails the process of assisting in problem-solving and working through mathematics content, the program merged the roles of tutor and mentor and the roles of tutee and mentee. Tutoring without mentoring, however, removes the important leverage of building relationships. Mentoring mirrors tutoring, in the beginning, because it passes the expertise of the tutor onto the tutee. Furthermore, mentoring cultivates both study skills and positive behavior, creates resilience and self-reliance, provides context for the exchange of information and knowledge (which, in the case of P2N, bridges the gap between mathematical theory and practice), and cultivates leadership competencies in both mentor and mentees. For mentees, it also increases the capacity for service to others in the future just as their mentors are currently serving them.

3.5.1 Culturally responsive mentoring

Prepare2Nspire works to incorporate culturally responsive mentoring into the daily lives of students as a way to empower and strengthen the relationship between tutors (mentutor) and tutees (mentutee). Particularly troubling is the myth that culture does not matter in the teaching and learning of mathematics [31], especially when many states continue to have large academic and opportunity gaps between students of color and white students [32]. Paying attention to "issues of race and culture in the way we teach mathematics has incredible power to disrupt the troubling opportunity gap" [31]. Using what students already bring to class acknowledges that such issues exist and addresses them by providing a strategy to mentor African American students from urban schools.

3.5.2 The shaping of mathematical identity

Small learning communities form the foundation of Prepare2Nspire. These table groups are named for underrepresented STEM scholars like Mae Jemison, an African American astronaut and scientist, and Katherine Johnson, an African American mathematician known for her computation work for NASA. The naming of the communities using underrepresented scholars is intentional. To help students see themselves as people who can excel in science and mathematics, they should see and know previous scholars who have succeeded in STEM fields this way.

While mathematical identity is a social construction [33, 34], participating in mathematics classes has a profound effect on the development of that identity. Racialized narratives [35, 36] are among the factors that influence it. More often than not, schools have perpetuated deficit narratives by placing students from underrepresented populations into remedial courses that make it nearly impossible to participate in advanced study. Students, in turn, begin to identify as being incapable and unable to perform academically, believing the implicit message that they aren't capable of doing and being better. Such messages are internalized, creating these deficit narratives and low self-worth even when students have the skill set or prior experiences to demonstrate they can be successful. These "[deficit] identities intersect with already existing stories about other kinds of social identities" [35, 37, 38]. P2N pushes back against this notion by transforming student mathematical identity.

Cultivating positive peer relationships [39, 40] through the use of learning communities is an approach to influencing the formation of mathematical identity. Lieberman [41] asserts that learning among low achieving students increases when they are placed in empowering roles. Situated learning suggested by Lave and Wenger [42] is a model that places learning within social relationships. Thus, community participation is imperative when cultivating mathematical identity, and positively affects the mathematical identity of the tutee [43]. The P2N near-peer model is an example of mathematics support situated in a social setting. Positive encouragement from peers is an effective and motivating strategy. As one P2N participant states, "I really like how when we come here we build community, and at the same time we're also learning [math]. And we meet people who are from different backgrounds" (personal interview, December 2017).

3.6 Structure of Prepare2Nspire

3.6.1 "Prepare": reverse the current trend

In almost every accountability measure in Minnesota (Minnesota Comprehensive Assessments MCA-II and Minnesota Comprehensive Assessments MCA-lll) and nationally (National Assessment of Educational Progress—NAEP), certain groups of students consistently lag behind their White peers [44]. African American, Native American, and Hispanic students, as well as students from low socioeconomic backgrounds, perform behind their peers in academic preparation, high school graduation, and college attendance and completion. In addition, these students are often enrolled in fewer STEM courses in high school and college. The STEM job market is growing, with specialized fields that will not include students from the aforementioned groups if they do not have a background in mathematics and other STEM courses. Studies by NAEP and Jett [45] reveal that the "overwhelming number of low-achieving students in algebra are black and Hispanic and attend big urban, high-poverty schools where they are more likely to fall through the cracks" [46] and that African American and Hispanic students are disproportionately underrepresented in advanced mathematics courses. Jett [45] and others [35] assert that the highest predictor of college readiness and completion is the taking of higher-level mathematics courses during high school. Prepare2Nspire is located in an urban community where mathematics failure is common. If the trend of disproportionate underrepresentation of marginalized students is to be reversed, foundational math failure must be made a high priority in urban educational settings where the numbers are most staggering. Succinctly, prepared students can reverse this trend.

3.6.2 "2": the participants

Prepare2Nspire was developed to support two cohorts of students: eighth graders and eleventh graders. Students in these cohorts are referred to as mentutees, since they are recipients of both mentoring and tutoring [47]. The design of the program is strategic, with middle school and high school students seeing college undergraduates pursuing higher education especially in mathematics or other STEM fields. These undergraduates, called mentutors, are also active participants in the program as they develop different skill sets like leadership and teaching (**Figures 4** and 5).

Figure 4.
Prepare2Nspire.

Figure 5.
Prepare2Nspire at UROC Spring 2017.

The original design of the program matched one undergraduate with three eleventh graders and six eight-grade participants. As the program has developed and evolved over the last 10 years, outside circumstances may have altered the exact number of students from each cohort within a community, but the near-peer model has only become stronger, regardless of the changing number of participants. The undergraduate remains the foundation of each community while supporting both eighth and eleventh graders and as eleventh graders support eighth graders.

3.6.3 "Nspire": the role of technology

Graphing calculators have transformed how students think mathematically in a classroom and on assessments. Prepare2Nspire is influenced by the graphing calculator with the same name. Each participant receives a graphing calculator and is taught how to use it effectively. Since mathematical thinking is influenced by technology, and technology can be used on standardized assessments, participants are taught how to move between the multiple representations which are incorporated into the teaching and learning of mathematics in general, and in algebra specifically. Given that technology is an integral part of STEM occupations, this tool can be an advantage when preparing for this pathway IF students know how to use it.

When students attend each week at their table communities, they work, eat and talk with the same people. All of these activities are an intentional part of building relationships which, in turn, enable authentic conversations about algebra. The sense of community transforms how participants think about mathematics.

3.7 The immersive maker space program

Building on prior literature and experiences from the supporting programs Building Bridges to Design and Prepare2Nspire, we used an inclusive lens to create and deliver immersive maker space programs for underrepresented students in grades 4–12 in summer 2020, 2021 and 2022. The project-based making exercises focused on the intersection of design and mathematics, drawing on historic design precedents from ethnic minority communities including African, African American, Hmong, and Vietnamese communities, where underrepresented student participants in this program came from. Using design precedents from diverse communities helped our team create a "culturally-responsive approach" that is inclusive and relevant to student participants. We exposed K-12 students to design, engaged them in hands-on experiences, and created opportunities for them to collaborate with underrepresented mentors. We also used design precedents from underrepresented designers to illustrate contributions to the built environment.

Through extensive literature review on maker spaces and underrepresented students, focus group meetings, ideation and mockup sessions with University researchers, and collaboration with community and school partners, we co-designed and created a curriculum for an immersive maker space in a city with a poor record of inclusive excellence. Our goal was to offer hands-on experiences in design, 3D modeling, online experimentation, making, and digital fabrication to promote STEM/STEAM learning. The immersive maker space was implemented online in 2020 and 2021 due to the COVID-19 pandemic and in-person in 2022 with grade 4–12 students at the Robert J. Jones Urban Research and Outreach-Engagement Center (UROC) in

North Minneapolis, a school zone with an exceptionally high educational achievement gap. Throughout the program, students' learning was measured through survey responses and informal interviews.

3.8 Program curriculum and activities

The program curriculum included College of Design students from diverse backgrounds sharing their career interests and projects via videos. The design and STEAM videos included introductions to fractals, geometric principles, the golden rectangle, and the Fibonacci sequence. Fractals in design and architecture were presented through a cross-cultural lens, showcasing fractal geometry in the work of underrepresented designers like David Adjaye, including his design of the African

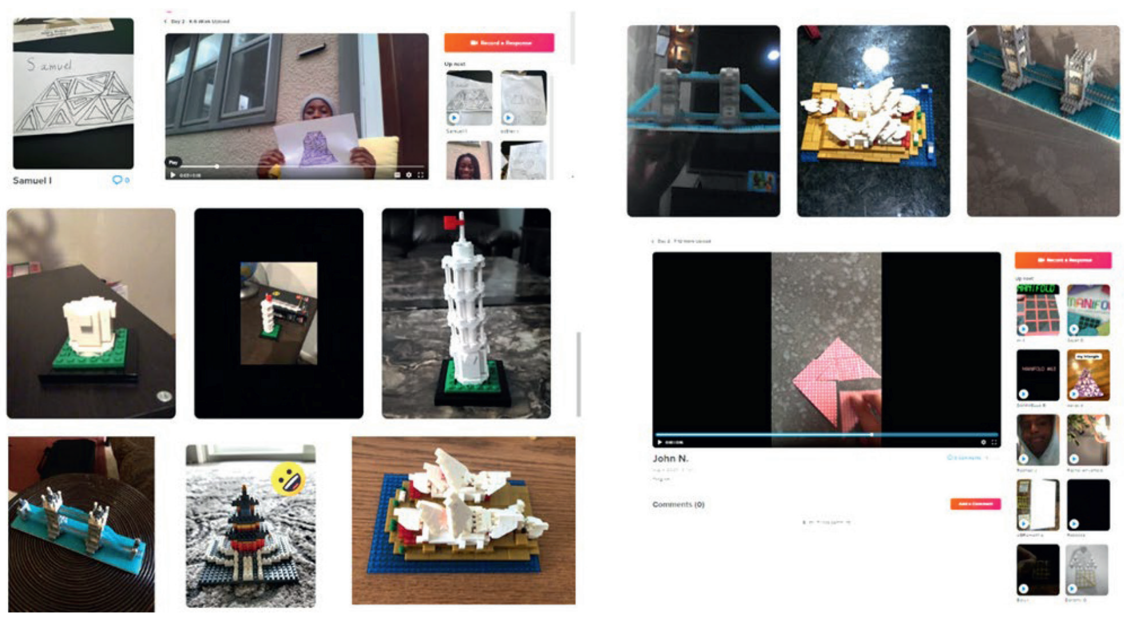

Figure 6.
Summer 2020 student sketching, paper folding, and LEGO and building blocks projects.

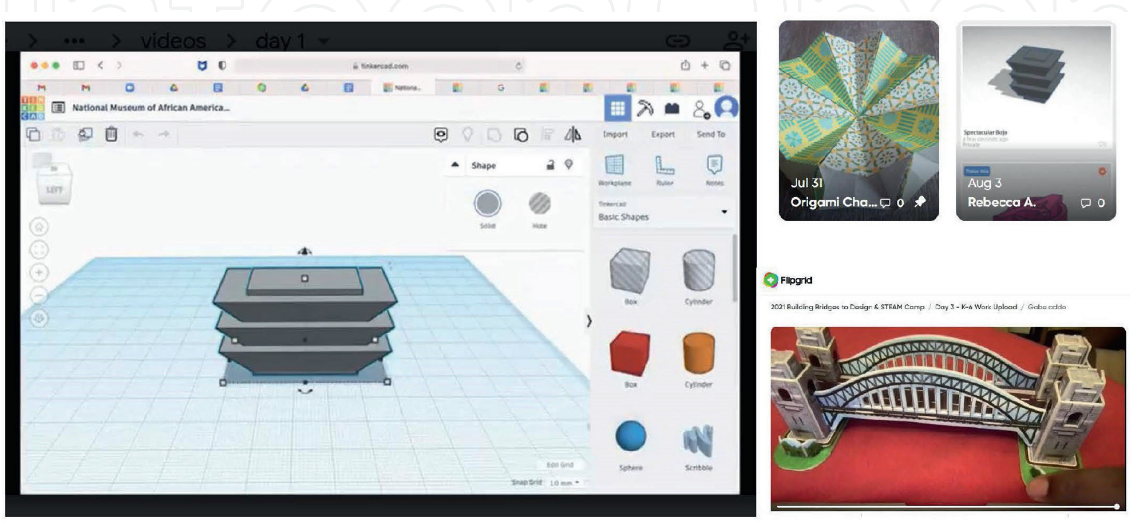

Figure 7.
Summer 2020 3D modeling in TinkerCAD and paper folding projects.

American Museum in Washington DC. For the introduction to mathematics, graphing calculators, and coding, students engaged in hands-on learning about how to code and automate devices. Hands-on paper folding exercises were integrated so students could learn about various math principles while folding structures and origami forms.

For sketching, 3D modeling, and 3D printing, students were introduced to 3D modeling in TinkerCAD using Cartesian coordinate systems, points, lines, and basic geometric shapes such as cubes, planes, and spheres. They learned rapid prototyping through 3D printing of the TinkerCAD models they created. For example, they created massing models of the African American Museum in DC in TnkerCAD. They learned about the massing and composition of the structure, which are extruded trapezoidal geometric shapes stacked vertically to form the building facade. This exercise provided students with the opportunity to learn about the intersection and relationship between mathematics and design principles.

Figure 8.
Summer 2022 3D modeling in TinkerCAD and 3D printing.

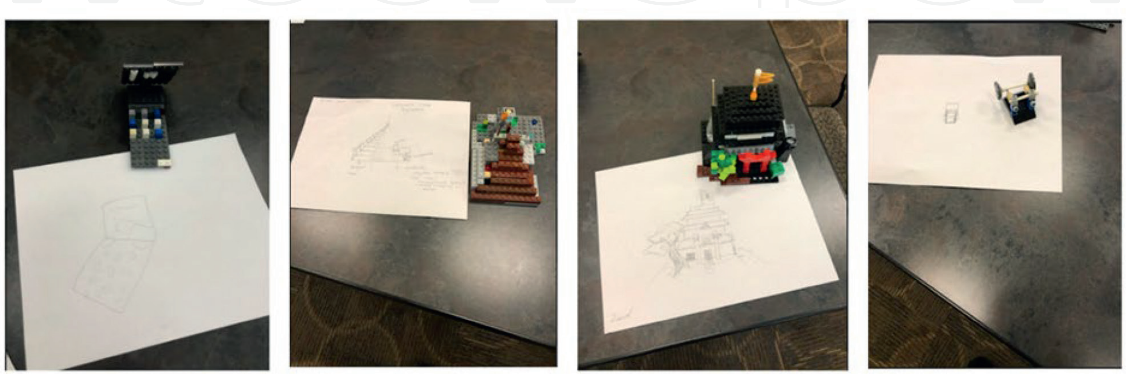

Figure 9.
Summer 2022 sketching and LEGO exploration.

For LEGO and building block modeling, students experienced and learned about design and mathematics by building models of global buildings, including the Khufu Pyramid, the Sydney Opera House, the Tower Bridge, the Pisa leaning tower, and skylines in Japan and Dubai Skyline (**Figures 6–9**).

4. Discussion and findings

To support our goal of implementing the maker space program and engaging underrepresented students to promote future success in STEAM, we measured students' learning throughout the program using surveys and informal interviews. Students completed pre-surveys prior to participating in the program and post-surveys after the program. To help the authors learn about the effect of the program on student learning, attitudes, and engagement in the program, sample survey questions were targeted towards asking participants about their experience before and after the camp. For example, participants were asked about the design and mathematics careers they know, the STEAM skills they were learning, and their best experience in the program (**Figure 10**).

The 2020 camp had to be delivered virtually due to the COVID-19 pandemic lockdown. From the 2020 cohort of 64 campers (34 grade K–6 and 30 grade 7–12 students), the majority of the campers—81.5%—considered the camp informative and interesting on a Likert scale of 1–5 points. No camper rated the program as not informative or interesting. When asked what they learned in the virtual summer camp, students reported learning about design. For example, one participant quotes "you can start designing and drawing and someday that dream of yours might come true." Another noted "I learned about the different types of designs people do on a daily basis which made me into design." Another participant noted "I learned about possible career paths in design. I also learned about certain buildings." When asked about the best experience in the virtual summer camp, participants reported enjoying the virtual design firm visits, origami, and LEGO building. One participant reported "The best part was when people that do different types of designs and when they showed us what they do every day on the job and explained how things work at their

Figure 10.
Word cloud illustrating best experience in Summer 2021.

offices." Another reported "Building the Origami helps me think better." Another reported "I really liked how challenging the LEGO building was."

The 2021 camp was also held virtually due to the COVID-19 pandemic. From the 2021 cohort of 30 campers (18 grade K–6 and 12 grade 7–12 students), the majority of the campers—72.2%—considered the camp informative and interesting on a Likert scale of 1 to 5 points. No camper rated the program as not informative or interesting. When asked what they learned in the virtual summer camp, students reported learning about mathematics and design. For example, one participant noted "I learnt that math and art have a good way in incorporating itself in designing projects." Another noted "Fractals is a concept in math that deals with space and dimensions." On modeling, another participant noted "I learnt that 3D printing is sometimes used to small-scale a building like a model." When asked about the best experience in the virtual summer camp, participants enjoyed the origami, sketching, LEGO building, and modeling exercises. For example, participants reported their best experiences as follows: "seeing the different people and what branches of engineering they worked in," "trying to build the Japanese skyline," "drawing the fractals and building the origami," and "I liked the crafts and the origami, and it was interesting."

The summer 2022 camp was delivered in-person. For this summer experience, the Arts were included in the STEM focus, so the focus was Science, Technology, Engineering, Arts and Mathematics (STEAM). The program followed Minnesota COVID-19 protocols to ensure a safe environment, and all participants wore masks during indoor activities. Since the camp was delivered in-person, more detailed pre- and post-surveys and informal observations were conducted. From the 58 registered campers, 23 attended the full 2 weeks of the summer camp and participated in the pre-and post-survey (7 grade K–6 and 16 grade 7–12 students). When asked in the post-camp survey how the experience would contribute to their future plans, participants reported wanting to become engineers, architects, entrepreneurs, fashion designers, computer programmers, and animators. Notably, a participant reported that the program taught "me how to create and provide helpful things to the economy." Additionally students reported that the experiences helped them with mental mathematics, technology, and logical skills. These findings, demonstrating stronger STEM/STEAM self-efficacy (**Figures 11** and **12**), support the program directors' intentions to use creative project-based learning exercises to promote future success. **Figures 11** and **12** summarizes the average Likert score of summer camp participants attitudes towards STEAM pre-and post-camp. For example, as illustrated in the diagrams the average Likert score for the following questions increased from the pre to post: *I think I can do well in STEAM (3.82 to 4.45), I think STEAM will help me even when I am not in school (3.73 to 4.00), I am interested in thing I learn in STEAM (3.73 to 4.05) and I enjoy doing STEAM projects (3.70 to 4.35).*

As seen in comparison of **Figures 11** and **12**, most participants reported that the program helped them understand STEAM as much as they can. The average Likert score of the other five questions shows an increase after the camp, indicating an increase in students' interest in the STEAM class. All students thought STEAM is important and enjoyed doing STEAM projects. Through the camp, they mastered many new skills, and believed STEAM would help them even when they are not in school. The summer design camp helped them improve their interest in STEAM. However, it looks like students were not looking forward to their STEAM classes in school. A paired-sample t-test was conducted to the pre-and post-test survey questions to determine if there was significant difference at the end of the camp experience. As

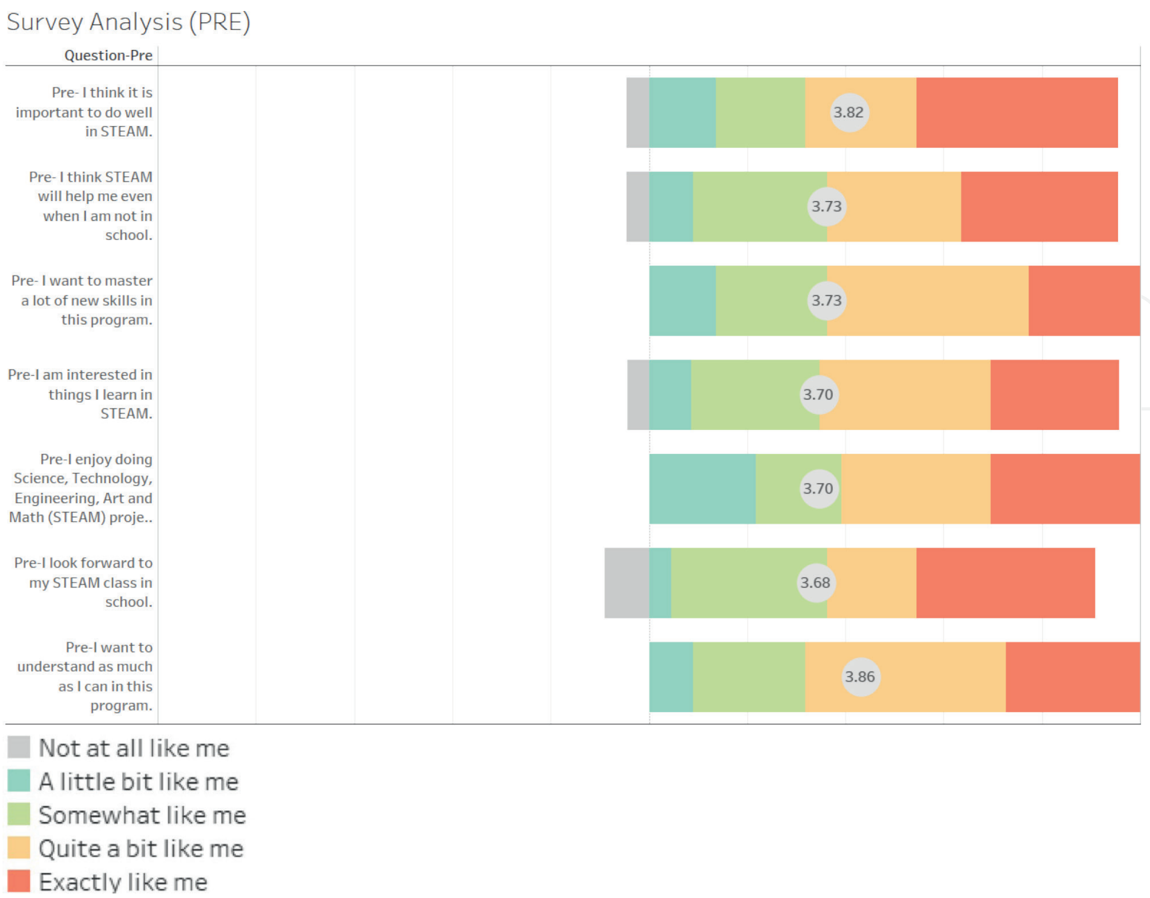

Figure 11.
Pre-Survey of 2022 Summer Camp participants attitudes towards STEAM.

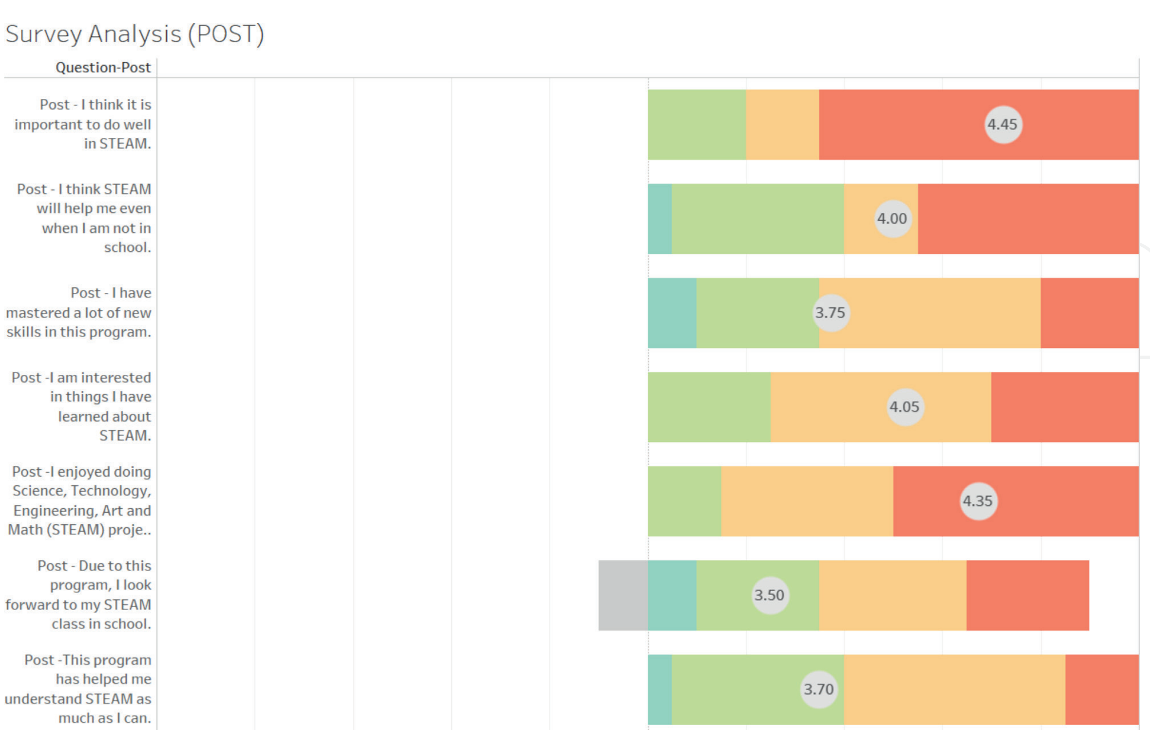

Figure 12.
Post-Survey of 2022 Summer Camp participants attitudes towards STEAM.

Survey questions		Pre-test		Post-test		Sig.
Pre	Post	Mean	SD	Mean	SD	
I think it is important to do well in STEAM.	I think it is important to do well in STEAM.	3.82	1.26	4.45	0.83	0.06
I think STEAM will help me even w hen I am not in school.	I think STEAM will help me even when I am not in school.	3.73	1.16	4.00	1.03	0.43
I want to master a lot of new skills in this program	I have mastered a lot of new skills in this program.	3.73	0.98	3.75	0.91	0.94
I am interested in things I learn in STEAM.	I am interested in things I have learned about STEAM.	3.70	1.11	4.05	0.76	0.23
I enjoy doing Science, Technology, Engineering, Art and Math (STEAM) projects.	I enjoyed doing Science, Technology, Engineering, Art and Math (STEAM) projects.	3.70	1.15	4.35	0.75	0.03
I look forward to my STEAM class in school.	Due to this program, I look forward to my STEAM class in school.	3.68	1.29	3.50	1.28	0.65
I want to understand as much as I can in this program.	This program has helped me understand STEAM as much as I can.	3.86	0.94	3.70	0.80	0.55

Table 1.
Student Interest in STEAM pre- and post- summer camp. Mean, Standard Deviations for Pre- and Post-test data and t Test results (n = 23).

shown in **Table 1** there was significant difference in pre-and post for the question *I enjoy doing STEAM projects*. Our limitations are the small sample size in the in-person summer 2022 camp due to the COVID-19 pandemic. A larger sample size will be needed to show any statistically significant difference before and after camp.

In terms of the program directors' goal to close the learning gaps due to the COVID-19 pandemic, the hands-on experiences in 3D modeling in TinkerCAD and in coding and 3D printing provided the opportunity to tackle digital inequities and the lack of access to current technologies faced by underrepresented students. Overwhelmingly, student participants mentioned 3D printing, modeling, and coding when asked about their best experience post-camp.

In terms of the goal to use an inclusive lens of STEAM learning, the project-based curriculum used a "culturally-responsive approach" incorporating design examples from underrepresented and minority designers to teach about fractals, geometry, design, and architecture. The visual and design examples came from patterns, visuals, architecture, and ornamentation from African, African American, Hmong, Vietnamese and global cultural examples, helping student participants see role models and a reflection of themselves in the project materials.

5. Conclusion

Findings from the program across the years indicate a high level of engagement and positive learning experiences among program participants. By learning about design and mathematics, participants gained broader perspectives and discovered new interests and career paths. Additionally, our findings highlight how understanding the connections between different disciplines helps foster creativity and innovation. Our findings are consistent with those of authors such as Gauntlett [29], that found LEGO experiences offer students creative thinking opportunities [29], and Marsh et al. [22], that highlighted the importance of exposing underrepresented students to maker spaces [22]. Similar to previous authors, we found that anecdotal evidence from this program showed underrepresented students learned about their cultural roots from the program experiences [23].

As the UMN student body is not diverse, programs like this can provide pathways to future careers and bridge educational disparities. The program instills in participants the motivation to continue exploring these disciplines, and helps them develop relevant knowledge and skills for the future. Universities and educational institutions play a critical role in promoting diversity, equity, and inclusion in education and future careers. Programs aimed at increasing the representation of underrepresented students, such as those from low-income or minority backgrounds, can reduce educational disparities and provide these students with the skills and resources they need to succeed in their chosen fields. By creating inclusive and supportive environments, universities can help foster a sense of belonging and empowerment for underrepresented students and help them reach their full potential.

The COVID-19 pandemic caused widespread learning losses, particularly among students from underrepresented communities who may have faced additional challenges such as limited access to technology and disrupted home environments. To bridge these learning losses, this program introduced initiatives such as:

- Implementing remote learning technologies and online resources to make education more accessible.

- Offering summer programs to help underrepresented students develop knowledge and skills in disciplines like design and mathematics.

- Providing access to digital experiences, technologies, and digital fabrication that are crucial in today's technology-driven world. Specifically, via this program, underrepresented students learned how to design via 3D printing, laser cutting, and mathematical calculations.

It is important to address the learning losses caused by the pandemic and to ensure that all students have access to the resources they need to succeed in their education. By working together, educators, policymakers, and communities can help mitigate the impact of the pandemic and ensure that students have the opportunities they need to reach their full potential.

One of the biggest challenges in carrying out the above initiatives is funding. Scaling up these initiatives to reach more underrepresented students and have a greater impact requires significant financial resources. It is crucial to find innovative and sustainable funding models that can support the scaling up and larger impact of these initiatives. This could include partnerships among government, business, and non-profit organizations, leveraging existing infrastructure and resources, and exploring alternative funding sources such as crowd-funding and social impact bonds. Ultimately, the key to overcoming funding challenges is a combination of creativity, persistence, and collaboration. By bringing together stakeholders from different sectors and working together towards a common goal, it is possible to secure the funding needed to provide access to digital experiences, technologies, and digital fabrication for underrepresented students.

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