2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #34543

Art and Engineering in Kindergarten (RTP)

Dr. Diane Elisa Golding, University of Texas at El Paso

Diane is an educator and proponent for K-12 engineering education and the education of future teachers.She is an assistant professor at the University of Texas at El Paso (UTEP). Diane serves as the director for the UTEP YES! She Can program that support minorities and minorities within minorities in personal and STEM self-efficacy. She earned her undergraduate and graduate degrees from UTEP and holds a doctorate from the Rossier School of Education, University of Southern California.

Dr. Heather Kaplan, University of Texas El Paso

Art and Engineering in Kindergarten (RTP)

Introduction

In the race to lead the world in academic standing, the US has formalized the Kindergarten curriculum and swept away the center-oriented classroom design of play, exploration and socialization to a more academic setting [1]. Visual art and engineering are two subject areas with precarious footing in the K-12 U.S. education system. One fading away with each grade level and the other emerging only in recent years as a legitimate content area. The Texas Education Agency added the Engineering essential knowledge and skills in 2015 and, while engineering is now a recognized subject, many K-5 teachers, especially, do not feel prepared to integrate engineering into their pedagogy [2].

The idea of early childhood makerspace as a place to facilitate engineering teaching and learning is a relatively new notion. While the makerspace concept began in the early 21st century, it's standing in higher education settings and high school curricular activity is steadily increasing in acceptance and practice. The idea of a makerspace in public school Kindergarten is novel, and especially in the southwest region. This paper describes an ethnographic case study of a kindergarten makerspace and researcher lead collaboration within a local elementary school that focused on promoting STEM learning for underrepresented populations through makerspace explorations bounded in STEAM practices. This paper and research ask, "What do kindergarten makerspaces look like in the El Paso-Juarez border region?", "How do engineering and art intersect in kindergarten makerspaces?" and "What occurs, is experienced or learned in these intersections in a kindergarten makerspace?"

We contend that skills and knowledge developed in makerspaces straddle STEM, specifically the design process commonly discussed in engineering education, in relation to the Engineering is Elementary model [3] and studio art practices, described by Hetland et al's [4] Studio Habits of Mind. Our approach, very much like Lachapelle and Cunningham [5], encouraged a natural engagement in the design process, presented in Figure 1 below, which meant that children may communicate their design and even do so as they created their solutions in lieu of drawing a plan. Students communicated their thinking even as they synchronously planned and created. Similarly, children could change their designs to improve traps as they were in the creation stage, in order to "promote creativity and a solution" that best suited the problem [5]. This model is representative of skills students need for 21st century jobs and is intentional as a nonlinear model of problem-solving and is open-ended at each stage of the design process.

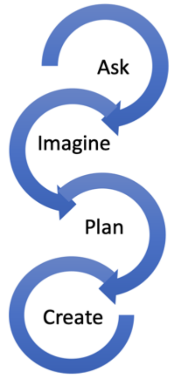


Figure 1. Engineering Design Process based on Engineering is Elementary [3]

According to Douglas and Jaquith "the Studio Habits of Mind describe what artists do" [6], not only this but according to Hogan et al. [7], "they capture the way that artists think." Like the engineering design process, studio habits of mind highlight that making is more than mere activity and that practices and processes of making not only produce knowledge, but they also produce the conditions for continued inquiry, and they shape the mind in ways that allow for proclivity toward certain dispositions and the possibility for continued discovery and creation.

After studies failed to draw causal relationships between the study of the arts and improved test scores, Hetland et al. [4 p. 7] developed the Studio Habits of mind from empirical study of art classrooms as a way to describe "the kinds of thinking developed by the arts [that are] important in and of themselves, as important as the thinking developed in more traditionally academic subjects." According to Hetland et al. [4], the eight Studio Habits of Mind include: Developing Craft, Engaging and Persisting, Envisioning, Expressing, Observing, Reflecting, Stretching and Exploring, and Understanding Art Worlds.

Hetland et al. [4] define the eight Studio Habits of Mind in the following ways:

> Develop Craft- *Technique*: Learning to use tools (e.g. viewfinders, brushes), materials (e.g. charcoal, paint); learning artistic conventions (e.g. perspective, color mixing) *Studio practice*: Learning to care for tools, materials, and space.
>
> Engage and Persist- Learning to embrace problems of relevance within the art world and/or of personal importance, to develop focus and other mental states conducive to working and persevering at art tasks.
>
> Envision- Learning to picture mentally what cannot be directly observed and imagine possible next steps in making a piece.
>
> Express- Learning to create works that convey an idea, a feeling, or a personal meaning.

Observe- Learning to attend to visual context more closely than ordinary "looking" requires, and thereby to see things that otherwise might not be seen.

Reflect- *Question and Explain*: Learning to think and talk with others about an aspect of one's work or working process. *Evaluate*: Learning to judge one's own work and working process, and the work of others in relation to standards in the field.

Stretch and Explore- Learning to reach beyond one's capacities, to explore playfully without a preconceived plan, and to embrace opportunity to learn from mistakes and accidents.

Understand Art Worlds- *Domain*: Learning about art history and current practice *Communities*: Learning to interact as an artist with other artists (i.e. in classrooms, in local arts organizations, and across the art field) and within broader society.

Likewise, Bers [8] identifies positive, sustaining behaviors that move beyond problem solving and subject-centered knowledge of technology including coding and STEM makerspaces. She refers to these behaviors as the six Cs of Positive Technological Development (PTD) and they include collaboration, communication, community building, content creation, creativity, and choices of conduct. Bers [9] explains that these behaviors ultimately "promote developmental assets." Like the studio habits of mind, the six Cs of Positive Technological Development consider the development of the whole person and have broader application beyond a single profession or siloed subject area. Like students who can develop craft, engage and persist, envision, express, observe, reflect, stretch and explore, and understand worlds, students who can collaborate, communicate, build community, create content, choose their conduct and are creative possess ways of knowing and being that move beyond the objectives of one subject or profession. Lapachelle and Cunningham [5] point to the flexibility of the engineering design process as a possible nonlinear, open-ended learning cycle that may be revisited to rethink, discuss, and formulate new solutions, a quality shared by both the studio habits of mind and Positive Technological Development. While these skills are learned through a practice and immersion in processes which are often subject-centered these behaviors and practices hold greater potential for the individual learner than the subject learning alone.

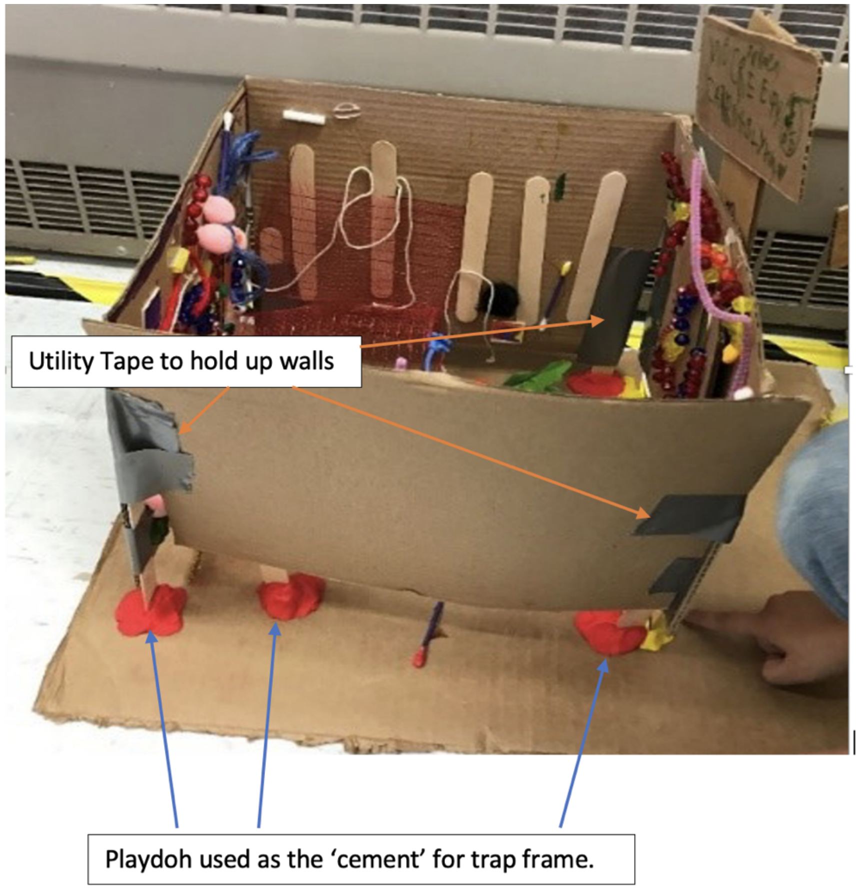
Our preliminary research indicates correlation of the engineering design process and the Studio Habits of Mind as defined through studies in arts classrooms through Bers' [8] [9] notion of Positive Technological Development. During the Creepy Carrots project, we witnessed many of the aforementioned dispositions and the following discussion will describe a few instances where the Studio Habits of Mind and the six C's of Positive Technological Development intersected. In the interest of time, we have chosen to explore those intersections that were most prevalent in our analysis. This is by no means an exhaustive analysis of the intersection of these behaviors in this study or possible in subsequent studies. The authors suggest that further study may reveal additional connections and deepen complexity and understanding of these intersections.

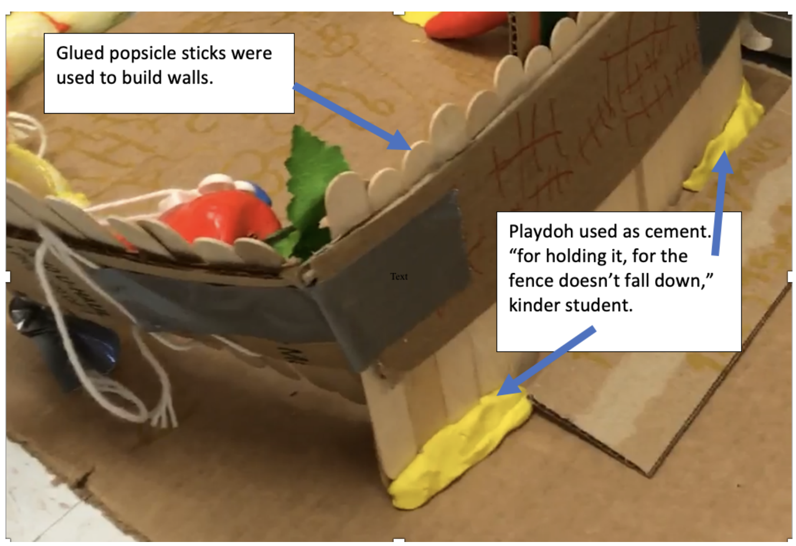
Background

The research to be discussed took place in a rural school approximately 20 miles from the local university and serves a demographic of approximately 400 prekindergarten through 5th grade students. Ninety-seven percent of students are Hispanic, 84% come from low socio-economic backgrounds and more than 50% are English language learners [10]. The researchers, one faculty member in the Art department and one from the Teacher Education department, were part of a collaborative effort to develop a Makerspace for use by the student population. Kindergarten students engaged in makerspace activities several times using stories to incite students' thinking about a problem.

The makerspace was located in the Pre-Kindergarten and Kindergarten wing of a rural school built in 1994. The classroom was large with a window across one wall that looked onto the playground and further to a field. The space had a bathroom, sink area and storage closet, and along one wall was a low chalkboard (yes, old school) that was easily accessible for the youngest students. The south wall was lined with tables that held materials for students to explore and use in their creations. The flooring was linoleum and there were 8 round 'creating' tables scattered in the center of the room. Interestingly enough, each of the tables were sized for adult use and after several requests for assistance the tables were made to size for young students. The researcher with an art background created another self-expression wall with paint that allowed students to draw and write on the wall's surface. The approach to the makerspace design supported the Reggio Emilia philosophy that the environment benefits the learning experience. Further, these spaces can provide a feeling of belongingness for students, as has been the case in makerspaces at the university level. [11][12]

For this paper, we begin with one of the stories shared with the kindergarten students, Creepy Carrots by Aaron Reynolds. This fictional text was read and discussed as a preliminary activity to provide a problem for students to think about followed by students' designs of a solution to the problem (the Youtube read aloud may be found here: https://youtu.be/NJnIEbVLq90). The crux of the problem is that Jasper Rabbit has been eating up the carrots in Crackenhopper Field and the carrots decided to put a stop to Jasper's feasting. Their solution was to stalk the poor rabbit until the only thing he wanted was to be rid of the carrots! The five-year-old students decided something had to be done to help Jasper. Prompted by their teacher and one of the researchers, the children were encouraged to create containment structures. In order to facilitate their ideas, the students were introduced to a variety of materials available to use to create their solutions. Students put their imaginations to work to plan, design, and construct frameworks to contain the creepy carrots. In the artifacts below, the 'cement' of choice was playdoh and utility tape was applied to hold the walls together. Two groups utilized popsicle sticks glued together to serve as the walls of the containments.





Artifact 1. Two examples of ‘cementing’ the frame.

The students chose to communicate with their group to work through how to build the frames and how containment walls or fences were designed. These structures, imagined, planned and created by 5-year-olds were incredibly creative and unique to each set of students working together in collaboration. The next section is a discussion of the interconnections of engineering and art processes along with samples of students' artifacts.

Analysis: A Selection of Three of the 6Cs and Their Corresponding Habits of Mind Communication

Bers defines communication as "the exchange of data and information" [9 p. 135]. Implied in this definition is the importance of transmission; undiscussed is the mode of transmission. While this definition is decidedly one located within the language of technology it does not preclude the language of art. Affirmatively, the Studio Habits of Mind echo the importance of communication. In particular, both *Express* and *Reflect* deal with different aspects of communication. The first *Express* involves the notion that artmaking involves the communication of feelings or ideas and that artmaking is a practice in which the many modalities of art can express internal states or larger concepts. For instance, here it is assumed that an image is a form of communication, and therefore, so is a sculpture, performance, installation, etc. Likewise, *Reflect* involves the practice of questioning and explaining which importantly involves the ability to read one's work with and through the eyes of others. It implies the communicative nature of artmaking and asks that the maker be able to not only assume the role of reader or audience but that the same maker engage in discussion with others about their reception of and understanding of the work.

Because children worked together in small groups, one of the most prevalent behaviors observed during the Creepy Carrots project was communication. We witnessed communication within the groups, between groups, and through the practice of explaining or performing the work to an interested adult (in this case us - the researchers). During the process of creation in their small groups, the children negotiated the form their expression would take, this practice involved the reciprocal behaviors of expression and reflection. Students were able to move between the creation or expression of ideas to viewing or interpreting their work or the work of their peers, in order to evaluate or understand the unfolding collaborative containment structure. Not only did the students work together require that they communicate with each other, but their projects also reflected the way that ideas and inventions moved among groups. For instance, more than one group of children described the use of lasers to contain the carrots and in each group the same shiny blue or red gems represented these technologies. This kind of mimicry illustrates the ways that ideas flow and are communicated during children's social learning explorations and is often seen in children's drawing practices [13]. Likewise, students' performative explanations to an interested adult not only exhibited the students' ability to communicate their process and ideas to another but these explanations were more often performative negotiations of meaning making between children. When two young girls described the interior living conditions of their containment structure, disagreement about whether their creation is a crab to enforce containment or a saltshaker for cooking ensued. The first girl exclaimed to the interested adult, “There’s a crab.” Promptly the second girl interjected, “That isn’t a crab, this is his little salt!” The first child replied, “That isn’t his salt!” to which the second child replied, “He [the contained carrot] wants to cook something. He’s gonna cook his socks.” Here we see how the performative act of communication is a complex and unfolding practice of negotiation that is dynamic and complicated. Meaning making is constituted and negotiated between actors during the act of reflecting, evaluating, and reporting.

Collaboration

Bers explains that collaboration is defined as “a process where two or more people work together to realize shared goals” and that it promotes caring or “the willingness to respond to the needs of other individuals, to assist others, and to use technology as a means to help others” [9 p133]. In the Creepy Carrots project not only were children grouped together and asked to collaborate through the entire project, and in order to solve the initial problem of how to contain the sneaky carrots, but the particular instance of building foundations to prevent their structures from falling was a more pointed example of the importance of collaboration to the practice of problem solving. When students experienced difficulty getting their structures to remain standing, the kindergarten teacher posed the question to the entire class and collaboratively the class explored possible solutions to this structural dilemma. Not only did this collective action allow for deeper learning within engineering to emerge but together students were able to explore and address problems that may have overwhelmed single groups alone.

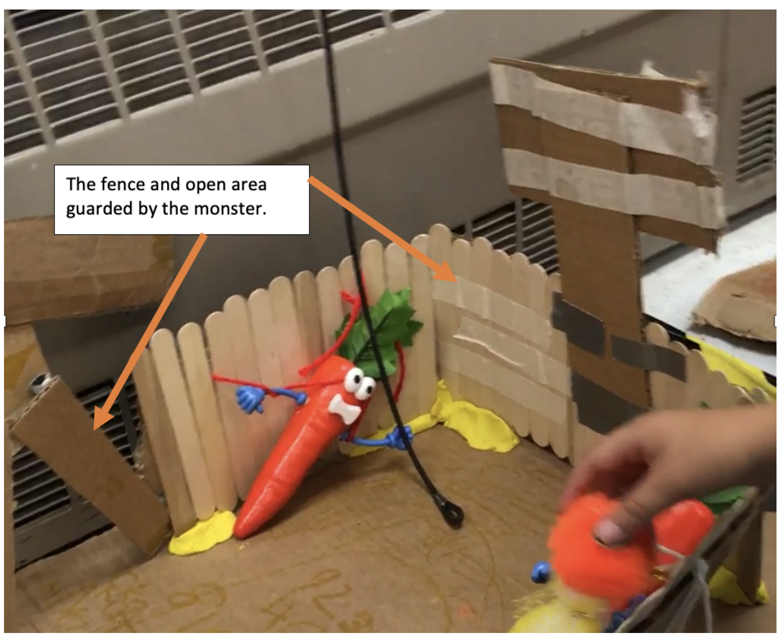
The practice of artmaking is often a collaborative practice, but it is not necessarily so. In fact, widely held understandings of the lone artist as genius promotes notions of artmaking as an individual act. Public conceptions of popular artists like Vincent Van Gogh, Leonardo da Vinci, and Jackson Pollock perpetuate this myth that most art is the belabored product of an individual artist working in solitude. While there are many historical examples of the artist genius, many of the works attributed to a single artist are indeed the result of many collaborative actors working under a studio or as a collective. For example, the masterful works of Rembrandt van Rijn were produced by his studio and the artist may have only completed sections of the work. Surprisingly, the Studio Habits of Mind tend to follow popular and schooled notions (especially those of high school students) of individual production and do not explicitly address notions of teamwork, group thinking, or collaboration. In spite of this oversight, certain Habits of Mind might lend themselves to this sort of behavior. In particular *Stretch and Explore* which is defined as “learning to reach beyond one’s capacity, to explore playfully without a preconceived plan, and to embrace opportunity to learn from mistakes and accidents” might best be achieved through collaboration. Specifically, if one were to be paired with a more capable peer (Vygotsky), a child’s ability to reach their capacity could be supported. Likewise, explorative play and embracing mistakes are often facilitated by successful collaborations. Additionally, the Habit of Mind *Understand the Art World* involves “learning to interact as an artist with other artists” however, interaction can include but does not necessarily involve collaboration [4].

Creativity

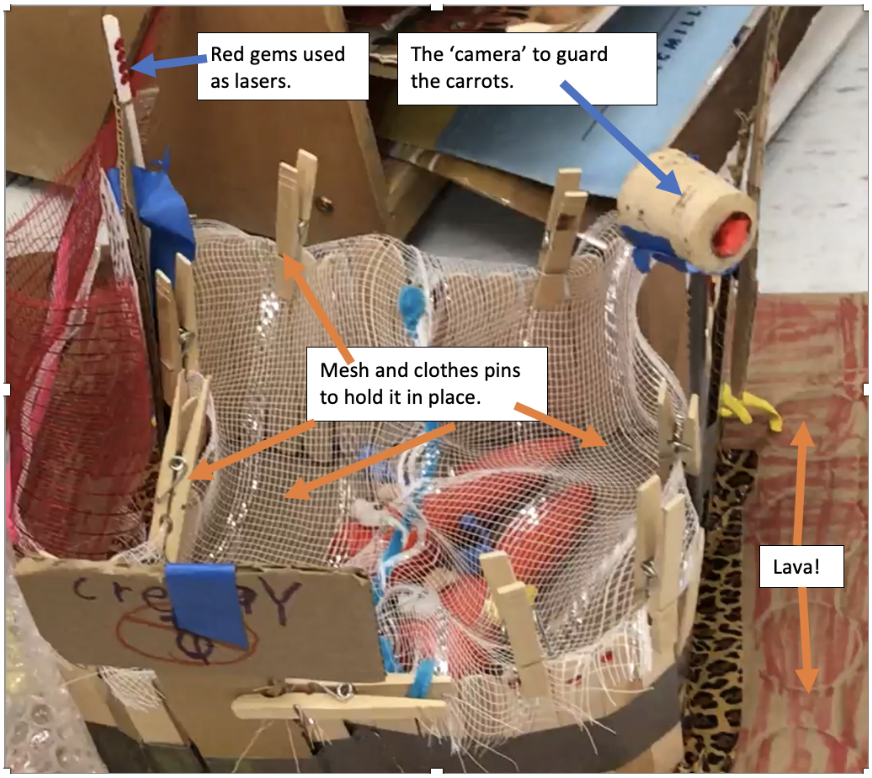
Bers' definition of creativity as "creative expression" or "[the ability to] imagine new ways of using ... tool[s]" is rather thin but not unusually so [9 p. 142]. Creativity is an elusive concept that often refers to behaviors that involve invention, exploration, and play that lead to new forms, ideas, and understandings. It might be likened to the Studio Habit of Mind [4] envision which is defined as learning to picture mentally what cannot be directly observed and imagine possible next steps in making a piece. While a conception of creativity that hints at the involvement of imagination, this notion might be inadequate to represent the fullness of creativity. In other words, creativity could involve a process of creation that may or may not involve an a priori mental picture or acts of imagination and rather creativity could involve unfolding practices of exploration, experimentation, and invention that are not foreseen but could be attributed to imagination, possibility, and inventiveness. Rather than focus on one, one might contend that all of the Studio Habits of Mind coalesce to describe a proven practice of creative expression, exploration, and invention that could be referred to as a form of creation or creativity. In so far as the children created new forms (i.e. idiosyncratic containment structures) through exploration, imagination, invention, and play, we can conclude that the children were engaged in creativity.

To be sure, even though elements of mimicry and repetition were located across different iterations of the Creepy Carrot containment systems, each process and product was a unique expression of the negotiations of collaborative decision and choice making, embodied unique problem solving that expressed the group's priorities and perceived problems, and were artifacts of inventive tool use. Each group was tasked not only with working together but every decision along the way from which materials to use to what those materials expressed to how they would be combined represented a complex set of decision making and negotiations between the participants. This can be seen in the variety of approaches, the richness in the products, and the variety of expression from structural adaptations, adornment, and signage. Each group expressed different priorities and problems through their creations. For instance, the girls' group identified a need to consider the carrots' living conditions once detained. While one of the boys' groups was concerned with creating and depicting escape deterrent systems like lasers, cameras, sticks, tape, and lava. Finally, each group invented different approaches to using the supplies and tools. One group utilized and glued together modest cardboard strips to create a large, flat representation of a monster [Artifact 2] that lorded over an open, yet penitentiary-like yard defined by popsicle sticks [Artifact 3]. Another created a camera from wine corks with large red gems affixed to one side and taped with blue painters' tape to sturdy plastic straws that allowed the camera to loom over the carrots who were contained by a sparkly craft mesh affixed to a popsicle fence with clothes pins [Artifact 4]. The final group used cardboard and duct tape rather than popsicle sticks to define the perimeter of their carrot containment structure. They then adopted an interior design-like approach of decorating and considering the amenities of space as if to entice the carrot to inhabit the space rather than to escape [Artifact 5].

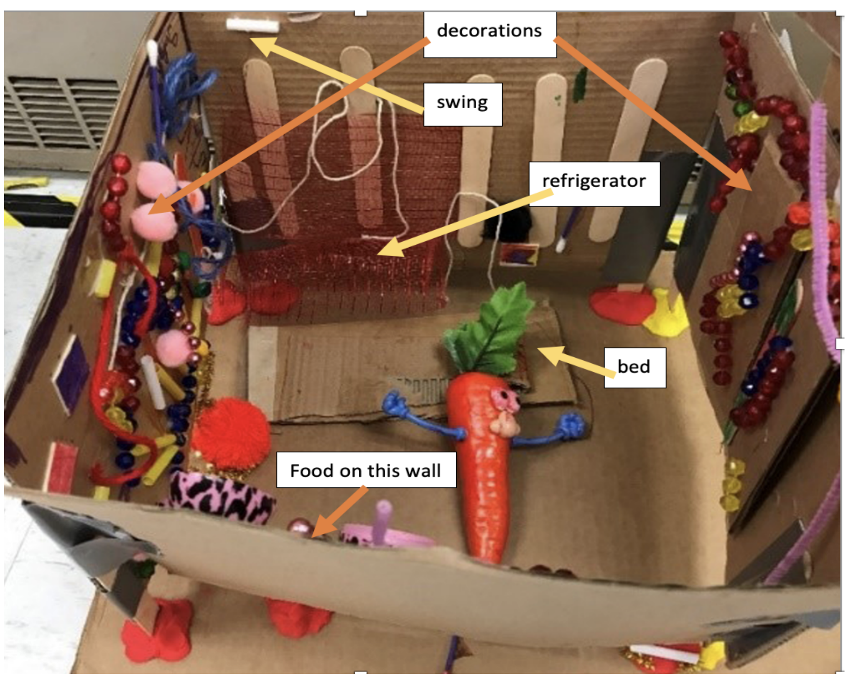
Artifact 2. A monster guard to ensure the carrots' imprisonment.



Artifact 3. The fencing in a penitentiary-like yard.



Artifact 4. Covering the trap from top to bottom.



Artifact 5. A containment with all the amenities a carrot could ever want.

Conclusion

In efforts to leverage the educational playing field, it is crucial that we consider all means to do so. Our Hispanic students bring a wealth of talent and backgrounds that must be used in the classroom to help them express their understandings. This case-study research suggests that explorative, STEAM-enriched kindergarten makerspaces not only offer students opportunities to problem solve and express their ideas through dynamic processes and idiosyncratic forms, but they also experience and practice skills, behaviors, and habits that are not only integral to successful STEM education and the STEM professions but are also crucial to developing the whole child.

The overlay of the engineering design process, habits of mind and at least three of 6 C's of Bers [9] Positive Technical Development is unmistakable. These researchers will continue to investigate with the question "What kind of learners do we want our young children to become?" [12]; how do we help them to get there? and, finally, can we use all the ways of cogitation to develop multifaceted, innovative, creative, critical thinkers? Here we have discussed how five-year-old children have used the engineering design process to construct a solution and in the process of doing so, have exhibited the Studio Habits of Mind to create significant and new meaning to their constructs in an early childhood makerspace. Our intent is to further investigate the intersectionality of engineering, art, and young children's thinking.

References

[1] D. Bassok, S. Latham, A. Rorem. Is Kindergarten the New First Grade? *AERA Open*. January 2016. doi:10.1177/2332858415616358

[2] R. J. Hammack. "K-5 teachers' perceptions of engineering education and perceived barriers to teaching engineering." *2018 ASEE Annual Conference & Exposition*. 2018.

[3] C.P. Lachapelle & C.M. Cunningham, "Engineering is elementary: Children's changing understandings of science and engineering," in *ASEE Annual Conference & Exposition* (Vol. 33), March 2007.

[4] L. Hetland, E.Winner, S. Veenema, and K. M. Sheridan.. Teachers College Press, 2007.

[5] C.P. Lachapelle & C.M. Cunningham, Engineering in elementary schools. *Engineering in pre-college settings: Synthesizing research, policy, and practices*, 61-88, 2014.

[6] K.M. Douglas, and D. B. Jaquith. *Engaging Learners Through Artmaking: Choice-based Art Education in the Classroom (TAB)*. Teachers College Press, 2018, p. 14.

[7] J. Hogan, L. Hetland, D. Jaquith, E. Winner. Studio Thinking from the Start: The K-8 Art Educator's Handbook. Teachers College Press, 2018, p.8.

[8] M. Bers, M. Umaschi, A. Strawhacker, and M. Vizner. "The design of early childhood makerspaces to support positive technological development." *Library Hi Tech* (2018).

[9] M. Bers. Coding as a Playground: Programming and Computational Thinking in the Early Childhood Classroom (2nd edition). Routledge, 2021, p. 131.

[10] Bill Childress elementary School Profile (2021): xxx TX. (n.d.). Retrieved from https://www.publicschoolreview.com/billchildress-elementary-school-profile

[11] M. E. Andrews, M. Borrego, & A. Boklage, "Self-efficacy and belonging: the impact of a university makerspace," *International Journal of STEM Education*, *8*(1), 1-18, 202.

[12] R. M. Carbonell, M. E. Andrews, A. Boklage, & M. Borrego, "Innovation, Design, and Self-Efficacy: The Impact of Makerspaces," in *ASEE Annual Conference & Exposition, Tampa, 2019, Florida. https://peer. asee. org/32965*.

[13] M. Wilson and B. Wilson, Teaching Children to Draw: A Guide for Teachers and Parents. Prentice Hall, Inc., 1982, pp. 64-67.