Pathways to Neverland: How Play Can Teach Us New Ways to Calculate

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Abstract

Beyond project-based learning and the STEM to STEAM movement, there is a hidden element found in design education that could help build the skills necessary to be both visually artistic and analytically systematic. “Playful Calculation,” as I have come to call it, is a way to bridge the gap between these different modalities of thinking. We can use rules and algorithms along with intuition to be artistically creative. To further this pedagogy, I have documented what happens when children play, and have begun translating these observations into ideas on how we can build algorithmic thinking into foundational art and design studies. Being playful enables creativity, and it can also enable new modes of thinking. Thinking algorithmically will be essential to designers and architects as they move beyond being "users" of new technology, to becoming hackers and creators of new technology themselves.

Playing Beyond Reality

Being playful and being procedural are often understood as two opposing modes of thinking. While playfulness is often linked to the arts and creativity, procedural driven methods are linked to machinery and less intuitive ways of performing a task. I would like to challenge these misconceptions and present an argument that places procedural driven thinking (also known as algorithmic thinking) as a type of play within itself. As design education expands to adapt new technologies, algorithmic thinking will become increasingly important to work with these tools and integrate them into our design process.

The importance of play in the design process is often overlooked in design education. However, certain technologies are bringing back to the forefront the element of play in how we perceive and design space. The Oculus Rift, for instance, is a tool that is not just changing design visualization, but could also change the overall design process. Anyone who has had the "Oculus experience" knows that this is much more immersive than 3D stereoscopic viewing or other virtual reality predecessors. To quote Howard Burns'[i] response, after viewing my computer model of Palazzo Chiericati through the Oculus Rift, he exclaimed, "We don't need to go to Vicenza anymore, we have it right here!" True enough, the Oculus Rift gives the viewer the closest experience to being "in" a space without physically being there, but this is only the tipping point.

In a recent research initiative at MIT, we looked at the feasibility of a fully immersive design environment[ii]. We wanted to move beyond using the Oculus Rift for project visualization, and see if we could actually perform design tasks within the VR space at a 1:1 scale. The end product I must admit was clunky (as most prototypes are), but it worked! We used the Oculus Rift, Microsoft Kinect, a hacked Wii Fit board, and programmed the entire experiment in Unity[iii]. We experimented with the "kit of part exercise", a problem set given to most architecture students in their first year of study[iv] (Ockman & Rebecca Williamson, 2012). Instead of fiddling around with physical wooden scale models, through our system the designer is able to walk around a VR world and move the full scale kit of part components with their arms and hands. They can design and construct almost as a child would in building a play fort.

Figure 1: Student working on the kit-of-parts problem through virtual reality

What Happened to Play?

The use of the child metaphor is intentional, because much of my research on design education falls in line with what many have said in that "play" is essential to learning (Dewey, 1938; Paley, 2004; Thomas & Brown, 2011). In spite its importance, the element of play seems to decrease the higher we move up in education, and design education is not immune to this epidemic. The 2001 AIAS Studio Culture Task Force wrote a comprehensive report on the various ills of studio culture (Dutton, Koch, Schwennsen & Smith, 2002). Students are often experiencing high levels of stress, frustration from lack of clarity, and often carry a gloomy sense of defeat (Casakin & Shulamith, 2008). This is not the description of a playful environment. Stuart Brown, (2009) says that, "*Play energizes us and enlivens us. It eases our burdens. It renews our natural sense of optimism and opens us up to new possibilities.*" There is a disconnection in our educational experiences. We begin our educational journey in kindergarten, where learning is all about play, but as we progress through grade levels something happens. By the time you find yourself in architecture school, playing to learn is a vague memory.

The absence of play became even clearer when I observed my own students for the first few days of a graduate seminar I taught called *Rule-Based 3D Modeling: Learning Through Play*. For every class I used one of the three hours and called it "Play Time." On different days, students were given play objects (from toys to video games) in which they were guided through the cycle of playing, reflection, and discussion. The first day they were presented with ping pong balls, plastic cups, string, paper, and wooden dowels; they looked at me with great confusion when I gave the simple instruction to take these and play for 15 minutes. In contrast, my toddler daughter and son would have no problem with this assignment. The problem would only exist if I pulled out those materials and said NOT to play with these things, or simply asked them to share with each other. Yet, for these bright graduate students there was a moment of hesitation, a nervous laughter, and a puzzled look begging for more instruction. Throughout the semester students eventually loosened up, and began to relish in that hour of play. The semester ended with students "playing" their final projects. Each student created their own unique computer modeling applet.

A New Way to Play

This seminar was trying to push the envelope on design education and bring us back to a place where play is central to learning. At the same time, emerging technologies like the Oculus Rift are presenting new playful ways to approach design. In each of these cases designers and educators will need to learn a new set of skills to play in this metaphorical playground. They will need to learn new ways to calculate; without this skill they will not gain access to the playground. In using the term "calculate" I am not only referring to mathematics, nor am I limiting this term to the usage of computer languages (Java, C++, C#, Python, and MATLAB to name a few).Calculation is inclusive of these things, but can also extend beyond the digital back into the domain of tangible objects. Designers should willingly embrace the multiple forms of calculation.

For a long time architects have held on to "sketching" as the primary skill that gave them creative superiority over other professions (Allsopp, 1952; Lawson, 1990; Lawson, 2004). This was our main "super power" so to speak, in keeping authority over several aspects of the design process. While sketching is not going away, sketching skills alone will not save architecture and design from the coming age, where design professionals are not just "users" of new technology, but hackers and creators of new technology themselves. Sketching is one particular way we calculate with the eye, but there are other intuitive and algorithmic ways of thinking.

This extended perspective of calculation, has a lot to do with what I have been passionate about in researching the changing face of K-12 STEM education. Beyond project based learning and beyond the STEM to STEAM movement, there is a hidden element found in design education that could help build the skills necessary to be both visually artistic and analytically systematic (Stiny, 2006). "Playful Calculation," as I have come to call it, is a way to bridge the gap between these different modalities of thinking. Playful Calculation is the process of creating rules and algorithms to document the moves and gestures of the design process. The process is like writing recipes for design. These rules can be written as a reflective process after one performs a series of design actions, or a designer might begin with writing the rule set to begin the design process. By starting the design process with the rule set (or algorithm), the designer can still rely on intuition to drive the process as they can accept or reject the emerged forms that are generated. To further this pedagogy, I have documented what happens when children play with objects that lend themselves to be described by simple algorithmic rules. I have then translated these observations into ideas on how we can build algorithmic thinking into foundational art and design studies.

Observations on Play and Design

When I first came up with the *"Shape Game"* I was watching my own three year old daughter as she played with scraps of transparency paper on which I had drawn irregular hexagonal shapes. Similar to *Tangrams*[v] she began sliding them along our kitchen table, amusing herself as the shapes began to embed into each other creating patterns. When a shape emerged that she recognized, she would pause and say things like, "Look a diamond!" From this observation I spent weeks developing a simple game that would allow children to play with shapes in a similar fashion.

Figure 2: Child playing the *Shape Game*

The *Shape Game*, now fully developed, is a game in which players manipulate small transparent shape pieces with bold outlines to make a variety of patterns. The game can be played on any surface, but for my study I often used a light table to enhance the transparency of the shapes. This allowed the children to play this as a game of 2D lines and shapes[vi]. With these transparent pieces, the children would slide them around creating an array of patterns just as one would do in looking through a kaleidoscope.

As the study evolved I further developed the game by introducing a set of sixty pattern cards that each held specific configurations of sets of four shape pieces. Because each shape pieces is identical, at first glance most players were confused on how these elaborate patterns could be formed with four simple pieces. When they looked at the pattern card they saw many shapes on the pattern card that did not match the four identical shape pieces. However, once they began laying the shape pieces on top of each other, they began to see the novelty of embedding and shape emergence (Knight, 2003). The compositions were greater than the sum of its parts. Terry Knight (2012) would call this learning through "slow computing." With their eyes they calculated, and with their hands they carried out the computations.

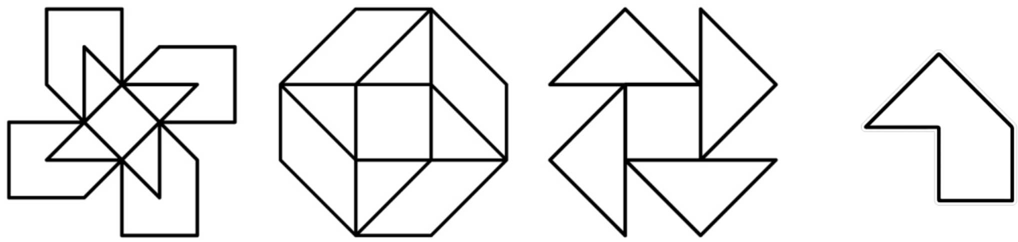

Figure 3: Examples of three pattern cards (left) generated by 4 shape pieces (as the one seen right)

The last rendition of this game occurred with an older audience in which players were asked to dictate to a game partner the necessary configuration to layout the shape pieces to achieve a specific pattern[vii]. The player giving instructions had to keep the pattern card concealed from the person they were giving instructions to. The one receiving instructions was only allowed to manipulate the four shape pieces. Here I observed several types of strategies as students gave instruction. I saw this as their way to "audibly program" this manually driven design making process. They were exercising algorithmic thinking, creativity, and play all interwoven.

In all three ways of playing the *Shape Game* I noticed the strong presence of informal visual calculation. While it has been said that children have ways of counting and calculating before the years of formal instruction (Butterworth, 2005), the same can be said about the arts and calculating with the eyes. In observing children playing this game I identified distinctly the player's usage of the same isometric actions we find in transformational geometry: translation, rotation, reflection, and glide reflection (Knight & Stiny, 2001). These became informative building blocks as the children progressed through different versions of game play, and were most useful in the final game version when older players were audibly programming. Players were moving beyond playing with a kit of parts, to playing with a kit of actions. The collection of these actions can be understood as an informal algorithm. These things were all learned through game play and not formal instruction.

A second case study on the noticeable difference of learning infused by playful calculation can be seen in what's being done at NuVu Studio in Cambridge, MA[viii]. NuVu is a progressive alternative education environment that offers advanced courses to high school aged students. Each course last two weeks and range in subjects from computer games, robotics, graphic design, and fashion (to name a few). Students enroll in these classes throughout the year. Consistently this learning center is inspiring minds and challenging our notions of school and learning. For the summer of 2014 the theme was "Fantasy" and I taught as an instructor for the video game studio. Along with my fellow game instructors (a veteran video game sound designer and a recent MArch graduate) we lead students along the process of developing their own prototype video game.

In total there were five projects developed by teams that ranged from groups of 2-3 students. The students had no previous background knowledge in game design, and only a handful had ever touched 3D modeling software. To scaffold the learning experience we decided to present them with a video game "kit of parts" that held the components you would find in any 3D or 2D "platformer" game. Students then used this as their launching point to analyze and understand computer code, grasp the hierarchical logic of game assets, and finally they would deconstruct the kit into unique projects of their own.

Looking back at the studio I can see several experiences that stand alone as learning principles for any K-12 learning environment. Video games naturally invite the spirit of play into the learning experience. As mentioned earlier, play is a very essential to learning, but Singer (2011) points out that play is also essential to any creative endeavor; it opens the learner to flexible thinking (Eisner, 2002; Langer, 1997). Secondly, this studio is built on the pedagogy of "learning by doing" (Dewey, 1938; Hetland, 2007). We did not hand out text books, or give formal lessons on C++ or Java Script (the main computer language used to code the games), rather we allowed them to learn the fundamentals of these languages through hands on manipulation, trial and error, and of course on-line resources. Students learned quickly how to use online communities to find answers to questions, while embracing "debugging" and code errors as part of the creative design process (Roblyer & Doering, 2000).

Conclusion

Video Game design is a great example of play, STEM and the arts. The creation of video games requires analytical/algorithmic thinking, math, and technology know-how. On the other hand the decisions the students made on the game's story, aesthetics, music, feel, and sensational experience are without doubt artistic decisions. All required various calculation modalities, yet the learners were in a constant state of play. Even in using traditional hand held media to design (as in the *Shape Game*) we can teach students to process their ideas algorithmically. Playing with rules does not diminish the free intuition of the design process, but rather strengthens it by providing a documented recipe to the creative process. If STEM is to truly become STEAM it should do so through this pedagogy. New technology and algorithmic thinking are strongly interwoven. As we begin to create new technology for design it will only be strengthened if we approach its use with algorithmic thinking, visual calculation, and of course play. I am optimistic about the future, and hope we can all be flexible enough to keep learning, keep innovating, and keep playing.

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[i] Howard Burns is a famed professor of Architecture History. He is a 1961 graduate of Ancient and Modern History from Cambridge University where he was a King's College Fellow. He has taught art and architectural history at the Courtauld Institute in London (as the Slade Professor of Fine Art), the University of Cambridge, King's College (as a Fellow), Harvard University (as the Robert C. and Marian K. Weinberg Professor of Architecture,) and the University in Ferrara.

[ii] The Oculus Rift study was a part of the 2014 MIT MSRP program and a continuation of research conducted in the Design Computation department of MIT School of Architecture and Planning. The involved participants were Derek Ham (MIT PhD student in Design Computation & project manager), Donnell Pinder (undergraduate FAMU Architecture major) and Takehkio Nagakura (MIT Professor of Architecture & Lead P.I.).

[iii] The Oculus Rift was used as the virtual reality stereoscopic viewing and head tracking. The Microsoft Kinect was used to track the body and allow virtual interaction with objects with the player's arms, hands, and feet. The Wii Fit Plus Board enabled the user to navigate a larger space than what was allowed in the small viewing radius of the Kinect. Unity 3D was the final key tool that was used to manage the input and output of all the used devices. It also held the digital model of the kit of parts used in the demonstration.

[iv] The kit-of-parts exercises has been in schools of architecture since the late 1970's but traces of its existence can be seen as far back as the Bauhaus. The exercise is often presented with students making spatial compositions with a set of three dimensional primitives on a gridded base. The pieces are then assembled and

discussed. A popular version of this exercise is also referred to as the nine-square grid problem.

[v] *Tangrams* are a popular game that originated in the original set of Froebel Gifts. The game consists of a set of colorful tiles in a variety of primary shapes: triangles, squares, rectangles, and sometimes circles and semi-circles.

[vi] The game play study was conducted at the Boston Children's Museum in Boston, MA. The exhibits in the museum are mostly hands-on and range in subject material from literacy to science and mathematics. The museum has a long history in research areas centered on developmental child psychology. As a result, protocols are already set in place to allow researchers to conduct their studies in several of the spaces sanctioned by the museum. The studies were conducted by Derek Ham (MIT PhD student in Design Computation) and Rosa Manzo (MIT undergraduate Architecture student).

[vii]This part of the study was conducted with a mixed group of undergraduate students from multiple disciplines.

[viii] NuVu Studio was created by Saeed Arida, Saba Ghole, and Andrew Todd Marcus. NuVu's pedagogy is informed by the architectural design Studio where instructors guide students in hands-on problem-solving to solve complex, comprehensive problems.

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