More Seeing in Learning

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Abstract

Recently, creativity has received increased attention for educational programs from primary to tertiary levels. This research examines the intricacies of the creative process to understand what creativity is and how an educational environment can nurture creative learning through seeing and doing. I argue that the architectural design studio deserves further attention for its pedagogy that trains students to see and act at a faster pace. Based upon my teaching experience and research with students who excelled and struggled in the design studio, I designed a case study to examine the design studio through a working educational program, NuVu, which is a multidisciplinary program for high school students. The NuVu case study offers surprising successes and challenges of modifying the architectural studio for both students and instructors; namely to adapt to the studio culture with its critiques and prototyping and to balance the 'seeing' and 'doing.' The main contribution of this work is to shed light upon how the design studio cultivates creative thinking and how it can be adapted successfully for a different context outside of its architectural confinement.

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Acknowledgements

It is been a great journey to get here. I have meandered and walked through the many long corridors of MIT physically and metaphysically. During this journey many people have left a lasting impact on me as a person and on my research.

First and foremost, I would like to thank my advisor, George Stiny, whose work inspired me to pursue research on education and creativity. Rather than thinking of architecture as a peripheral discipline, he showed us how other disciplines can greatly benefit from architectural education.

I have known Edith Ackermann since I landed at MIT. Her endless generosity and deep insight into educating the creative mind guided me throughout my years at MIT. I felt the impact of Bill Porter not only through my direct contact with him but also through the students he has taught and inspired.

To Nasser Rabbat who relentlessly pushed me to finish. To Sinan and Ibraheem for the support from home.

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Preface

Seeing in learning: Why seeing?

This dissertation is a tribute to my advisor who taught me how to see new things in a world that encourages mindless behavior. It only took five solid years. Every time I thought that I made the switch, I easily reverted back to my old ways. We are conditioned from an early age to see the world in a particular way and to maintain that view. Even when we play with our Lego blocks, we build structures from predetermined shapes. We don't see the fact that we can manipulate the design space rather than use predefined blocks. At most schools, we are expected to memorize information over and over again. In college, we do the same – memorize. The whole premise of universities is to teach you foundational knowledge in the hopes that you will later utilize that knowledge. In all stages of education, we are taught rules and more rules and very little seeing. This dissertation addresses why seeing is needed and how to bring more seeing into education.

I study in the Computation Group within the Department of Architecture at MIT. When someone hears the word computation, usually the first things that come to mind are computers, symbols, or the Turing machine. I initially entered the group to study and research these things. However, the way I see these 'things' has evolved since I began my PhD research. Computation no longer means calculation in the traditional sense of combining symbols. It became about seeing. Turing's machine was replaced by Stiny's shape. Calculating with shapes enabled me to see in a new light the possibilities of computation. Every time you look at shapes, you see something different. When you combine them, something new emerges. Upon seeing that new shape, do you become stuck or do you discover a way to continue? Is it okay to be stuck as long as you find your way out? Shape grammars (SG) provide an alternative computational system that embraces this kind of ambiguity.

In contrast with logicians who invented the computers we use today, Stiny describes shape grammars as an artist's attempt to invent the computer. This statement underscores the importance of abandoning the divide between science and art. Culturally speaking, most artists hate talking about rules, and most scientists hate talking about artistry and indeterminacy. What SG does, is to show that both art and science follow a similar process comprised of seeing and doing.

People often ask me why an architect is studying creativity and education. Architecture is a "creative" discipline, so I seek to understand how architects learn to work creatively. But how are architects taught? Mainly through the design studio. What is so valuable about the pedagogy of the design studio? That is the story of this dissertation.

Donald Schön's work on the design studio led me along this path to explore the value of the design studio outside of its architectural context. When I started thinking entrepreneurially, it was not difficult to understand his value proposition. I was somewhat shocked that nobody had implemented his ideas before. On top of using Schön's analysis of the design studio, I use shape grammars to explain how it works. Shape grammars provide a more precise description of the pedagogy of the design studio, allowing us to then adapt the studio model for a different context.

Chapter 1

Introduction

Education is in a desperate search to find ways that will make students score higher. Standardized test scores can bring more money or a cloud of shame upon a school. In an environment that is obsessed with quantitative assessments, the arts get left out. Many people in education and political circles argue in support of art education at schools because it actually improves test scores on core subjects such as math. Even President Obama is on board the arts-education bandwagon. In his 2008 speech, Obama declared:

> People understood, even though they hadn't done the scientific research back then we have done now, that children who learn music actually do better in math, children whose imaginations are sparked by the arts are more engaged in school.

Subsequently, the US government opened doors to applicants for the Race to the Top program. States compete to tap into 4 billion dollar fund the federal government set aside to "reform" education.[1] The pathway to reform stipulates that states follow certain guidelines as outlined by the federal government, including more standardized testing and curricula. In this view, the only benefit from an arts education is the belief that it actually improves students' academic performance on tests. Studying art for the sake of art is no longer valid. Art education is treated as an appendage to the core subjects, and is valued for its "instrumentality" in teaching these core subjects.

A recent study by researchers affiliated with Harvard's Project Zero challenged Obama's logic.[2] Their research showed that there is no credible evidence showing that arts education actually improves test scores. Despite this spoiler study for arts proponents, the researchers advocated in their next book that arts education should be championed for its own sake. Arts education may not improve test scores, but its effect upon the habits of the

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[1] For further information: http://www2.ed.gov/programs/racetothetop/index.html
[2] Ellen Winner and Lois Hetland of Project Zero

mind enhance observational acuity, clarity, reflective capacity to question and judge, and openness to exploration, to name only a few.[3]

The rift between science and art runs very deep in our culture and especially in education. It goes back to the Enlightenment Period that started the technically rationalized, industrialized culture and so began our obsession with numbers. A conceptual revolution happened when Galileo decided to shift his attention away from the qualitative and more towards the quantification of relationships. It represented a fundamental shift in the way we perceive and represent the world. The search for order began and our ability to use that to harness nature increased. The same values that permeated the Industrial Revolution, from the need to control and predict to the desire of efficiency, are still the same values we cherish today. It is the same values that Obama's educational reform agenda rests on, in an effort to create order and manage a complex system.

In the late 19th century, psychology drove education into a technicized, cognitive culture. Psychologists at the time were interested in turning their field into a scientific enterprise that emulated the work done in the so-called "hard sciences".[4] The leaders of this movement were the likes of Galton in England, and Helmholtz and Fechner in Germany. By the early 20th century, most schools except for a few independent schools followed the same path of psychology. Schools would become as efficient as manufacturing plants. According to that vision, students were raw material to be processed according to prescribed specifications.[5]

During this whole process of turning schools into efficient operations, science and art became estranged. Elliott Einser, an emeritus professor of Art and Education at Stanford University, reflects that, "Science was considered dependable, the artistic process was not.

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[3] Lois Hetland, Ellen Winner, and Shirley Veenema, *Studio Thinking: The Real Benefits of Visual Arts Education*, (New York: Teachers College Press, 2007)
[4] Eisner, Elliot W. "What can education learn from the arts about the practice of education" *The Encyclopedia of Informal Education,* 2002, www.infed.org/biblio/eisner_arts_and_the_practice_or_education.htm
[5] Raymond Callahan, *Education and the cult of efficiency; a study of the social forces that have shaped the administration of the public schools.* (Chicago: University of Chicago Press, 1962)

Science was cognitive, the arts were emotional. Science was teachable, the arts required talent. Science was testable, the arts were matters of preference. Science was useful and the arts were ornamental. It was clear to many then as it is to many today which side of the coin mattered. As I said, one relied on art when there was no science to provide guidance. Art was a fall-back position."[6]

This debate itself about the value of arts education evokes additional problems. Art advocates seem to find themselves continually on the defensive. They write articles and publish books either to say that arts education actually improves test scores of "core" subjects or that the values that arts education nurtures are very different from what hardcore sciences offer and, therefore, should be valued for its own sake.

We are in need of a fresh look at education that transcends this divide between art and science. Art is important and science is important. Each side of the spectrum does not want to acknowledge the other. Art and science do not need to be two separate things; both emerge as a result of rigorous scrutiny and creative thinking. Art making involves rules and science involves artistry. That is the premise on which this dissertation is built. This research ultimately merges both processes in an educational program.

Before delving to the specifics of the dissertation, I want to share a quote by Colin Rowe in which he explains the role of architectural education.

> I presume architectural education to be a very simple matter; and the task of the educator I am convinced can be quite simply specified as follows:
> 1. to encourage the student to believe in architecture and modern architecture;
> 2. to encourage the student to be skeptical about architecture and modern architecture; and
> 3. then to cause the student to manipulate, with passion and intelligence, the subjects or objects of his conviction and doubt.[7]

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[6] Elliot W. Eisner, "What can education learn from the arts about the practice of education?".
[7] Colin Rowe, "Architectural Education in the USA," Lotus International, no.27 (New York: Rizzoli Publications, 1980), 43.

Although he is talking about architecture, this can be applied anywhere. First, encourage students to believe in what they are doing. Then, doubt it; then manipulate it with passion and intelligence.

This dissertation begins by providing a definition for creativity that is inclusive and productive; a definition that bridges the divide between science and art. I start the chapter by talking about the importance of seeing and mindfulness. I reference Ellen Langer's extensive work on mindfulness and how it could turn our lives verging on boredom into lives that are rich and exciting. Although Langer offers a great background to mindfulness, she talks about it only in the context of art and other "creative" activities. What is the role that mindfulness plays in the creative process? Then, I follow by surveying the modern research in creativity, which started in the 1950's by studying the personality traits of creative people all the way to studying the impact of the physical environment on creativity. I later show the shortcomings of these definitions. Creativity is not restricted to certain "creative" people. All of these of definitions of "creativity" rest on words that require even more definitions, words such as novelty and domain experts.

The beginning of a definition of creativity starts with William James who talks about reasoning in terms of sagacity and learning. Sagacity can be thought of as mindfulness or seeing. Learning can be thought of as doing or consequences of seeing. Sagacity is the difficult part of reasoning and the part that is hard to teach. The more characters one derives from a phenomenon, the more genius there is. Following the same framework of sagacity and learning, Stiny talks about creativity in terms of embedding and recursion in the context of design.[8] Embedding, like sagacity, denotes the ability to divide a shape into parts, establishing a temporary hierarchy. After establishing a temporary hierarchy, a rule gets applied, then a new hierarchy gets established, then a rule gets applied, and so forth. A hierarchy change denotes a shift in our perspective. In this vein, creativity is defined as the ability to see something, then do something accordingly, see again and so forth. Every

[8] George Stiny, "What Rule(s) Should I Use?" (Forthcoming)

moment of seeing triggers a set of actions. The faster we see and do, the more likely we will develop a better solution and create better products.

My question is how can we train students to learn ways that are both mindful and creative? I am arguing that the architecture design studio pedagogy trains students to see and act at a faster pace. In chapter 2, I draw on the extensive creativity research to understand the processes of learning and to make the arguments that more seeing is needed in educational systems. Chapter 3 makes the case for the design studio as the pedagogical model for teaching creativity. I discuss the particularities of the design studio and how it fosters seeing in doing. I draw upon my own experience teaching design studios and in-depth case studies with two students who struggled to adapt to the studio environment. The final chapter provides an extensive case study to test my hypothesis. I use what I learned from my creativity research to develop a working educational program, NuVu (pronounced as New View). NuVu is a multidisciplinary program for high school students; it derives its pedagogical approach from the architectural design studio. In conclusion, I explain the surprising successes and challenges of modifying the architectural studio for non-architects, both students and instructors, and I describe the parameters in which the design studio successfully brings more seeing into learning, and I offer insights for future work teaching creativity in a multidisciplinary program such as NuVu. The main contribution of this work is to shed light upon how the design studio cultivates creative thinking and how it can be adapted for a different context outside of its architectural confinement.

Chapter 2

Understanding Creativity

Being Middle Eastern, I eat pita bread everyday, sometimes multiple times a day. Naturally, I had long ago mastered the technique of making a pita sandwich. It begins by toasting the circular bread to be perfectly crispy then slicing open the edge three-quarters of its circumference. After the filling is spread inside, the sandwich is ready to be rolled up and enjoyed.

One day I began making sandwiches, as usual. I cut the toasted bread and began to spread the hummus inside when a non-pita expert accused me of making an error. How could someone who grew up eating square, sliced bread and regularly purported to be 'not eating carbs' tell me how to make a hummus sandwich? "Shift the spread so it doesn't spill out of the sides." Why had it not occurred to me to explore this idea before? Making a sandwich may be a trivial thing, but I pondered this oversight for a long time.

How could I have made hundreds of sandwiches, sometimes with messy fingers afterwards, without connecting the spills to the spread's direction? I made sandwiches mindlessly, failing to see a better approach. Even after years of experience, I needed a shift in perspective.

All of us need to see better. The lesson is surely not that my kitchen skills were lacking. Instead, the significance is that someone with fresh eyes can change a person's perspective on tasks that are routinely performed, perhaps even performed mindlessly.

The difference is seeing. We have the tendency to fall into habitual actions, consequently making us miss out on more than just convenient strategies like sandwich making, but from also perceiving the world differently.

This chapter examines the rich work that uncovers **why** seeing in learning is important.

Mindfulness

> Mindfulness is an effortless, simple process that consists of drawing novel distinctions, that is, noticing new things. The more we notice, the more we become aware of how things change depending on the context and perspective from which they are viewed. Mindfulness requires, however, that we give up the fixed ways in which we've learned to look at the world.[9]

Popular newspapers, stimulus grant applications, and parents are all asking how children can learn more and learn better in school. How can today's twenty-first century students become tomorrow's innovative entrepreneurs? The above excerpt from Langer's On becoming an artist, suggests we pose the question differently. How can students be open to learning more mindfully?

Langer's work argues that the traditional processes of learning - rote memorization, over-learned basic skills, "right" answers – actually prevent students from *mindfully* learning. For instance, one of Langer's studies with colleagues investigated how slightly modifying textbooks *may* encourage creative use of the material by changing statements written in absolute terms to have more conditional meanings. The students who read the more open-ended text outperformed the control group when asked to make creative use of the information and the group tended to enjoy the material more than the control group.[10]

Usually when people know they will be tested after an activity, their level of pleasure changes. Why do students complain about solving math homework, yet buy magazines with brainteasers? Would people enjoy doing Suduko if the activity were timed and graded? Langer argues that an important distinction between work and play is the freedom to draw distinctions in the process. During enjoyable tasks, we draw pleasure from noticing interesting aspects. In work, we too often are constrained by rigid steps without the freedom to explore. The same is true in many history lessons; little freedom exists to get to

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[9] Ellen J. Langer, *On becoming an artist: reinventing yourself through mindful creativity*. (New York: Ballantine Books, 2005), 231-38.
[10] Ellen J. Langer, *The power of mindful learning*. *Reading, Mass: Addison-Wesley, 1997), 29-30.

"know" the answer. Dates, names, and outcomes are memorized. The student's ability to enjoy the process and seek surprising outcomes is inhibited.

The mindful approach to any activity entails three particular characteristics: "The continuous creation of new categories; openness to new information; and an implicit awareness of more than one perspective. Mindlessness, in contrast, is characterized by an entrapment in old categories; by automatic behavior that precludes attending to new signals; and by action that operates from a single perspective."[11] To this end, instructing students to solve problems in prescribed manners limits their ability to investigate their surroundings and to test novel ideas.[12]

Instead, mindful learning allows learners to distinguish contexts within the material. Students apply original definitions or hypotheses to explain phenomena. In this way, the history student can continue to hypothesize and apply new perspectives to events.

Placing the emphasis upon learning the basics often leads to *overlearning* the basics. Instead, when we learn from the beginning that alternatives exist, we learn mindfully and are more open to multiple perspectives. Moreover, initial learning with alternatives may improve the learning. Langer explains that Mozart, Beethoven, Schumann and Glenn Gould recommend organ practice to enhance playing the piano and Yehudi Menuhin believed his violin performance improved after playing the viola.[13]

For Langer, mindfulness, or what we understand as the *seeing* ability, is the only ingredient in the creative process. Langer follows the traditional view that creativity is restricted to activities like painting or music. This distinction prevents us from understanding why everyone who picked up a viola while practicing the violin did not rise to the levels of Menuhin. Seeing is an important part of the creative process, but it is no more than half the story.

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[11] Ibid., 4.
[12] Ibid., 121.
[13] Ibid., 27.

Dissecting the Creative Process

Creativity has been studied, analyzed, dissected, and documented. But still a generally accepted definition of creativity does not exist. There is no consensus on what it is, how to learn it, how to teach it, or if indeed, it can be learned or taught. Nonetheless, a long history of creativity research exists to shed light upon current debates.

Generally speaking, creativity is defined as the creation of a novel product that has value to certain people. But modern creativity research began in an attempt to understand the creative personality. Dr. J. P. Guilford, the president of American psychological Association pioneered studies in the 1950s finding that "behavior traits come under the broad categories of aptitudes, interests, attitudes, and temperamental qualities...a creative personality is then a matter of those patterns of traits that are characteristics of creative persons."[14]

Identifying creative individuals' personality traits became of great national interest. The establishment of the National Science Foundation (NSF) boosted creativity research in an effort to identify the most promising scientists. Creative individuals were selected and then tested to identify particular personality traits. The contribution of this project and similar studies showed that creativity and intelligence are indeed different traits and require different measurements. In a seminal study at the University of Chicago in 1962, Jacob Getzels and Philip Jackson studied 6-12th grade students and found creativity and intelligence to be statistically independent after a certain point.[15] This study serves as the primary source behind the *Threshold Theory*, which asserts that creativity requires a certain threshold of intelligence, around an IQ of 120, but beyond that level, creativity does not increase with higher intelligence. The main difference, according to those studies, between creativity and intelligence is that intelligence requires *convergent thinking*, producing a

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[14] JP Guilford. "Creativity," *The American Psychologist.* 5 (1950): (9), 444-54.
[15] Jacob W. Getzels and Philip W. Jackson. *Creativity and intelligence; explorations with gifted students.* (London: Wiley, 1962).

single right answer, while creativity required *divergent thinking*, generating many potential answers.[16]

Two of the most widely used measures of divergent thinking are the Torrance Tests of Creative Thinking (Torrance, 1974) and the Wallach-Kogan creativity tests (Wallach & Kogan, 1965). These tests sought to identify children with high creative potential in order to direct them into careers that require creativity. Additional goals included transforming education to fully realize each student's creative potential. However, these programs failed to convincingly demonstrate that they actually increased students' creative abilities and high scores on divergent thinking tests did not correlate with real-life productive output.

Other significant studies to scientifically determine traits of a creative personality include Donald MacKinnon's Institute of Personality Assessment and Research (IPAR) team at the University of California at Berkley. The team studied peer-nominated, successful architects, inventors, engineers, writers and mathematicians. Over one weekend, each subject underwent a battery of personality and intelligence tests. The study determined that their highly creative subjects exhibited the following traits:

- above average intelligence,
- discernment, observance, and alertness,
- openness to experiences,
- balanced personality,
- a relative absence of oppression,
- pleasant childhood, and
- a preference for complexity.[17]

By the 1970s, psychologists realized a general "creativity quotient" did not exist. Most researchers in the field came to the consensus that divergent thinking tests did not predict one's creative ability and that divergent thinking is not, in essence, creativity. Rather, the research indicated that creative achievement entails a complex combination of both

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[16] Keith Sawyer. *Explaining creativity: the science of human innovation.* (Oxford: Oxford University Press, 2006), 44.
[17] See MacKinnon, 1978 for a full explanation of the research project.

divergent and convergent thinking, and creative people are adept at moving between these supposed binary approaches during the creative process.

In light of these findings, a new group of psychologists began studying creativity by analyzing shared mental processes. This period's theories, centered on the creative process, generally agree that the process consists of four basic stages: preparation, incubation, insight, and verification.[18] Although this began to detail the particular stages within the process, its basis is inherently limited by assuming the creative process is linear, based on one major insight. Instead, the creative process is very cyclical and involves a series of minor-insights; the four stages are fused together as opposed to being sequential.[19]

Putting Creativity in Context

While the earlier creativity research assumed that creative people held innate characteristics, which were clearly distinct from that of noncreative people, a shift in the 1970's moved the emphasis from the individual to the socio-cultural context of creativity. Examining the social and environmental contexts of creative work brought the meaning of creativity itself into question.

Teresa Amabile's work, *Creativity in Context*, concludes that social appropriateness cannot be avoided in creativity research.[20] Thus, she proposes a consensual definition of creativity: a product is creative when experts in the domain agree it is creative. People working in a particular domain define the appropriateness, meaning that the definition of creativity is fundamentally and unavoidably social. While examining personal tests that measured one's creativity, she discovered that an implicit subjective assessment existed within the tests.

Amabile wanted to circumvent the "objectivity" problem that persisted in previous creativity tests by suggesting that a panel of experts should judge whether something is

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[18] Sawyer, *Explaining creativity*, 58.
[19] Silvano Arieti, *The intrapsychic self: feeling and cognition in health and mental illness.* (New York: Basic Books, 1976), 18.
[20]Teresa Amabile. *Creativity in context.* (Boulder, Colo: Westview Press, 1996).

creative or not. An inherent problem with many of these definitions of creativity is that they are circular definitions that beg for more explanation. For instance, in Amabile's definition, who decides on the experts of the field who determine the creativity of a product? More experts? What is creative for one person is not creative for others.

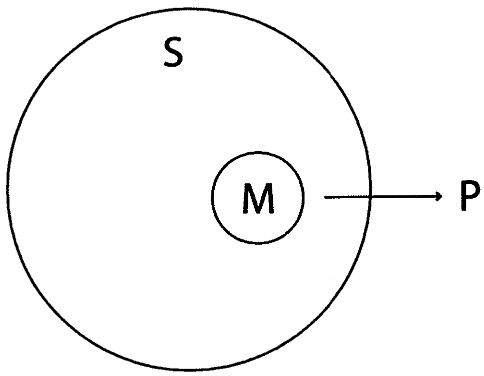
Defining the Creative Process

Long before cognitive studies and socio-cultural studies on creativity, the theorist William James explained what we now consider creativity as a reasoning process in his seminal book, *The Principles of Psychology*. James identified the reasoning process as the ability to deal with unprecedented situations - situations for which we do not have predetermined resources.

Reasoning has two key stages: sagacity and learning. First, *sagacity* is the ability to discover components that lie embedded within the larger piece; in other words, sagacity is seeing. Second, *learning* is the ability to recall a character's consequences, concomitants, or implications and apply them accordingly; in other words, learning is the ability to apply rules. Sagacity is the ability to extract a certain character out of a fact that in turn becomes equivalent to the whole fact from which it comes. Then, learning is the ability to recall the consequences suggested by that extracted character.

With sagacity and learning, a reasoner is able to make inferences from a set of concrete objects. The reasoner deals with novel data in a way that surpasses common associative thinking and identifies what peculiarity it contains.[21] A reasoner is able to break a fact (S), which does not lend itself to any concomitant, into parts. Then the reasoner realizes one of its noticeable attributes (M) and that becomes the essential part of the whole fact. This attribute has properties or consequences (P) which the fact until then was not known to have, but which, now that it is noticed to contain the attribute, it must have. The perception that S is M is a *mode of conceiving* S. The statement that M is P is an *abstract or general proposition*.

[21]William James, *The Principles of Psychology*, (1917), 330.



James makes a clear distinction between reasoned thought and empirical thought, which simply associates phenomena in their entirety. James distinguishes between the reasoning and empirical thought using everyday examples. When buying a piece of fabric, a person may say that the cloth looks as if it will fade, merely that something about it suggests the idea of fading. This thought process is based upon a previous experience of buying clothing that faded after washing and wearing. In contrast, a reasoned judgment believes that the color's dye is known to be chemically unstable and will therefore fade. Understanding that the dye is a part of the cloth links the cloth to the idea of fading. Similarly, an understanding from past experience that a man's finger tip appears coarse from the view of a convex vase tells us nothing about what the link is between the convex glass at the image that appears. Reasoning is when a violin player makes inferences from a brief experience with a viola and applies the insight in more experiential violin playing.

Empirical thinking or rule-of-thumb thinking consists of trains of images that suggest one another. Empirical thinking is reproductive. Placing an ice cube by the fire results in melting. Hearing a dinner bell infers that dinner is ready, but the inference is merely association.

In contrast, reasoning is productive. Creative reasoning consists of connected thoughts. The connections are not merely suggested, but are *embedded* by preceding thoughts. Given unfamiliar data, the empirical thinker will deduce nothing, but the reasoner will extract inferences despite his or her ignorance. Reasoning consists of analysis and abstraction, whereas empirical thinking does not break apart aspects and recognize its separate attributes.

More Seeing than Learning

Typically learning is apt to be more developed than one's sagacity. The seeing ability to seize new aspects in concrete things is more rare than the ability to learn old rules. This is both natural and also reinforced in the traditional methods of education as described by Langer. For example, students are taught to focus on mastering the rules of a scale on the violin rather than to extract unique chord structures.

Every reality, fact, or phenomenon lends itself to endless attributes and properties. But when we conceive of S as merely M we neglect all other attributes and attend exclusively to this one. For James, there is no absolutely essential property of any one thing. The essence of a thing is that one of its properties may be so important for one's interests on a particular occasion. On another occasion, the individual might extract a completely different property of that thing. And these properties vary from person to person and from hour to hour. Reasoning is always for a subjective interest, to attain some particular conclusion, or to fulfill some special curiosity.

What makes us extract certain properties and not others? James offers two reasons: first, our practical or instinctive interests; and, second, our aesthetic interests. These two factors are what largely influence our sagacity. To reason, we need to be able to extract the right characters. If we extract the wrong character, it will not lead to the conclusion we are seeking.

> *How are characters extracted, and why does it require the advent of a genius in many cases before the fitting character is brought to light?* Why cannot anybody reason as well as anybody else? Why does it need a Newton to notice the law of the squares, a Darwin to notice the survival of the fittest?[22]

[22] Ibid.

James attributes our ability of extracting characters to human superior "association by similarity." It is the ability to call other, and bring into consciousness at once, instances that have an analogy to the phenomenon at hand. The image below illustrates the particularities within association by similarity. James explains the case of A, with a character m in it. One might initially fail to notice m. The association occurs when A, calls up B, C, D, and E, which are similar to A in possessing *m.* Calling this association in rapid succession means that *m*, being associated almost simultaneously with such varying concomitants, will appear and attract recognition.

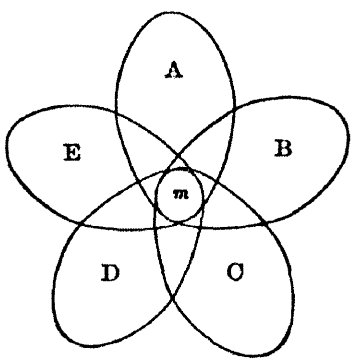


Fig. 80.

Although James does not address creativity explicitly, he refers to the makeup of a genius. Genius is synonymous with the possession of extreme association by similarity. Our association by similarity is the prime condition of success.

> This answers the question why Darwin and Newton had to be waited for so long. The flash of similarity between an apple and the moon, between the rivalry for food in nature and the rivalry for man's selection, was too recondite to have occurred to any but exceptional minds.[23]

James, in his thorough explanation of reasoning, provides the groundwork for defining creativity; a definition that does not distinguish between art and science; a definition that does not rest on other definitions.

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[23] Ibid., 361.

Seeing and Doing in Shapes

> It's a question of what calculating would be like if Turing and Post had been painters instead of logicians...painting and calculating together – what an exotic idea.[24]

Mindful learning, sagacity, rules, and creativity are complex processes, but can be better understood through shapes. Stiny's work on shape grammars (SG) provides a visual explanation on how these processes occur. I employ SG as an epistemological thread throughout this dissertation to illustrate *seeing* and *rules*, and how students move through steps of the learning process. SG is a computational system that treats *seeing* as well as rules as integral parts of the creative process. SG can become very technical, but the intention here is to illustrate how the process works and how it offers new insights into human learning. [25]

Calculating with shapes implies an intentional contradiction. Calculation is supposed to be a deterministic process where symbols get combined. Shapes, on the other hand, are hard to pin down. Every time you look at them, you see something different. "Shapes are subtle and devious. They combine to confuse the eye and to excite the imagination. They fuse and then divide in surprising ways. There are endless possibilities for change."[26] How then, can one build a computational system that combines these seemingly contradicting concepts?

Stiny, a mathematician in a design department, learned to calculate with numbers and symbols at MIT as an undergraduate student. Calculating then meant combining symbols according to given rules. The shift occurred when Stiny began calculating with shapes. Shapes take calculating into a more sophisticated dimension that leaves room for ambiguity.

SG are particularly interesting in the context of creativity because they provide an explanation that accounts for seeing and recursion. When talking to engineers and even linguistics, rules or recursion are what defines creativity. Engineers have developed amazing models that solve very complex problems. Artificial inelegance theorists think that

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[24] George Stiny, *Shape: talking about seeing and doing*, Cambridge, (Mass.: MIT Press, 2006), 21.
[25] For that, Stiny's book *Shape* provides a comprehensive study of SG.
[26] Stiny, *Shape,* 21.

we can someday build an "intelligent" machine based on the Turing machine. In contrast, for artists, seeing is what defines creativity. Artists' work tries to show us a different perspective on the world, just like the Duchamp's fountain. It may appear that a cultural divide exists between the two groups. SG claim that no such divide exists. The difference between how artists and engineers work is the frequency in which they alternate between seeing and recursion. Artists tend to see more and engineers tend to apply rules more. SG provides a framework that integrates the seeing and recursion, so that both depend on rules in one and the same process.

Seeing how it works

Every rule $A \rightarrow B$ in a grammar consists of shapes A and B. Meaning that "when and if you see A or a like of it, you replace it with B."

The rule applies to a shape C if the formula

There is a transformation t such that $t(a) \leq C$ is satisfied.

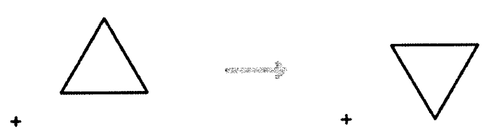
In this case, a new shape C' in may be produced according to the formula

$$C' = [C - t(A)] + t(B)$$ [27]

This replaces the part of C that's like A with another part that looks like B.

Aside from the mathematics, this is how it works visually. Here is an example that illustrates the process:

The rule is



The rule states that every time we see a triangle, we can rotate it 120 degrees around its center point. Let's start with a shape like this

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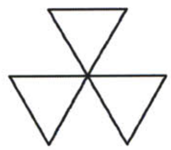
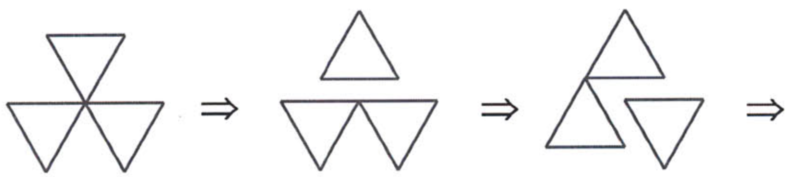
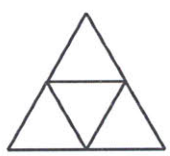
[27] Ibid.

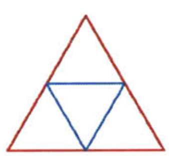


And here is how we run the computation:

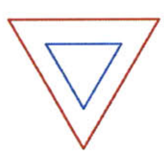




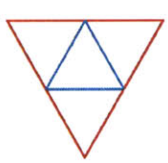
Suddenly, we have a shape that has 2 triangles rather than three. Here is our first shift of perspective. That is, the Ah-ha moment. This happens all the time in the creative process.



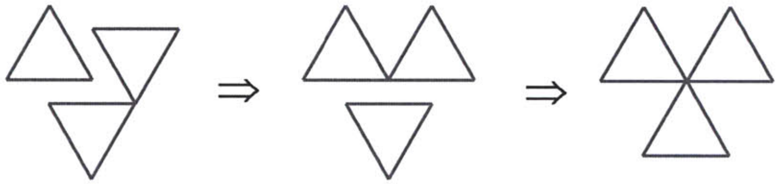
Let's pick the big triangle and rotate it 120 degrees to get



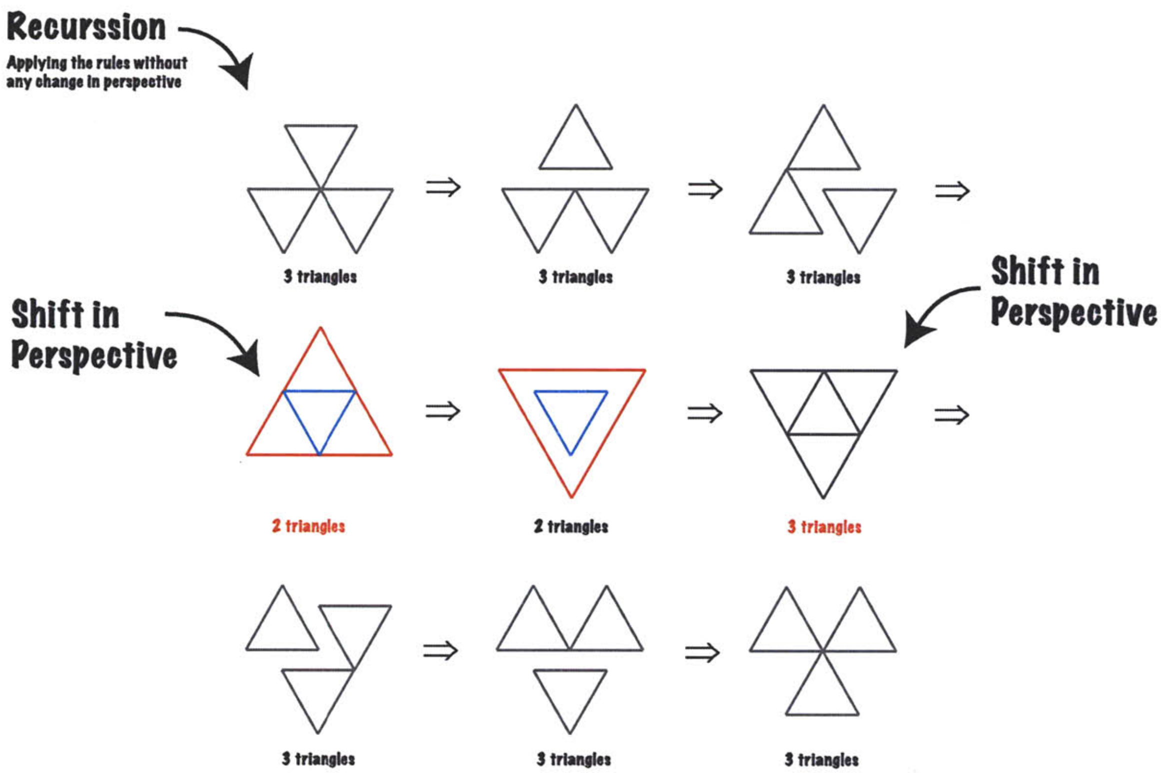
Now we only have 2 triangles, without question. We rotate the small triangle and we get



and we continue from there by applying the same rule on the 3 small triangles:



and here is the whole process:



It seems that it is impossible to get to the final shape using the rotational rule only. This was made possible by recognizing the emergent shapes along the way. In stage four of our computation, we suddenly have two new triangles on top of our three triangles; in stage five, we have only two triangles. In SG, structure is a temporary thing. Whenever a rule applies to a shape in a computation, the rule implicitly provides a description or a structure of the shape that guides the action of the rule. One does not need to divide the world a priori before one starts doing things. SG do not say that structure is not important. It is just saying that structures or hierarchies have to be temporary. The moment we freeze them and focus on rule application we neglect the benefits of seeing.

Just like any fact or phenomena does not have any permanent essence (according to James), for Stiny, shape is always ambiguous. It does not lend itself to one definition. There are always infinite readings. Everything can change in front of your eyes every time you look at it. Seeing, which is the ability to embed shapes, becomes an integral part of the process.

> There are no definitions to conform to, and there's no vocabulary to build from. It is all fluid and in flux. Constituents - atoms, units, and the rest of it – are merely occasional afterthoughts.[28]

The whole process above exemplifies the creative process; it alternates between seeing and doing. It shows how seeing works in a creative process. Rather than talking about the creative process in terms of phases[29] for instance, we have an original way to define it. This definition, albeit technical, helps us avoid all the circular definitions we surveyed earlier. It also cuts across the cultural divide that exists between "creative" and "not creative" disciplines. It avoids addressing the quality of the "creative" product. It does not discriminate between people who are judged to be creative and those who are not.

Creativity is the ability to change perspective on an idea. It is not about coming up with one single insight. It is about an iterative process that takes that initial insight and turns it into something valuable to the inventor and the society around. It is about being able to abandon and change ideas that don't work any more. It is about taking decisions under difficult situations. Creativity is about reasoning under ambiguous situations.

A recent and well-known design challenge contextualizes the significance of such a learning process. The challenge asks groups of individuals – kindergarteners, business school graduates, CEOs, administrative assistants, etc. – to build the tallest tower possible using

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[28] Ibid., 130.

[29] The German physiologist and physicist Herman Helmholtz described the creative process in terms of: saturation, incubation, and illumination. Henri Poincare added verification at the end. In the early 1960a, the American psychologist Jacob Getzels contributed the important idea of a stage that precedes saturation which is problem finding.

dry spaghetti, string, tape, and with a marshmallow on top.[30] Out of the array of participants, the worst groups were recent business school graduates. They spent the majority of the allotted time analyzing the problem and prototyping one solution. By the time they implemented their solution, it failed and the clock ran out. Surprisingly, or not, kindergarteners continually outperformed the business school graduates. By the time the clock ran out, these five year-olds quickly built many models allowing them to learn immediately from failures and move forward to more optimal designs.

This challenge reveals a number of insights about education, but for this research, the most important of that is the iterative process. The kindergarteners produced more successful towers because they quickly prototyped, gained feedback, and used that feedback to improve the design.

After understanding the creative learning process, the next task is to understand how we can teach creativity. William James acknowledges in one of his footnotes that teaching someone to become a genius, i.e. a better observer, is a very difficult task. He leaves that for "Theory of Education."

> There may be rules for observing. But these, like rules for inventing, are properly instructions for the preparation of one's own mind; for putting it into the state in which it will be most fitted to observe, or most likely to invent. They are, therefore, essentially rules of self-education, which is a different thing from Logic.[31]

My dissertation addresses this question by asking, is there an educational model that makes us better observers?

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[30] Tom Wujec's "Marshmallow Challenge" is available at http://www.marshmallowchallenge.com/Welcome.html
[31] James, *The Principles of Psychology*, 332.

Chapter 3
The Design Studio: More Seeing

> The architectural studio has developed traditions of learning-by-doing – the tradition of project-based education, which often seems innovative when it is introduced to other professional schools; the more particular traditions of work, review, and criticism; and the less easily nameable traditions that inform the ways in which groups of students learn from and with one another. These have evolved gradually over many years, and contribute to a rich context for learning-by-doing.[32]

In response to William James' acknowledgement about the difficulty in teaching one to be a better observer, I argue that the design studio's pedagogy can extend beyond the architectural context to other fields. As Schön stated in the above excerpt, the architectural studio is based on observation, learning-by-doing. This method of teaching embraces *sagacity* or 'seeing.' It is at the core of design and it is the most challenging skill for a beginning designer to refine.

In this context, seeing means much more than the act of visual perception; it is about noticing new things, extracting new characters, and changing perspectives. The emphasis on seeing comes as a consequence of the lack of rules, a notion that Rittel has captured as "awesome epistemic freedom:"

> There are no logical or epistemological constraints or rules which would prescribe which of the various meaningful steps to take next. There are no 'algorithms' to guide the process. It is left up to the designer's judgment how to proceed. There is no - logical or other - necessity to want or to do something particular in response to an issue. Nothing has to be or to remain as it is or as it appears to be; there are no limits to the conceivable. There is a lack of 'sufficient reason,' which would dictate to take a particular course of action and no other.[33]

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[32] Donald Schön, A. *The design studio: an exploration of its traditions and potentials.* (London: RIBA Publications for RIBA Building Industry Trust, 1985), 6.
[33] Rittel, Horst WJ, "The reasoning of designers." *Arbeitspapier* A-88-4, (Stuttgart: Institut für Grundlagen der Planung, Universität Stuttgart, 1988).

In order to apply the design studio pedagogy to other fields, we must first understand the explicit and implicit particularities that enable the architecture design studio to function as a model for teaching creative thinking. We also need to delve deeper to examine the studio's existing and potential challenges and how those challenges may arise in a different context.

What makes the design studio a very different pedagogy from other fields, like engineering or business, is that particular emphasis on seeing rather than rules.[34] As such, architecture has always stayed on the margins within the modern research university, which is powerfully shaped by positivist philosophy. Practice is conceived as essentially technical. Practice's rigor depends on "the use of describable, testable, replicable techniques derived from scientific research, based on knowledge that is objective, consensual, cumulative and convergent."[35] In this view, architecture, which operates without a logical order, sits on the peripheries.

Professional education considers practice as an application of research-based knowledge to the solutions of problems of instrumental choice. There is a very distinct hierarchy in how knowledge is structured in professional schools and research universities. The foundation is the basic science component. The application of basic science yields engineering, which in turn provides models, rules, and techniques applicable to the instrumental choices of everyday practice.[36]

This hierarchy of knowledge permeates our universities today. First students are exposed to basic sciences, then applied sciences, and finally a practicum in which they are taught how to apply that knowledge to problems in practice. There is little room for ambiguity. Without that layer of basic and applied science, what is referred to as professional knowledge, professionals tend to get stuck and puzzled when facing new situations, situations that do not fit within existing frameworks.

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[34] Rules refer to that body of explicit knowledge that can be conveyed a textbook.
[35] Schön, *The Design Studio,* 14.
[36] Edgar Schein, *Professional education: some new directions*, (New York, McGraw-Hill, 1972).

A recent document by the MIT engineering faculty highlights division between teaching rules and seeing.[37] The faculty participants outlined their thoughts on the foundations of the engineering method to examine the role of engineering education in students' freshmen year and the interaction of engineering with the General Institute Requirements (GIR). Their findings indicate that one of the main goals of "engineering thinking" is:

> - to provide students with a rigorous, integrative, yet creative mode of thinking and problem solving characteristic of the engineering method that can be applied across disciplines and career paths, and help build a foundation for lifelong learning.

The document continues to explain that the 'engineering method' presents a unique way of solving technical problems which involves:

- An integrated, interdisciplinary view of problem solving;
- The concept of abstraction: the ability to break a complex problem into subsystems. Specifically modeling in quantitative terms critical aspects of the physical and human world, and necessarily simplifying or eliminating less important elements for the sake of problem analysis and design;
- *The development of larger abstractions and models;*
- *Design and synthesis as fundamental to the engineering design process.*

Although the method appears to be aligned with the design studio's aspirations, a clear distinction exists with the 'concept of abstraction.' The inherent problem with the engineering method is that when a system is broken down into subsystems, its decomposition is never reexamined. That specific categorization, although it was carefully done, remains the same throughout the process. Thus, even though the method purports to be a "creative mode of thinking," the focus is on rules with very little seeing, at least after the initial systems characterization.

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[37]See "Useful Abstractions to Useful Designs –Thoughts on the Foundations of the Engineering Method," (February 21, 2005).

Even as a "creative" discipline, architecture sets itself apart from other creative fields such as fine art or music by having one foot in art and another in science. Schön describes the unique position as, "a bi-modal life in the world of art and in the world of functional technical performance."[38] The architect is responsible for coordinating an array of disciplines within the making of a building, from structural engineering to electrical, from building materials to doors and windows.

What is the design studio?

The design studio is the backbone of architectural education. It is where learning-by-doing occurs. Other ancillary courses and seminars exist, but all are designed to support the design studio. Throughout the studio, students undertake a design project under the supervision of a studio master. The design project integrates students' knowledge and skills.

Architecture students spend most of their time in their own studios, an open loft-like space that is divided into working areas. Ten to fifteen students arrange their tables, books, drawings and models in that space and it becomes like a second home to many. It is even common practice for students to spend the night working on their projects and catching a few hours of sleep at their desks. Few people outside of architecture seem to understand why students become absorbed in the studio space. It is in this environment that students engage in private, parallel pursuits for a common design task.[39]

History of the design studio

The design studio environment traces its origins back to the concept of apprenticeship in the atelier and even further back to craftsman guilds in the Middle Ages. The design studio transformed during the Ecole des Beaux-Arts and the Bauhaus until it evolved into its present form.

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[38] Schön, *The Design Studio*, 30.
[39] Ibid.

The Ecole des Beaux-Arts, founded in 1648 in France, shaped the future of fine arts and architecture education. Upon admittance, students were assigned to an approved patron and atelier. They remained attached to this mentor for the whole period of their studies. The Ecole measured progress via a point system on a project-by-project basis. The Ecole des Beaus-Arts's demanding teaching method required mental and physical stamina to ideate, develop, and present an architectural project under pressure. The Ecole first introduced students to presentation skills such as freehand drawing, descriptive geometry, and the uses of pencil, charcoal, ink, and watercolor washes. The next stage, called *analytiques,* architectural studies, incorporated both compositional and presentation skills. Additional courses in structures and history provided theoretical basis for problem solving and the studio activities.

The design studio, itself, was founded on the *esquisse* system in which a project begins with a parti (*parti pris*), a commitment, suggested by the student in response to the design brief. Following the parti, a development process of 2 to 3 weeks ensues to turn the initial parti sketch into a fully developed project with plans, sections, and elevations. The goal of the esquisse system is to force students to adhere to the parti, obliging students to work out the inevitable difficulties of contradictions inherent within any scheme. A closed jury system, the norm of the Beaux-Arts period, reviewed students' process from the parti to the final project design. Reviews focused upon the work as opposed to the verbal reflection because it was thought that since drawings were the architect's primary form of communication, projects should stand-alone without verbal explanation by the designer. [40]

The Bauhaus school formed in 1919 by Walter Gropius in Dessau, Germany out of a response to the Beaux-Arts. Although the Nazis closed down the Bauhaus in 1933, its influence upon international architectural education continued. At the Bauhaus, the basic form of architectural education did not change, but the concept of design dramatically shifted. Unlike the Beaux-Arts, which refused to engage technology, the Bauhaus viewed design as an integral part of modern concepts of mass production and modern technology,

[40] Alexander Caragonne, *The Texas Rangers: notes from an architectural underground,* (Cambridge: MIT Press, 1995), 79.

and removed itself from the classical teachings of architecture history. The Bauhaus rejected the use of architectural precedent from an aesthetic, a sociological, and pedagogical point of view. Instruction at the Bauhaus was of a practical nature, providing actual work with materials in the shops and on buildings under construction. Design began with the investigation of materials and experimentation though hands-on work with metalworking, carpentry, and various other techniques. During the Bauhaus movement, the design studio took on the format of a laboratory and workshop rather than the "retrospective and imitative" atelier of the Beaux-Arts, the underlying belief being that a liberating spirit of inquiry would spur students' creativity. "[41]

The landscape of architectural education in the United States changed with the arrival of the two leading Bauhaus figures. Gropius moved to Harvard University in 1936 to head the Graduate School of Design and Mies van der Rohe moved to the Illinois Institute of Technology. By 1947, the transplanted Bauhaus program became the dominant force in US architectural design studios.

Examining the design studio

The current design studio environment is refined from the historical experience and influence of the Beaux-Arts and Bauhaus movements. To explain the particularities of the design studio pedagogy, this section provides an in-depth analysis of the design studio components. The information relies upon limited resources describing the components, namely Donald Schön's, *The Design Studio*, and more significantly upon my own observations from co-instructing four studios at MIT and interviews with instructors and students. While the purpose is to provide a general overview of the design studio, I intentionally ignore the slight pedagogical differences that exist between different domestic architectural schools and instructors within a school. Instead, the focus is to explore the basic components of the architectural design studio including the design problem, early exercises, conceptual development, critique culture, and reviews. Following the discussion on these explicit components, I describe implicit factors that in a design studio environment nurture more seeing.

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[41] Ibid., 144.

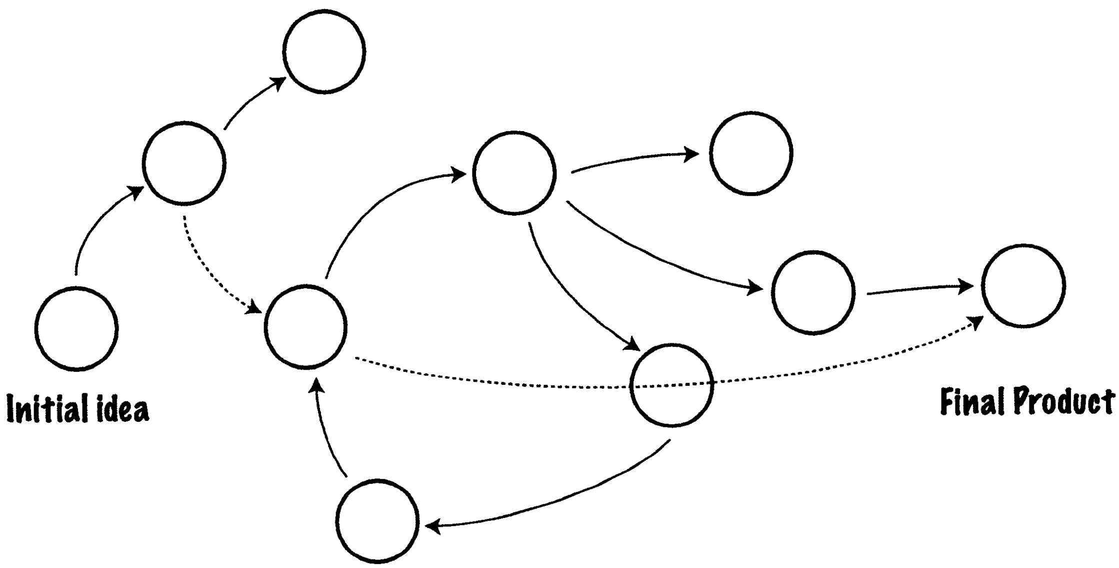
The Design problem

Every architecture studio begins with a design problem. For example, design a house, hospital, museum, or a bridge in a particular context. The design problem is given in the form of a brief or program that outlines client goals, user requirements, site conditions and other technical information that is a constraint on the problem. The topics differ widely from school to school and from one instructor to another. Generally, each design problem is unique. Even when instructors repeat a design problem, it is positioned within a different context. The design brief may be completely abstract or modeled after an existing community project with all its political, socio-cultural, organizational, economic and technical constraints. Different professors emphasize different aspects of the project; some emphasize the design process, while others focus on the building. The complexity of these problems generally increases, as students progress in the program. For example, students may begin with abstract spatial exercises in their first year and then move into designing a museum or even a large-scale urban area in the fifth year.

In one of the studios I co-taught at MIT, students were asked to design a new Museum of Sports and Athletics located along the Hudson River Park on the west side of Manhattan. It was anticipated that the different realms that would affect the architectural outcome, such as tectonics, landscape, museum, culture and technology would present competing and complimentary agendas of varying importance. The students would establish a conceptual response and generate design parameters to 'negotiate' these different realms. The result of this 'negotiation' would be an architecture of shifting 'gradients', an architecture of High Performance.

Conceptual Development

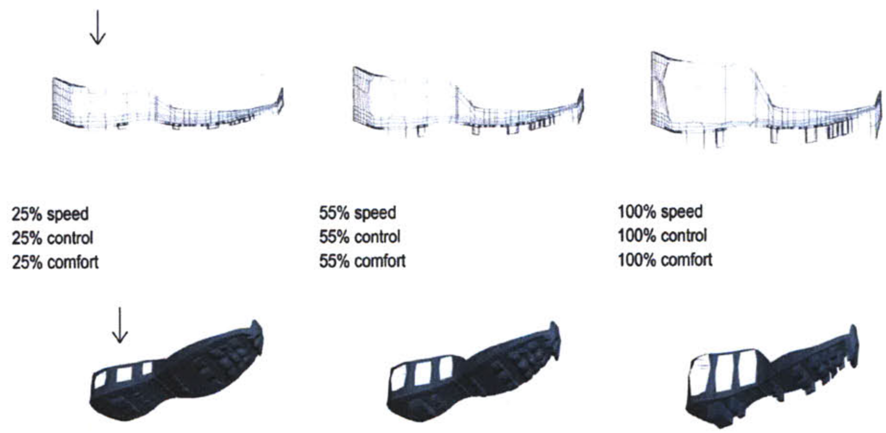
The design process is an open-ended exploration into the unknown guided by goals and constraints. There is not a 'right' answer. Although the goal is to create the best solution that satisfies the design problem with all of its complexity, there are many shifts and twists along the way, making it a very non-linear process. Hence, the emphasis is on the *process* of developing an idea, rather than on the first insight. Without knowing what to do or learn, students are expected to plunge into these problems. The gradual improvement of the concept occurs over the course of the semester under the studio master's close supervision. Instructors warn against the danger of students falling in love with their own ideas. The role of the instructor is to nurture a student's sense of detachment from his or her own ideas in order to examine the proposed solutions more critically.



Early Exercises

Design studios traditionally begin with abstract exercises to cultivate students' creativity and help them formulate frameworks, conceptual and technical, which can later be used in the final project. These exercises usually address specific issues pertaining to the topic and the scale of the studio; however, these exercises differ widely between studios.

In the Museum of Sports and Athletics studio, the assignment asked students to identify a sports object and elaborate on it, graphically as well as verbally, in terms of the high-performance aspects suitable to this investigation. This analysis addresses the formal, material, and structural systems that will guide students' designs and ultimately culminate in analytic and transformational diagrams, models, and drawings that suggest new architectural interpretations. For instance, one student focused on the sole of a sports shoe. The student's criteria to evaluate the performance included speed, stability, comfort, flexibility, and control.

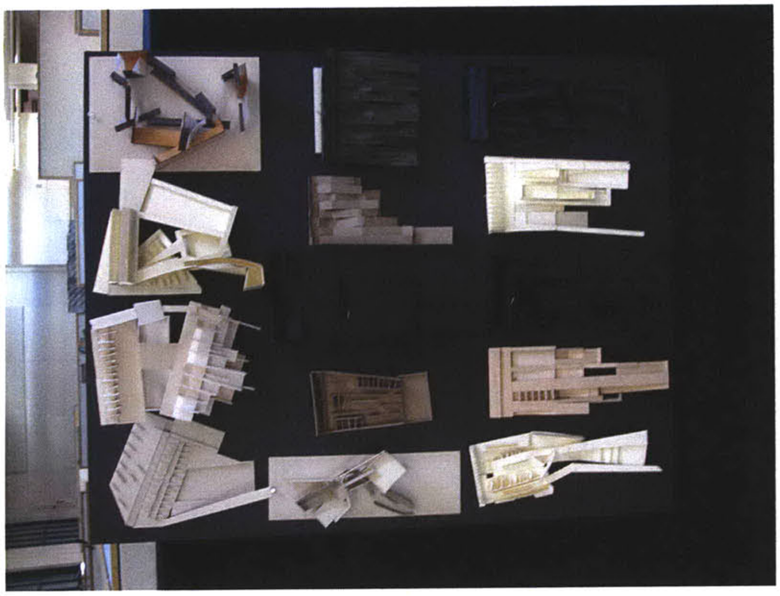


Prototyping

Students prototype or express concepts through sketching, and physical or digital models. Students need to be able to express their ideas very quickly in many different forms to progress through the demands of fast-paced iterations. What sets prototyping in architecture apart from other design fields is the issue of scale. Architects develop small-scale simulations to test a building before it is constructed. The architect must predict how the building will operate before changing the scale.

Prototyping with various media of expression shifts one's perspective and spurs new ideas. Each medium reveals aspects of the design that another medium does not show. Therefore, proficiency with fluid movement between different media encourages and cultivates seeing.

The standard medium in architecture is sketching on regular paper or tracing paper. Sketching quickly expresses ideas and tests configurations. Tracing paper, on the other hand, allows designers to manipulate an existing sketch by only extracting the lines needed for the second iteration. Another commonly used medium is 3-dimensional models, which represent the closest simulation to a building. Students may construct these models from cardboard, wood, metal or other materials. This picture illustrates the progression of a building prototype from a sketch model to the final one.



Students' ability to express their ideas, whether verbally, textually, or with drawings, affect to a large degree how the critique session goes.

Critique Culture

The project development is refined through the most significant part of the design studio - its intense critique culture, which manifests itself in frequent desk crits, pin-ups, a mid-review and a final review. Students are evaluated based on their commitment to their stated concepts. Essentially, the reviewer evaluates whether students are accomplishing what they set out to do, according to a student's own appreciative system. Students are asked to make explicit the parameters that will guide their concepts throughout the design process and are then evaluated based on these parameters and the decisions they accordingly take. Architecture refers to this process as "rigor," which is distinct from the quantitative rigor in other fields.

This critique culture shows students how to navigate the design process, and prevents them from becoming attached to a single perspective. Students progress forward with feedback from studio instructors, other students, or outside judges. However, students must work to bring a conceptual idea into a medium such as a model, diagram or drawing so that others can understand and provide feedback before moving to develop another conceptual idea.

The balance between being critical and productive is a key element in what makes the studio successful.

Very often, between desk crits, students "get stuck," meaning that the particular design iteration they are working through is exhausted or has reached a dead end. At this point, a student may need to abandon a concept and be open to alternative strategies. According to the designer, Bruce Mau, it is "the difference between a picnic and getting lost in the forest."[42] The process, although frustrating, teaches students how to navigate out of an unworkable situation.

Desk crit

A desk crit, short for a desk critique, occurs frequently during the course of the studio, sometimes even two or three times per week. After every crit, students synthesize all the feedback with their own critiques and produce another iteration for the upcoming crit. The frequency of the desk crit is what greatly distinguishes architecture from other forms of critique in art or music. This frequency places pressure on students to be productive and critical before and after each desk crit.

The desk crit is characterized by a partnership-like relationship between a student and studio master in which they communicate their respective ideas and critiques in search of what Schön describes as a **"convergence of meaning."[43]** The communication between the parties is not always clear or straightforward; thus, realizing the convergence may take many, many desk crits, or may even never occur. Generally, instructors communicate their feedback to students by showing parts of the process (e.g. constructing lines, illustrating consequences) for the student to imitate and also by verbal discussion.

Pin-up

A pin-up is similar to a desk crit except that students formally present their work to the instructor as well as all to fellow students in the studio. Students will restate the

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[42] Bruce Mau, " What is the Centre for Massive Change", retrieved 2010, from http://www.youtube.com/watch?v=XpRxAovJM7g&feature=related
[43] Schön, *The Design Studio.*

problem, outline the issues being address, and show their solutions and the process by which they arrived at the current solution. A pin-up exposes everybody in the studio to each other's work while hearing the instructor's specific feedback for each project. Although students mostly listen to the instructor's feedback, they also provide feedback and ask questions to other students. The pedagogical benefit is in learning from the mistakes and successes of others. It widens the students' perspectives by looking at how every other student in the studio saw and solved the problem and concomitantly creates a quality standard. Each pin-up illuminates the trajectory for the whole studio in terms of the expected outcome. Additionally, the pin-up space enables an instructor to contextualize general feedback to the entire class through an example of one student's work.

Mid-review and final review

The mid- and final reviews open the students to fresh perspectives and additional feedback. External reviewers are invited to provide analysis on students' presented projects. They bring a certain sense of detachment that neither the students nor the studio instructor has upon seeing the projects for the initial time. During the final review, students must defend their final projects by answering questions to define the conceptual ideas and explain the decision-making process that evolved into the solution. The final project is examined as a record of the design process and students explain their movement from the early concept to the final product. Aside from the quality of the final project, students are judged based on the decisions they made to move from one stage to the next. The decisions often raise theoretical discussions between the reviewers themselves. In turn, the dialogue itself provides educational value for the students.

The instructor's crucial role during the critique process is to quickly understand students' projects and their points of view, synthesize feedback, and propose new ideas and perspectives that are productive for the students. A great instructor is able to see the hidden potential in students' sketches and models. She is also able to express the most complex design issues and ideas in a simple and convincing way. Instructors develop critique strategies to reach that point of convergence with students more quickly. Schön describes the artistry of coaching as the capacity "to generate multiple representations of substantive knowledge and know-how, and shift easily from one representation to another… to move up and down the ladder of reflection…in such a way as to minimize her responsibility for triggering the student's defenses."[44]

A further distinction is needed between the value of a desk crit and a review. A desk crit is meant to help students look at their projects differently and see something they have not seen. It trains students to render their thought process more visible and to be accountable for their design moves. Thus, a desk crit is intrinsically productive. On the other hand, a review evaluation is meant to judge a student's decisions throughout the entire design process. During desk crits, the coach and students work cooperatively for the student to develop the best possible project. In a final studio review, the instructor often feels a sense of responsibility towards students' projects. The instructor often defends students' projects and asks questions that aid a student's presentation to help the student defend decisions during the presentation for external reviewers.

Implicit Components

There is usually a great deal of anxiety among first year students. Generally, nobody explains to students what architecture is or what is expected from them. They are thrown into the studio and are expected to adapt and operate successfully. However, they learn a lot about architecture and how it is taught from observing the class above them. The incoming students indirectly internalize the rules of the game. Under this assumption, a few years ago, the administration at MIT made a decision to move the architecture undergraduate class to the main architecture building where all Master of Architecture students are. They thought that this would ease the integration of new students into the culture of the design studio.

Another implicit factor that contributes to the success of the studio is the informal learning that happens between students in the same studio. Since students spend much of their time in the studio, this provides opportunities to interact, discuss, complain, copy, and explore solutions together. They learn various design skills and drawing and model construction

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[44] Ibid., 90.

techniques from each other. Although the studio environment is collaborative, the exceptional students who generally produce more drawings, sketches, models and alternatives set the pace for the rest of the studio students.[45]

What do Students Learn in the Design Studio?

Because of the lack of defined pedagogy in architecture schools, there is generally much anxiety among students and faculty about what they actually learn in the design studio. Unlike other disciplines that have concrete facts and a knowledge base, architecture seems to not have that solid foundation. So what do students learn in the design studio?[46]

It is all about cultivating *seeing*. Students' perspectives are continually shifting and new perspectives are incorporated. This is mostly evident by the stack of tracing paper on the desk of every student. These pieces of paper record the different moments of *seeing* through which students go through. The critique process is done so frequently so that students get trained to quickly come up with ideas, test the consequences of these ideas, shift perspective, test again, then shift again, until a better solution is obtained. Students are able to zoom in and examine a problem and then zoom out and reexamine it with a different perspective. They don't cling to their initial ideas but embrace the design process and the ambiguity that comes with it. They realize that the process is extremely iterative so the ideas change and evolve significantly during the process. This fluidity and flexibility of thinking is what defines the creative process.

Desk crits, pin-ups, mid and final reviews are all designed for this purpose, to cultivate *seeing*. A desk crit is about a student and a studio master, a pin-up is about the whole studio, a mid review is about other instructors in the school, a final review is about a much wider audience. The diagram below shows the points of critique students go through.

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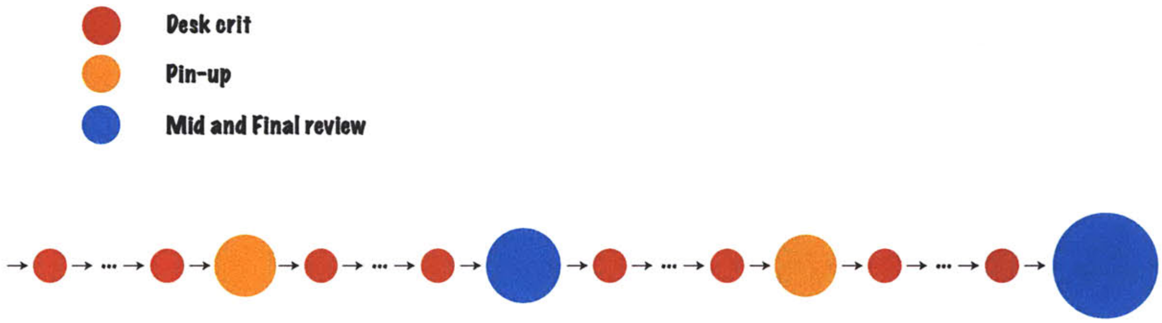
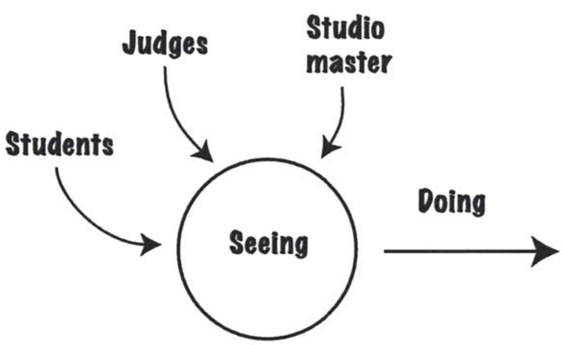
[45] Dana Cuff, *Architecture: the story of practice*. (Cambridge, Mass: MIT Press, 1991).
[46] When asking architects about what they learned in school, usually they refer to their ability to understand space and spatial configuration. They also refer to very refined presentation skills. However, you never hear them talk about an architectural way of thinking.



The process does not stop here. Students are expected to synthesize all this feedback and new *seeing* with their own perspective and produce a new iteration that reconciles all these different perspectives. To do so, students have to develop excellent prototyping skills that allow them to express their ideas quickly and eloquently. They learn how to use different media, from sketches, models, all the way to digital renderings.



In his analysis of the design studio, Schön argues that the studio pedagogy exemplifies the process of reflection-in-action, which is a kind of thinking that responds to unexpected outcomes that sometimes arise while we are doing something.[47] The process is characterized by an online experimentation, on the spot research, with the material in front of the designer. We test a *reframing* of the problem, we seek to confirm or disconfirm that the new solution can respond to the problem. That is what the design studio is about, especially during the desk crit or the dialogue between a studio instructor and a student. The instructor is a virtuoso performer. She learned to string out long and complex webs of moves, consequences, implications and further moves. Every move triggers many consequences. Imagine you move the wall over here. By doing so, you can expand that area,

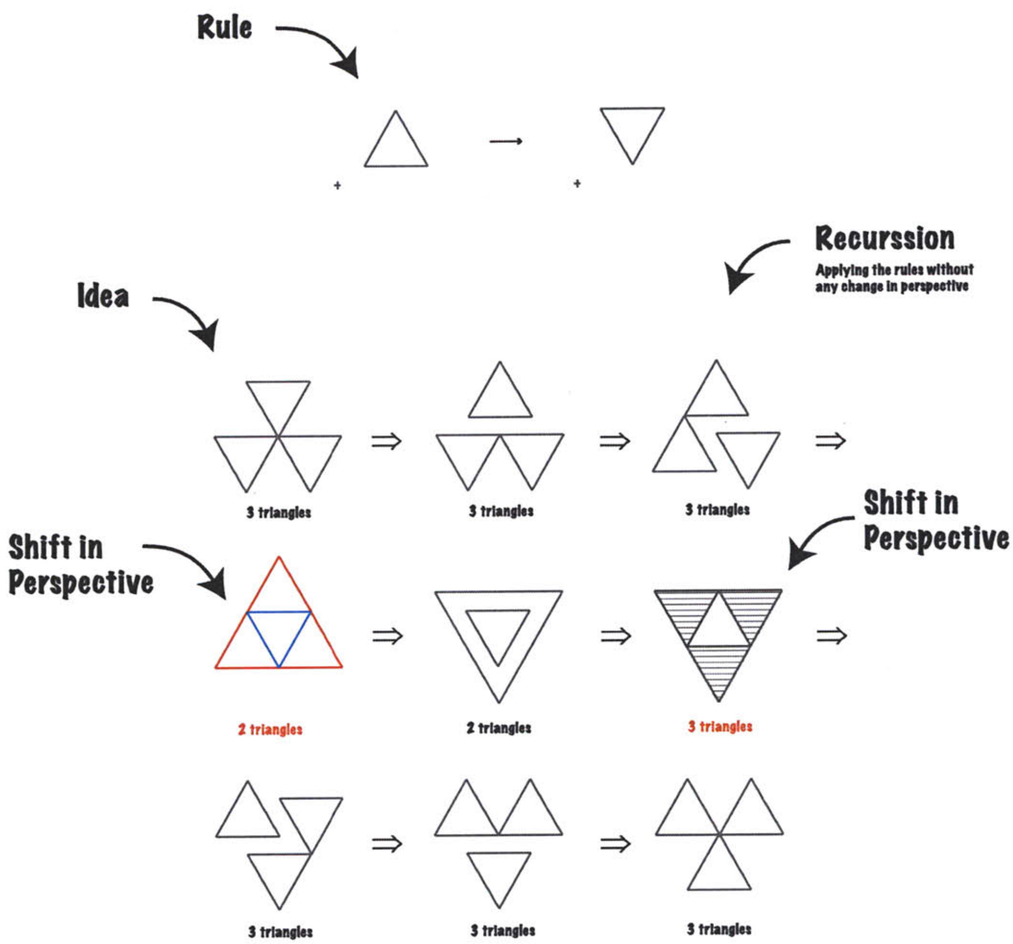
[47] Schön, *The Design Studio*, 23.

allowing the sunlight to come in, and allowing air to circulate. But you realize then that this move makes the building incompatible with the landscape. You scrape the idea and go back again to a previous iteration or start a new one. That is the type of process architecture students are deeply involved in. For Schön, this is the same process in which a practitioner of any field is involved in: "capacity to combine reflection and action, on-the-spot, often under stress – to examine understandings and appreciations while the train is running, in the midst of performance."[48] The architecture studio builds examples of practice and critical reflection on practice, into the core experience of learning architectural design.

Shaping the Design Process

The rule denotes the schemas that architects use to move through the design process. In this example, the rule states that every time you see a triangle, rotate it 120 degrees around its pivot. The process starts by applying the rule on the initial shape. After reaching a stage where applying the same rule does not further our solution, we try to shift our perspective on the issue. After changing our perspective, we re-apply the rule on the emergent shapes.

[48] Ibid., 27.



Stiny describes the design process as the ability "to interact with your work in the same unstructured way you argue about something new in vague and shifting terms that haven't been defined – to reconfigure what you're doing before and after you act, to react freely as you see things in different way." [49] Shape grammars capture the ambiguity of the forward and backward movements when perspectives shift on the fly in on the spot research.

Challenges of the design studio

In order to understand the intricacies of the design studio, it is necessary to extend the lens beyond its successes. In this section I focus on students who struggled to adapt to their architecture design studios. I use two in-depth case studies of students' efforts to reconcile their own creative ideas with the design studio pedagogy. Through the cases, I investigate

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[49] Stiny, *Shape*, 7.

the causes behind the difficulty of adapting to the learning environment. The experiences beg the question, can the specific pedagogy of the design studio be a barrier for learning? Or, rather, is the reason for failure the students' inherent incapacities to deal with architectural problems? Underlying these questions is the larger issue of whether the design studio is able to teach creativity to a range of individuals, whether artistically inclined or not.

Struggling to adapt is very relative in the context of my case studies. My conception is not related to grades, although it very well could reflect the grading of students. I understand the problem as a student who struggled to adapt to the "rules" of the design studio, a student who struggled to cope with their studio environments. That struggle sometimes reflected badly on their grades and their relationship with the studio instructor or, more significantly, their ability to continue in the field. Students who struggled in the design studio, yet demonstrated a strong creative capacity, provide more illuminating insights into the design studio structure and its resulting outcomes.

Over a 3-year period, I instructed 4 studios and attended numerous final reviews at MIT. This enabled me to follow architectural students' progression. As my research questions were formulated, I talked with 6 students who followed a similar experience, but ultimately, selected 2 for in-depth case studies. Emily and Bill exemplify the puzzle in the design studio. Both students are highly creative and intelligent (according to their peers and teachers and this author); yet, throughout their architecture studies, they struggled to meet expectations set forth by their instructors. Generally speaking, most students struggle in their first year of architectural education. There is an initiation period where students learn how to navigate studio norms - adjusting to the long working hours, criticism in desk crits and reviews, and relationships with instructors. However, most design students adapt to the studio pedagogy in their later years.

Emily and John stand out as two students who could not effectively adapt to the studio norms. Both students chose architecture because they believed their creativity could be utilized in this field. Emily sought a master degree in architecture after her liberal arts undergraduate education. She wanted to work in the same field that her father had practiced. John chose to pursue a bachelor degree in architecture because, unlike engineering or computer science, it allowed him to use his creativity and integrate multiple fields. The puzzle is that their creativity became a barrier. It was not understood, nor valued by most studio instructors. Neither student could communicate their concepts according to the "rules." Both Emily and John resisted instructors' feedback in the critique process and held to their conceptual ideas. Ultimately, these factors prevented their design processes from moving forward.

Their cases highlight particularities that are crucial within the iterative process to teach creativity effectively. These struggles in the design studio are not unique to John or Emily but instead illuminate challenges for all instructors and students who negotiate their relationship with one another to communicate ideas and receive feedback. Schön describes the relationship's ambiguous nature:

> The student does not yet know what he needs to know, yet knows that he needs to look for it. His instructor cannot tell him what he needs to know, even if *he* has words for it, because the student would not understand him.[50]

The student must learn by doing. According to Schön, the studio pedagogy rests upon this notion that the students are expected to find out for themselves. The responsibility is placed upon them to learn through design.

Adapting to the Studio Structure

The design process is iterative and the role of the instructor is to help students iterate, to gain a new perspective and enhance their projects. The feedback process may be disruptive for students new to the design studio experience, particularly for those coming from more academic learning fields such as engineering. Students may challenge the feedback if they believe their concept is not understood by the instructor or if they refuse to abandon core elements or, resultantly, if the master-student relationship breaks down. The burden is on the student to quickly adapt to each instructor's implicit rules at the beginning of a studio.

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[50] Schön, *The Design Studio*, 56.

Because many of the rules in a studio are implicit and not standardized, instructors' implicit rules vary. Students spend much time in the beginning of every studio trying to understand their instructor's particular implicit rules.

The desk crit is the first instance of feedback, or in the context of these cases, of criticism. When asked how he felt about his first desk crit, John responded, "resistance." Emily and John struggled with two core elements of the iterative process. The first is communicating their design through standard prototyping methods. The second is abandoning concepts that the instructor identified as "not working."

The 'rules' of the architecture design studio are learned through an initiation period. Emily felt that she did not understand the rules. In her first studio, she could not grasp the expectations, whereas she thought other students knew exactly what was the next step in the creative process. She felt that instructors gave more significance to other students' fluency with the system and subsequent confidence they exuded than the quality of projects.

In Emily's first studio project, students sat in the MIT chapel and created a response to the environment. She performed a dance. The instructor wanted a pretty charcoal drawing, his preferred method to communicate ideas. Her work was rejected that day and throughout the rest of the semester.

After reflecting on his six studios at MIT, John realized that he was not able to express his concepts through drawings.

> "I've never been able to get [concepts] out to the full extent to how things are portrayed in architecture. I feel like I've been designing things that are in environments that couldn't be captured in flat section, traditional plan design concepts. It's more explorable environments,"

Similarly, Emily never sketched. She was embarrassed by the quality of her sketching work. She did not learn how to sketch in class and asked, "How did everybody manage to do it?" Emily could not communicate with instructors through prototyping.

Explaining and Leaving the Concept

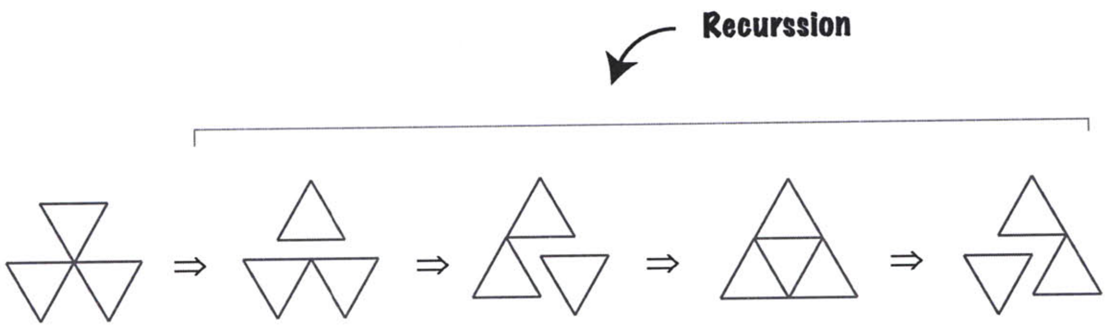
"Most people take the advice of the advisor and that's usually probably a better route." John regrets not taking his own advice. After desk crits, he did not adjust his concept based on the instructor's critique.

Emily grew frustrated with students' standard architecture projects or what she called "a stupid waste of creative energy to make a building that did not have a concept." In her view, students dedicated to the thinking process struggled more. Given the choice to produce a concept-less building or to sacrifice the building and keep the concept, Emily chose the latter path. She was gated, meaning that she could not move forward to the next level of studios.

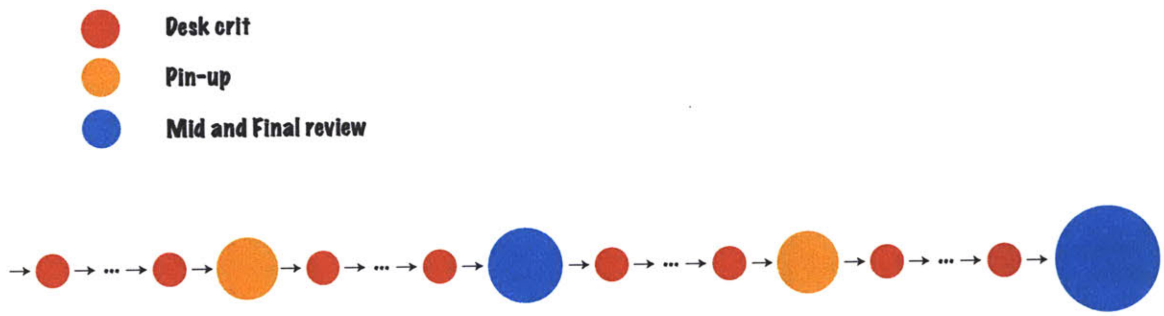
John's own rules came at a cost. Like Emily, he resisted dispensing concepts that he believed instructors did not understand nor realize its criticalness for implementation.

> "That diversion of me standing up for ideas that I wanted to integrate versus me letting certain things go, that's probably what has botched my projects in the end – holding too closely to the programmatic elements that I want to see as necessary to create the thing."

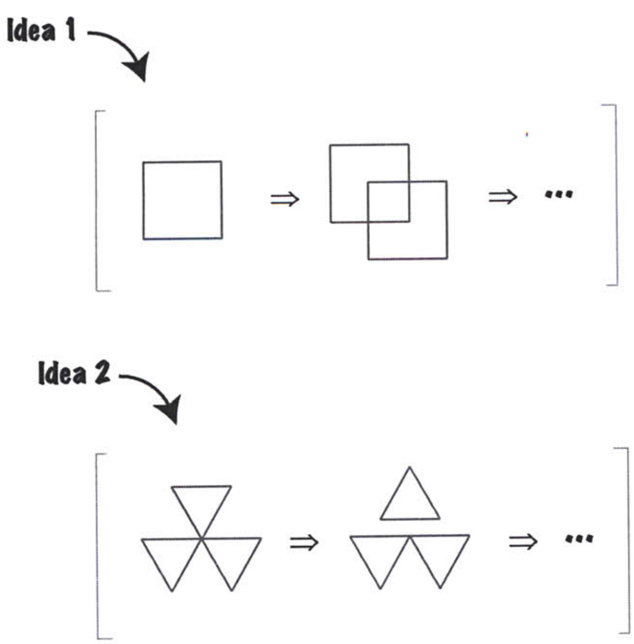
Emily also reflected that she held an unreasonable dedication to the concept. Her creative process was far more important than the practicalities of a building design.



Rather than revising and incorporating feedback during the desk crit (diagram 1 below),



John scrapped a design and started over (diagram 2 below). Therefore, moving forward through the complete process became a challenge.



Prototyping

Emily always felt more comfortable dealing with small-scale objects. The idea that these little models could translate into buildings was very foreign. John felt that his drawing abilities could not match the pace of shifting from small-scale to large-scale projects.

John had his own style and architecture studios worked at a very constrained scale, starting with small projects and moving to larger ones. His drawings failed to meet his expectations and his conceptual goals were difficult to embody in physical form. A bottleneck occurred during the prototype model. The prototype brought the question of whether or not the concept could be realized in a real world context to the forefront.

John attributes his struggle maintaining pace with the design process to being more of a recursive designer than an iterative. He becomes deeply involved in certain aspects of a concept, applying and reapplying rules, such that he rarely produced a complete iteration to match the iteration cycle.

Students – Instructor Relationships

How did instructors respond to Emily and John? For the most part, negatively. Emily and John felt they were not receiving sufficient feedback. In Emily's case, she felt a communication disconnect existed between her ideas and how the professors responded. In John's explorations, he and his professors understood the project ideas differently. Miscommunication and misunderstanding often resulted in a bottleneck late in the studio, where the basis for his entire project was questioned. This required him to rework projects as the final deadline approached, thus completing far less iteration than his classmates.

Why did Emily and John not accept the advice of their instructors? Admittedly, stubbornness may be involved. Looking deeper into the relationship between students and their studio instructors reveals a much more complex relationship than simply teacher – student. Schön refers to the 'contract' that exists between the two parties. This contract is implicit, embedded in the communication between students and instructors. The willingness of students to give the instructor's suggestion a chance and the openness of a teacher to challenge and defend his positions in what Schön refers to as a "willing suspension of disbelief"[51] This is not easy. It invokes dependency and vulnerability.

Emily never received encouraging words from her professors after the first week of the studio. She wishes professors had identified what she was doing well, instead of focusing on a building's shortcomings. Nobody actually told her how to make a building. Emily kept making guesses, searching for ideas that would please the instructor. She did not understand why the ideas were criticized, particularly because the instructor did not know how she looked at the project. He could not identify the lens from which she viewed the design.

Out of six studios, John dropped one because of a communication gap with the instructor near the end of the semester. In his most successful studio, he had the best relationship with the instructor. "He was trusting of my process." The instructor's feedback pointed out aspects that were good and encouraged John to move forward rather than picking apart what was not working.

Emily also struggled with these contractual relationships with instructors. Similarly, her most trusting relationship occurred with the instructor who pointed out what Emily was doing well. "Ann seemed to identify that there is something I was doing that is not exactly architecture but still had value, " Emily reflected. Ann told her not to take an architecture studio in the following semester and instead to take design classes at MIT's Media Lab. Ann was the only one who recognized that Emily was in the wrong place. Emily went on to thrive and complete an art degree.

> "In art, there are no rules, the rules are my own. The criteria
> for success or failure are not divorced from the process itself.
> The thing is always the result of the thinking process."

[51] Schön, *The Design Studio*, 57.

The significance is not that John and Emily struggled in architecture; it is that both of these accomplished students struggled to *adapt* to the design studio. Schön references a similar case in which one of the most intelligent students in the architecture studio had not "internalized some of the covert things."[52] The lack of defined rules and norms creates a highly competitive environment where students find themselves struggling to express concepts and, at the same time, to abandon the concepts.

Conclusion

This chapter examined the design studio from its historical development to the components that seek to realize its pedagogical vision. The particular way in which the design studio model nurtures iteration and critique facilitates more seeing. However, the chapter also highlights students' challenges to adapt to the design studio "culture," to become familiar with implicit "social" rules.

Before design studio pedagogy can be applied effectively outside of its architectural context, the concerns of adaptation in the initiation period must be reconciled. Because the architectural design studio is streamlined to funnel students through a particular professional process, the studio's pedagogy must adapt to accommodate a variety of learners with diverse interests. In this way, prototyping will take on more forms. For example, performing a dance may be the optimal expression.

[52] Ibid.

Chapter 4

NuVu: Seeing + Learning

My goal throughout this dissertation has been to understand the design studio pedagogy and how valuable it is in teaching creative thinking. First, I set out to understand the design studio by co-teaching 4 design studios at MIT. After researching and writing about my students who produced excellent work, I shifted my focus to investigate two cases in which students struggled to adapt to the studio environment. I wanted to understand and highlight some of the challenges of the design studio and to ask if it can accommodate people of different skills and backgrounds.

What follows is the story of a new educational program called NuVu (pronounced, New View) that builds on the studio model and addresses the problems highlighted in the previous chapter. NuVu is a modified version of the design studio. While keeping many of the core studio elements intact, I introduced major transformations to the studio. The following sections provide a comprehensive documentation of the development process behind the new program and its implementation phase.

I began with the idea that the design studio is an effective method to teach creative thinking. But the question remained: Where can this pedagogy be applied? Initially I wanted to focus on college level students but that proved to be very hard because colleges are highly institutionalized and adverse to change. Unsurprisingly, I found it difficult to convince academics and university administrators that anything could possibly be wrong with or missing from MIT or Harvard.[53]

I shifted my focus to understanding pre-college level education. The homeschooling community seemed to be an ideal fit for the new program. My vision relies upon abandoning the restrictions of standardized requirements and testing; thus, I wanted to design an educational program that operates outside the official educational landscape.

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[53] Although a few programs at MIT have been launched recently to teach problem solving skills through project-based and multi-disciplinary approaches, the process is done from an engineering perspective. At least, it is a move in the right direction.

However, my focus moved beyond homeschooling when I met with members of the leadership team at an independent high school in the metro Boston area. To my surprise, there was immediate synergy; the school was searching for an innovate program to enhance the existing curriculum and NuVu happened to address that exact need. Since then, we have worked closely with the school to develop a program that fits both of our ideals.

Middle and high school education is currently in the greatest need for change, from an emphasis on rules and exam evaluations to that of iterative, mindful learning. Focusing on this learning group lends an implicit multidisciplinary advantage. As opposed to college level education, independent high school is inherently designed to expose students to a variety of fields at the same time without the need to focus on a specific topic.[54]

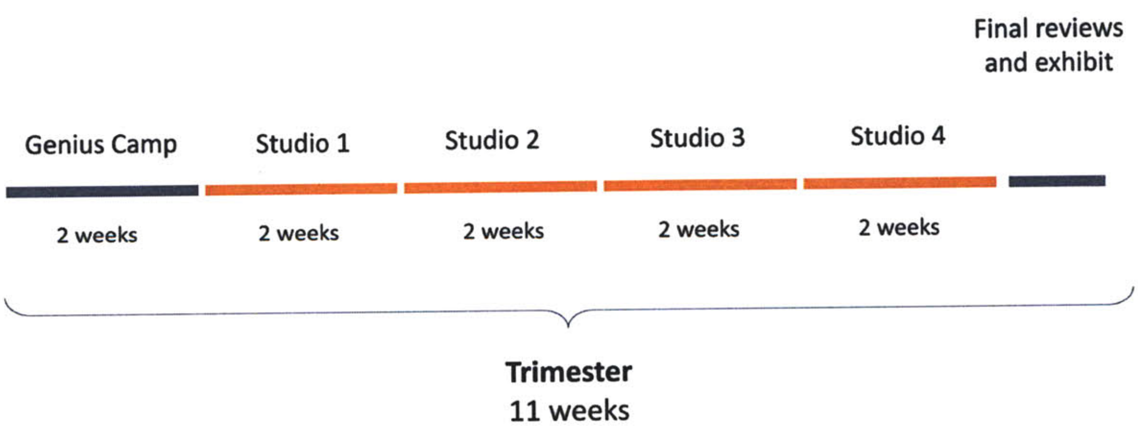
Young students tend to be more open to seeing the world in many different ways, but find themselves in a learning setting that emphasizes conformity. Rote memorization, learning and applying rules (over and over to the point of mindlessness) are seen as necessary initiation to high SAT scores and, ultimately, to tertiary institutions. Indeed, younger students are in need and are more developmentally open to exploration. Although currently no studies exist to support the claim, a few MIT architecture professors have told me that students who begin their architectural studies at a younger age tend to be more successful because younger students find it easier to adapt to the work traditions of the design studio. These students tend to be more open to changing their ideas without being committed to or 'stuck' with one perspective. Older students in the architecture studio find that the process of unlearning is more difficult; it may take longer to abandon their ideas before they are completely immersed in the studio environment. Thus, the partnership between the local high school and NuVu began to apply the design studio for young students in a multidisciplinary context.

[54] Unfortunately, a recent trend exists to create high school hubs for certain subjects such as math and science, or design.

NuVu: A New View on Education

NuVu is an innovative educational program with its pedagogy rooted in the design studio model. Students are taught within the framework of multidisciplinary studio projects rather than traditional subjects through hands-on problem solving. NuVu trains students to apply multiple perspectives to challenge and refine ideas over and over again until it becomes a natural way of learning. Our goal is for students to explore and learn mindfully in hopes of fostering a more creative generation, better prepared to solve today's complex problems.

The program is based on a trimester system lasting for 11 weeks. The first two weeks are dedicated to the "Genius Camp," which introduces students to the NuVu program. Then, students enroll in four two-week consecutive studios (see schedule below). A studio runs from 9 am – 3 pm during which students work solely on their studio projects without any other courses. The last week of every trimester is dedicated to preparing an exhibit of students' projects. Students work together with their Coaches to create an exhibit that can communicate their work to a larger audience. This increases the level of feedback and creates a space for more dialogue.



Every trimester operates with an overarching theme, such as "Future City" or "Science Fiction" or "Design for Development." The theme offers a loose structure for the studio topics but allows students to build upon the experience in previous studios. The individual studios can be understood as lenses through which students look at the theme differently. Every studio project will need a multitude of skills and knowledge bases that transcends disciplinary boundaries. Themes are broad enough to include studio topics that are very different in content and scope. The goal is to identify topics and studio projects that are contemporary and relevant, as well as engaging to the students.

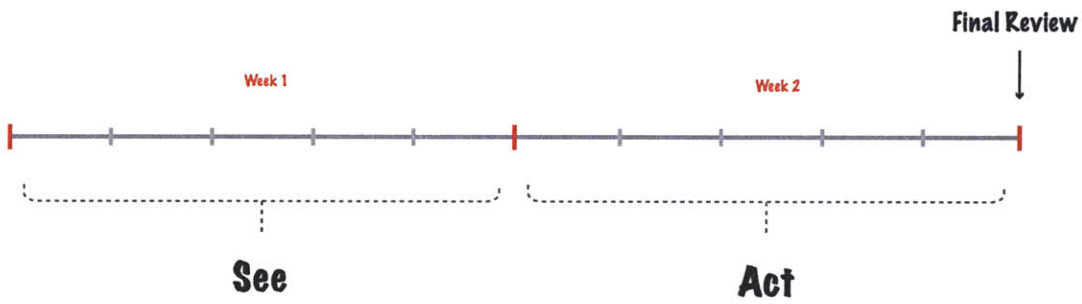
The Genius camp

During the first two weeks of every trimester, students integrate into the studio culture in the "Genius Camp." This period prepares students with the skills and tools necessary to express ideas. Technical skills are taught through daily mini-projects such as computer illustrating and digital media.

Two-week Studios

Traditionally, architecture studios run for a whole semester. At the same time, students enroll in other classes that support the studio. Architecture students often struggle to balance their studio with other course requirements. At NuVu, we want to avoid such conflict. Students should focus solely on the design studio without being distracted by other offerings.

Although the two-week schedule may appear too short to some observers, we found that engaging young students for extended periods of time proves to be difficult. The two-week period is enough to engage students in deep pursuit of a project. The first week is dedicated to understanding the basic concepts of the studio. The program is mainly composed of small early exercises that engage students in the studio topic. The second week is dedicated to the final studio project. The Coach begins by providing a general overview of a problem to the students, an ambiguous real-world problem with many potential answers. With the Coach's help, each student frames the problem from his or her perspective and enters into an iterative development process supported by the studio team of students and advisors. On the last day, we invite external judges to critique the students' work.



Coaches

To ensure our studio model is effective, we recruit coaches with expertise in exciting projects who are capable of handling the varied topics that we teach. Rather than having permanent teaching staff, our coaches are hired on a studio-by-studio basis.

We believe PhD students are ideal coaches for NuVu. Doctoral students work on contemporary and rigorous projects and have the flexibility to teach a two-week studio related to their research topics. In addition to PhD students, we also feature Coaches with well-established professions including artists, musicians, and filmmakers.

Another goal of the NuVu project is to engage institutions of higher learning in the Boston area. MIT has a long history of outreach to younger students in the Cambridge area and around the world. Splash, which attracted around 2400 students this past year, runs for a weekend during Thanksgiving. MIT students volunteer to teach short courses in whatever subjects they like at Splash. However, these programs do not directly interface with high schools in the Boston Area. These are infrequent events that invite the community to briefly experience MIT.

Assessment

Although we do not follow the traditional method to assessing projects by grades and numbers, we employ a rigorous evaluation process. At the end of every studio, a panel of external judges is invited to evaluate students' projects. This type of assessment fits the open-endedness of the process as judges may agree or disagree on project solutions. This particular evaluation process aims to help students reflect on their work. As with the design studio, we judge the process rather than the product. This assessment evaluates the decisions that students made in order to develop the final project.

We place special emphasis on students' portfolios. Each student completes a trimester with a portfolio of four projects. During the studios, students document their projects digitally on the website.

From our perspective, we flip the assessment equation. Rather than evaluating students, we want students to document and reflect on their own performance.

Implementation

Applying changes to the educational system requires cooperation with a multitude of stakeholders. Prior to implementing a pilot project, we held ten administration meetings, two parent meetings, ten presentations to students, sent one hundred twenty letters to potential colleges, two letters to parents, and ultimately waited for the school board to cast its vote of approval.

NuVu's partnership with an independent and well-established school in the Boston area, Beaver Country Day School (BCDS), came at an ideal time when Beaver sought to enhance its academic curriculum to train students for the twenty-first century. In 2008, Beaver presented its strategic directions that prepare the millennial generation of students who need to learn differently such that its "curriculum and programs will respond directly to the increased need for educational experiences that emphasize creativity, innovation and flexibility of mind."[55] The direction included connections with other private and public sector learning institutions to provide learning experiences that extend beyond the traditional classroom environments.

To be sure, Beaver is a unique school in that it can afford to seek out innovative models. The school is well regarded in an area filled with premiere private schools. Beaver is also able to bear financial risks in an effort to compete among the private schools in providing

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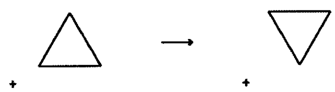
[55] Beaver Country Day School (BCDS), 2008. *Strategic Directions 2008.*

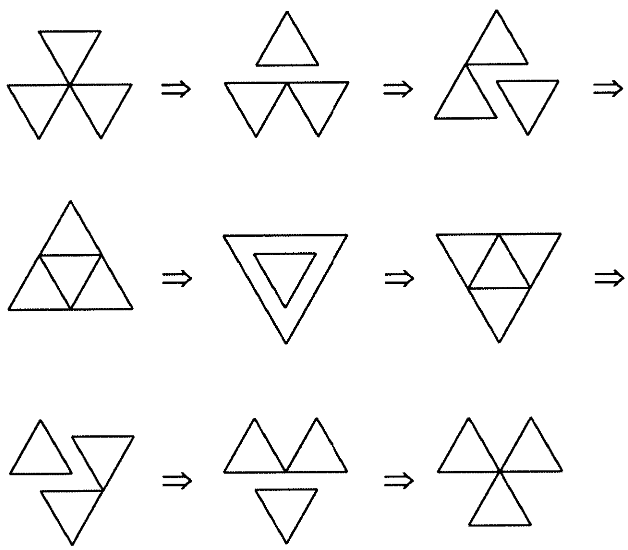
competitive curriculum. Beaver maintains a small class size and low teacher-to-student ratio. Yet, the school still sought the resources and knowledge base to complete the transformation to innovative, creative learning.

Our relationship with Beaver started because the leadership of the school was already searching for ways to incorporate creative thinking in their curricula. Beyond that, we needed to convince the school board with the project. That proved to be the most challenging issue during the process. The board is generally charged with maintaining the integrity of the school without rushing into hasty decisions that could affect the stature of the school. Although there was endless support for the project, a few voiced some criticism: "why can't we run a similar program in our school with our teachers?" or "why are we outsourcing our education?" After many formal and informal meetings, the school decided to approve the pilot phase. Beyond that, the continuation of the program will hinge on the success of the pilot phase.

A task force was later formed to oversee our relationship with Beaver. This direct interaction between the NuVu team and 6 Beaver colleagues proved very fruitful to share information, particularly for NuVu to learn about experiences with high school students. Together, the committee sent letters to 120 colleges to ensure that students who enroll in NuVu are not negatively affected in standardized admissions processes. All the responses indicated that colleges are in favor of the NuVu program primarily because it is a complementary program to BCDS's core program.

During the process of introducing NuVu to administrators, teachers and parents at BCDS, the iconic image as discussed in the previous chapters generated much interest. Administrators, teachers, and parents saw the image and understood what I meant by creativity and how the design studio operates. People requested copies of the image to explain to others how I described seeing, changing perspectives, and applying rules.





Piloting NuVu

The pilot project operated from March - May, 2010. We started the first two studios with 5 students then 6 more students joined us for the remaining two studios. Students had different reasons of why they wanted to enroll in our program. Mostly, they wanted to go through an educational experience markedly different from their traditional schooling. They also wanted to be more prepared for college. Some also cited enhancing their creativity as the reason to join NuVu. During our first day, we asked students to characterize their creativity in terms of left and right brain activity. Three of them were in the middle, one on the extreme left, and another on the extreme right. It was clear later on that students on the periphery were actually the ones who struggled. For instance, the student who referred to herself as an analytical person always followed the rules exactly. She believed that there is only one solution to every problem. While the other student who referred to herself as creative came up with many creative ideas but never executed them.

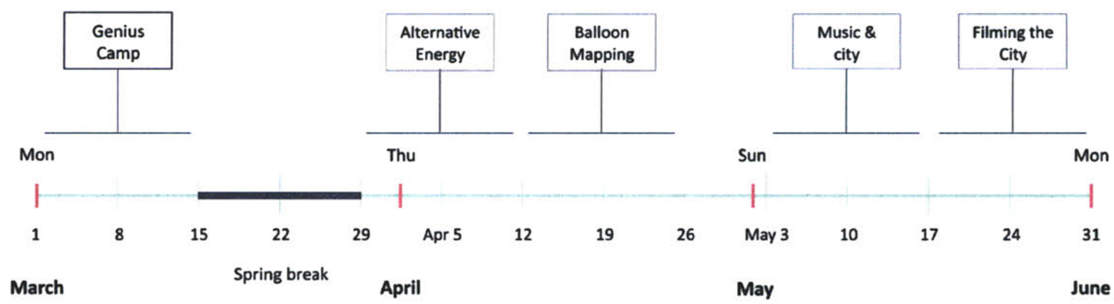
The pilot phase provided space to explore what approach is best suited for high school students and also an institution such as BCDS. In the pilot program, we encouraged experimentation and allowed coaches more freedom to conduct their studios. Although we designed all the studios with the coaches, we wanted to learn from coaches how they respond to the studio methodology.

The site of the pilot phase was the school itself, BCDS, in a large art room. Being at Beaver also allowed us to interact with the larger student body and teaching team of BCDS. This opportunity enabled spillover effects between NuVu's Coaches and the BCDS teaching staff. Together, we understood individual student's learning processes and customized evaluation accordingly. Additionally, some BCDS teachers visited the NuVu room and later began incorporating elements of project-based learning into their own lessons.

Our theme for the pilot phase was The Future City. Studio topics focused on understanding and improving the quality of life begins with the city. In this way, the studio topics focus upon historical and current issues in Boston, MA that allows students to work on problems in their own community.

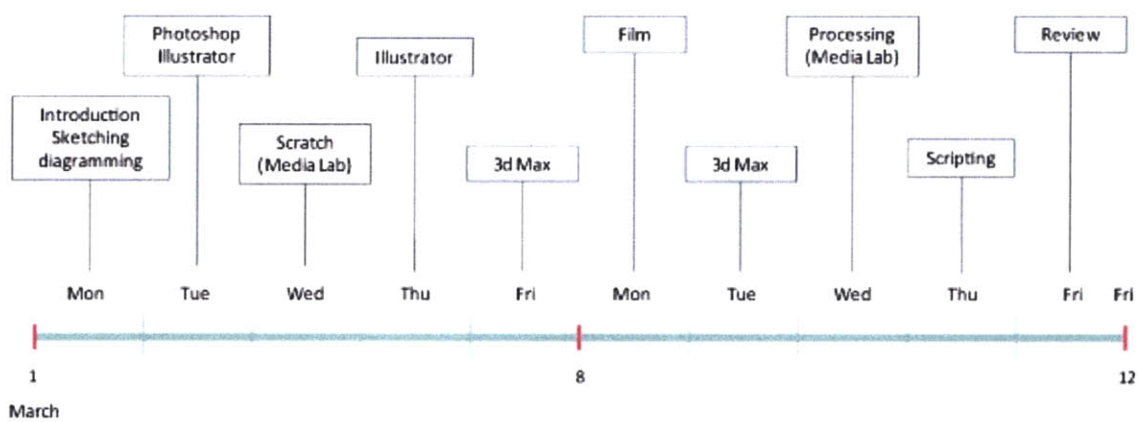
Students developed skills to analyze, evaluate and view the city from different frameworks including environmental, cultural, historical and infrastructural. Through experiments, interviews, site visits and analytical tools, students learned how to understand complex urban environments and to develop innovative approaches to problems that arise in cities.

We ran a Genius Camp for two weeks followed by four studios: Alternative Energy, Balloon Mapping, Interactive Music, and Filmmaking.



Genius Camp

The goal of the genius camp is to teach students the skills needed in the subsequent studios. We aimed to design a universal toolkit to accommodate studios.



Students learned hand sketching, Adobe Illustrator and Photoshop as well as 3D Studio Max. Interestingly, students quickly grasped the different software packages. In one instance, a student was able to construct a full 3D model of the school cafeteria in one day.

As part of the Genius Camp, NuVu spent two days at MIT's Media Lab building for skill-building workshops. Students developed familiarity with programs and moved through a set of early exercises to apply the tools to problems. For instance, to teach Adobe Illustrator, we asked the students to draw an abstraction of their faces. We did not provide additional instructions or restrictions other than each student should draw each other's faces. Their initial cartoonish results lacked sensibility. To remedy this, we asked them to imitate a famous artist, Jonny Wan, who devised a very particular method of abstracting faces. After further iterations, students began to see more details on their faces and to design unique images (see below).

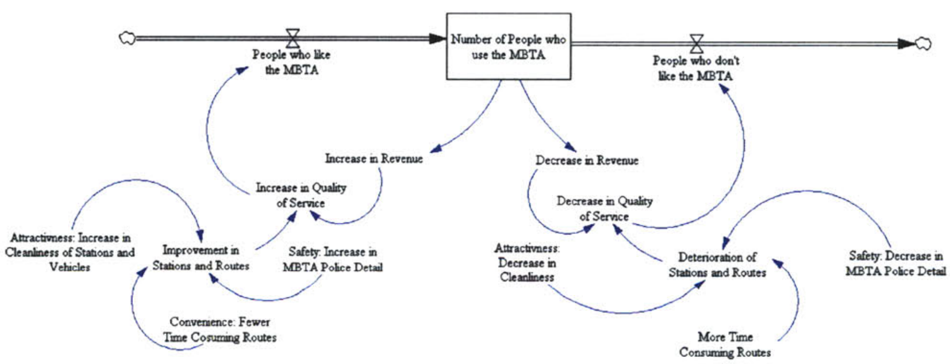
Jonny Wan's work is on the top while students' work is at the bottom.

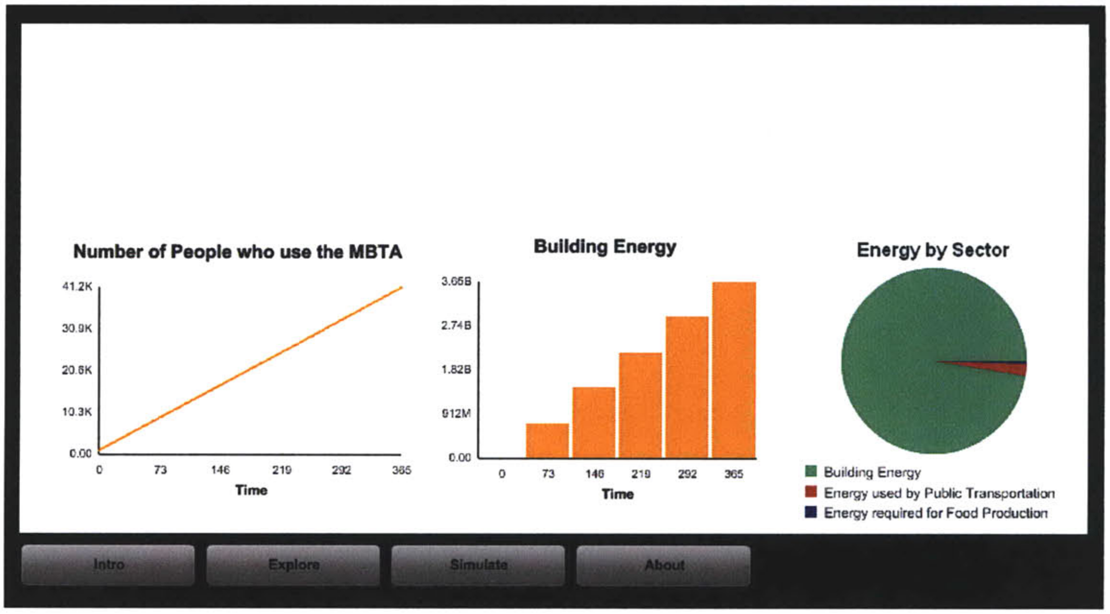
Studio 1: Alternative Energy

The first studio examined the energy usage in Boston, MA from a systems perspective. An MIT PhD student in the Building Technology group instructed the students to focus on a particular aspect of energy use.

The first week exposed students to the fundamentals of both energy generation and consumption and the existing energy alternatives. The theoretical introduction was coupled with a site visit to MIT where the class toured a gasoline co-generation plant as well as a solar panel installation and a nuclear fusion experimental set-up. In order to map out large-scale energy usage, the Coach introduced System Dynamics and explored Vensim as a tool for sketching out System Dynamics models.

Each student's work focused on a particular area - transportation, food production energy, and energy generation. Three of the students developed web-based models and then combined the individual models to form one model to evaluate energy usage in an overall system.





Studio 2: Balloon Mapping

In the second studio students shifted their perspective to view the city from above by designing a low-cost balloon mapping system. The Coach shared his thesis work developing a balloon mapping kit from the MIT Media Lab. The studio's objectives were firstly, to learn how to design the kit and, secondly, to use the kit to address social and environmental issues.

On the first day, before students established familiarity with balloon design or mapping, the early exercise asked students to quickly build a system that could fly over the school. The team designed a system to hold the camera from a sliced soda bottle equipped with two wings for stabilization. The Coach asked each student to document the process in a portfolio of designs and notes to be completed before beginning a new iteration.

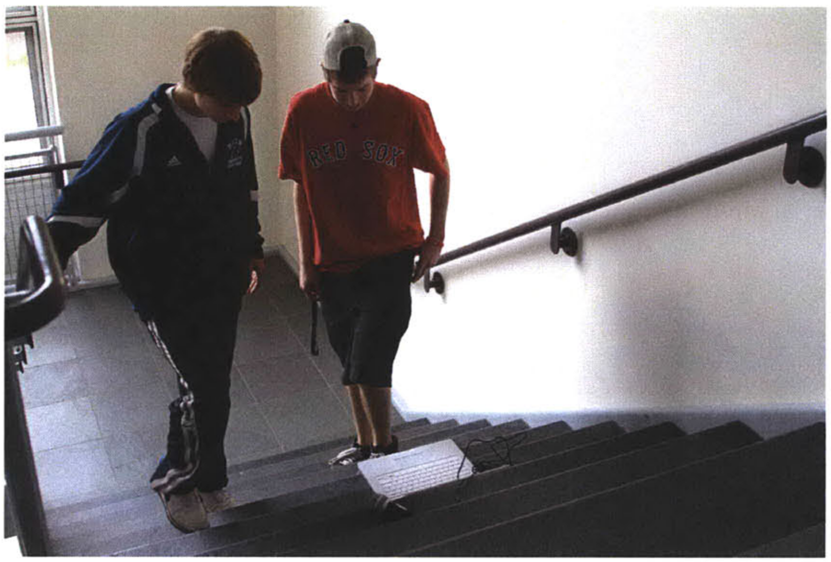
Students prototyped more advanced designs for camera 'capsules.' The Coach brought big blocks of Styrofoam and duct tape to quickly prototype ideas. The quick prototyping and testing gave students the confidence to explore new ideas without knowing whether a particular capsule could actually work. Students learned through these iterations and incorporated the findings to hold cameras horizontally and vertically and also a video camera that was tested over the Boston Harbor.

After the first week of introductory exercises, students began to explore how this technology, initially developed for low-income communities, could be applied in the city. NuVu students sought to map controversial sites in the surrounding community that change frequently or have experienced dramatic transformation not captured by standard sources such as Google Maps. One of the students captured images of the Boston University Bridge, currently under a renovation project.

Studio 3: Interactive Music

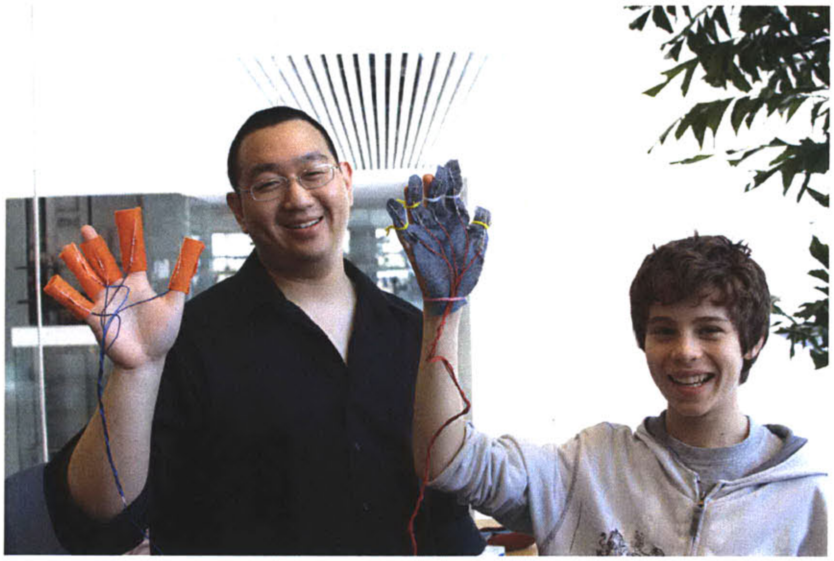
This studio familiarized students with the concept of sound and asked students to create interactive music installations. The Coach, a PhD student in MIT's Lifelong Kindergarten Group, is experienced with developing programming language and technology for young students. It is important to note that the program grew from 5 students in the previous studio to 11, allowing for greater collaboration and group work.

Early exercises exposed students to the concept of sound. The Coach asked students to make a musical piece out of found sound. After showing students how to record and edit sound, each group was given a microphone to record different sounds in their school. Students engaged with the open-endedness of the assignment and gathered creative sounds from various sources, including their other teachers.



For the second exercise, students worked to assemble and prototype with an interactive music tool at the MIT Media Lab. This exercise challenged the notion that our students had about making and composing music. The Coach gave a short lecture on music theory and David, a NuVu team member, lectured on circuits and ear anatomy. Students became familiarized with a Pico Board that can be connected directly to Scratch. The Board extends the programmability of Scratch into the physical world, as each Board is equipped with 4 sensors (a microphone, a slider, a button, and 4 inputs for resistance). The flexibility of these programs accommodates a variety of skill levels.

Students progressed to explore Drawdio, which is a simple interactive music piece that allows one to vary the pitch of generated sound based on the varying resistance that occurs when a circuit is closed. One group of students applied the system to two gloves equipped with different resistors on each finger. Thus, touching one's fingers generated various sounds (see below image).



For the final projects, students worked in four teams to develop interactive projects. For instance, the Musical Chair Project created an installation in which the movement of the chair determines the type of music that is played (see below). Students used a Wii remote control as a receiver to detect an LED fixed on the chair.

Studio 4: Filmmaking

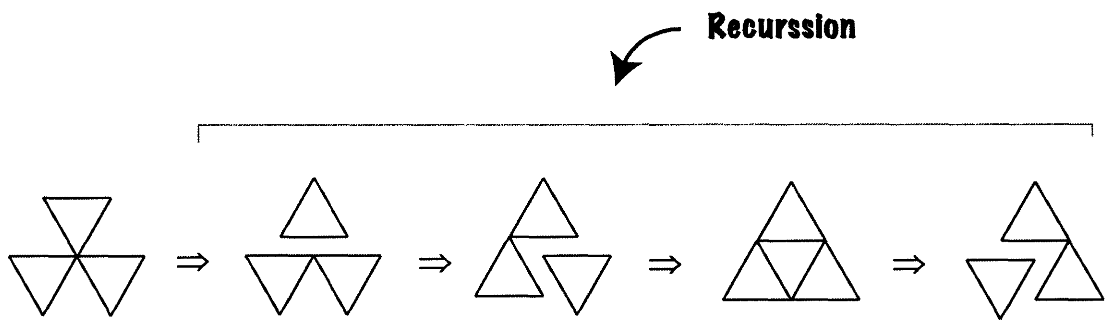
In the final studio, students created cinematic experiences to reflect an aspect of the city. In the first week the Coach, a documentary filmmaker based in Boston, MA, instructed students by moving between intense seeing and teaching exercises. The exercises incorporated both seeing and learning. The Coach showing film clips to open students to seeing cinematography techniques and to discuss directors' techniques in communicating messages. Students learned the basic skills of camera angles, shot entrances, movement, and sound. Then, the first exercise challenged teams to conduct interviews in which they role-played the positions of director, camera crew, interviewer, and acting interviewee. Immediately following, the coach critiqued the product pointing out aspects that worked, where rules were applied correctly, and aspects that did not work, for example, where the shot did not 'frame' the actor. Then, students incorporated the feedback into another iteration to improve the footage.

For the final projects, students worked in teams to produce short films. The Coach provided specific feedback on how to improve iterations and encouraged students to 'try again' and 'make it better.' Projects varied from a music video to documentaries to scripted dramas.

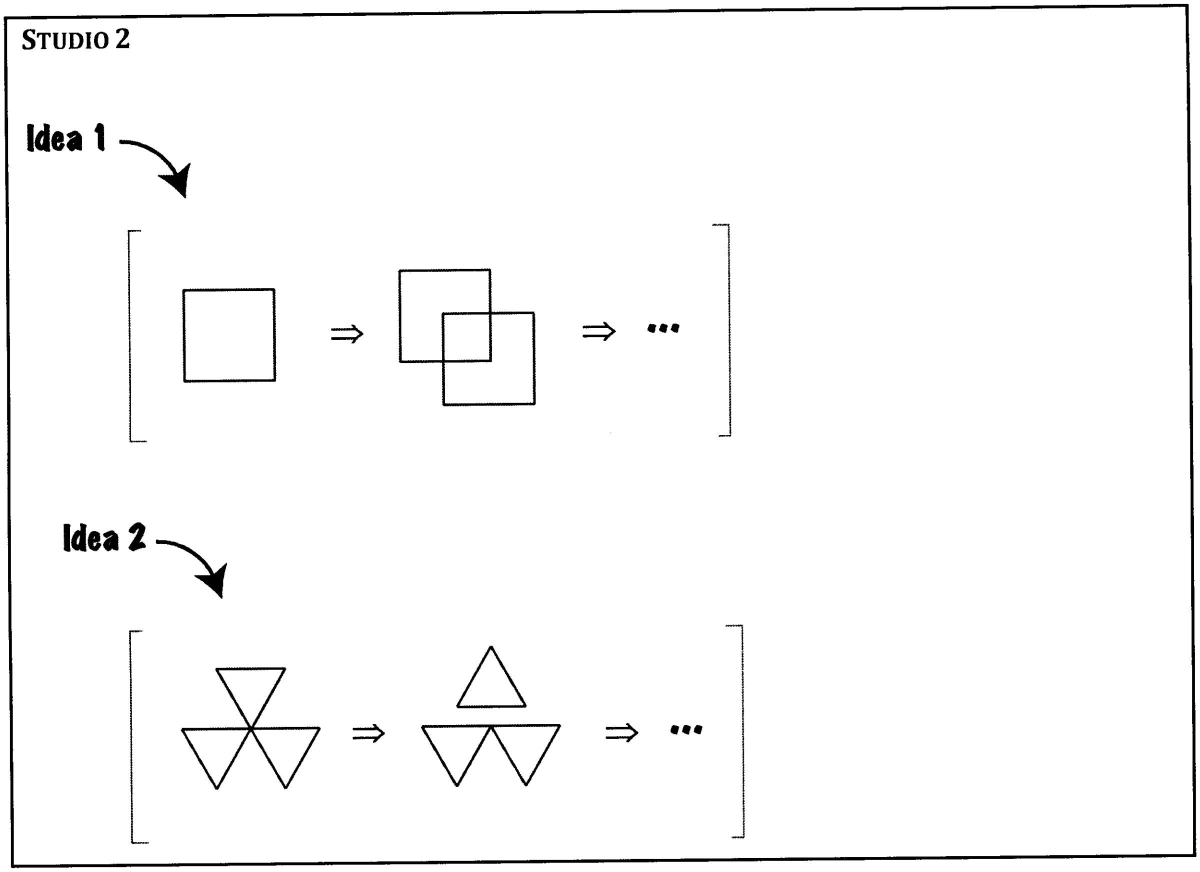
Balancing Seeing and Rules

The balance between seeing and rules evolved throughout the studios as the NuVu team and students adapted to the particular design studio context. Students moved between learning technical information or crunching numbers and sketching or reflecting. In the first studio, Alternative Energy, students selected a project and then applied rules – equation and technical details - to develop that system with equations and technical details that produced a complex, comprehensive system model.

STUDIO 1

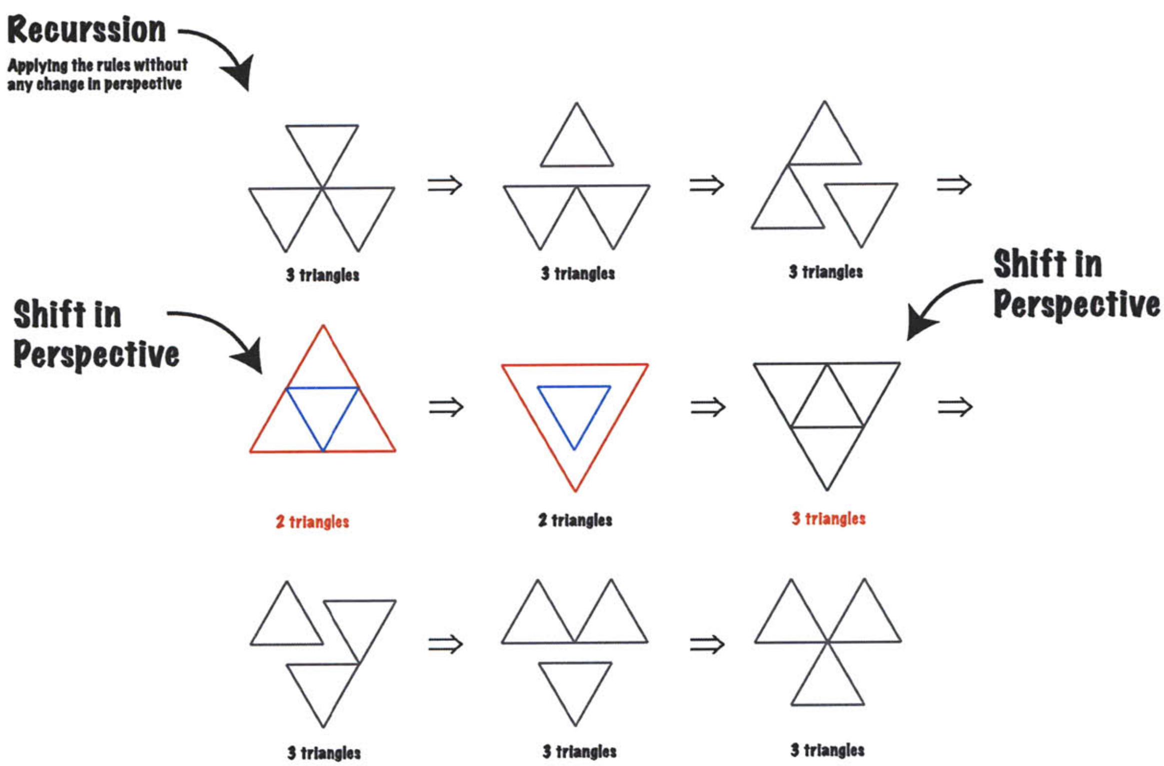


In contrast, the second studio, Balloon Mapping, fostered more seeing than rules. Students thought of an idea, which was quickly prototyped, but not carried to completion. One student wanted to build a hot air balloon that could carry a camera. The prototype failed because the technicalities of how a balloon could actually float were ignored. Thus, a new idea began and a new prototype started.

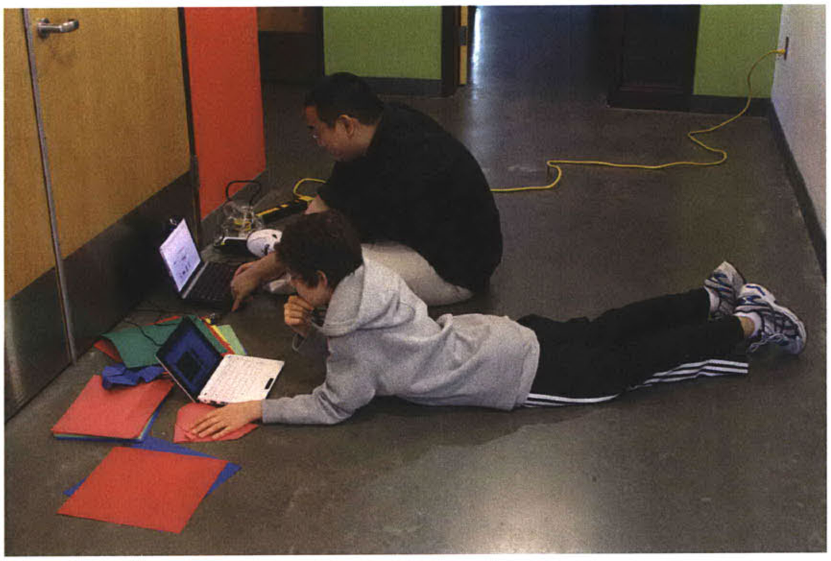


The third studio, Interactive Music, integrated seeing and rules. The Coaches brought an expertise of both music and technology to help students move between both processes. Students became more versed in the open-ended nature of the studio. They expressed ideas and prototyped more quickly. The lines between science and art blurred as students moved more fluidly between figuring out the electronics and programming and composing music that corresponds to people's movement.

STUDIO 3



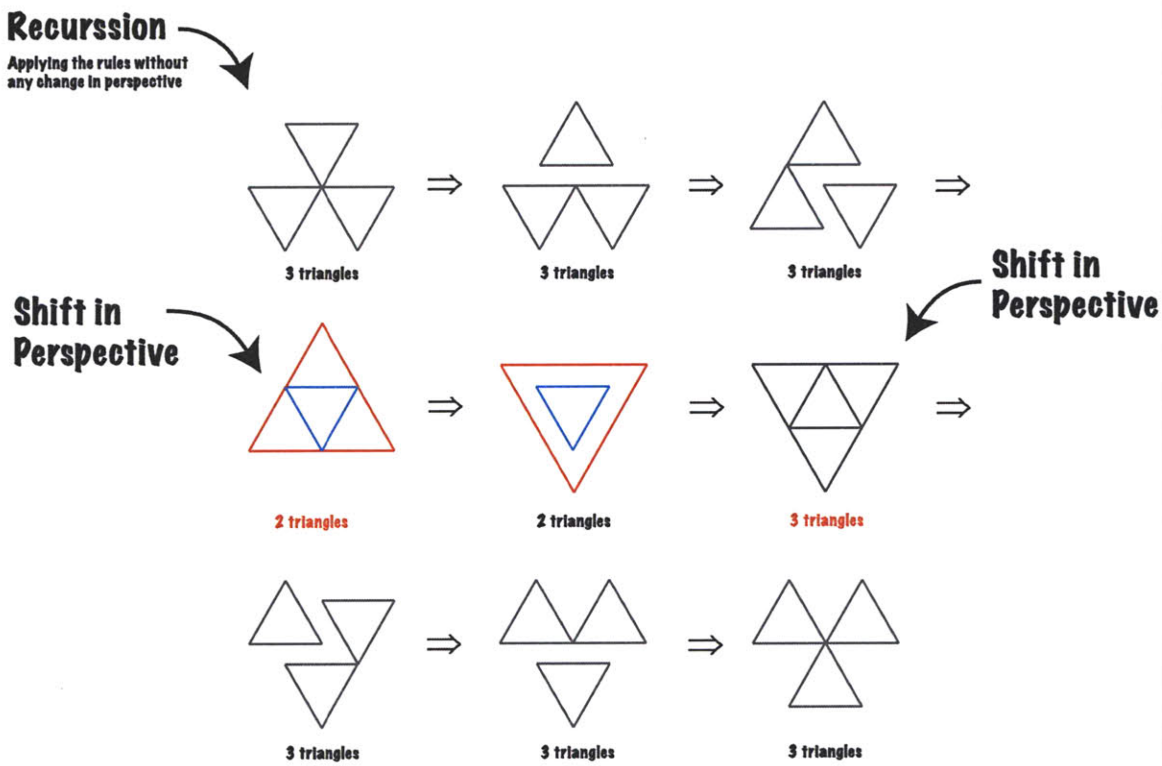
This studio's 'Music on the Fly' project produced music by flying paper airplanes. People interact with the installation by folding their own multi-colored paper airplanes and throwing them in the space. Although this project proved to be the most difficult from a technical standpoint, David provided the technical skills to move the project forward by building a vision system to track different colors. After that, the project team started calibrating the system to generate the desired music.



In the final studio, some students began to internalize the iterative process and moved freely between seeing and rules. The iteration became more rapid as students gained command of the learning processes. One particular group produced a music video working through many iterations and internalizing the Coaches feedback – applying rules and seeing more after each iteration.

STUDIO 4

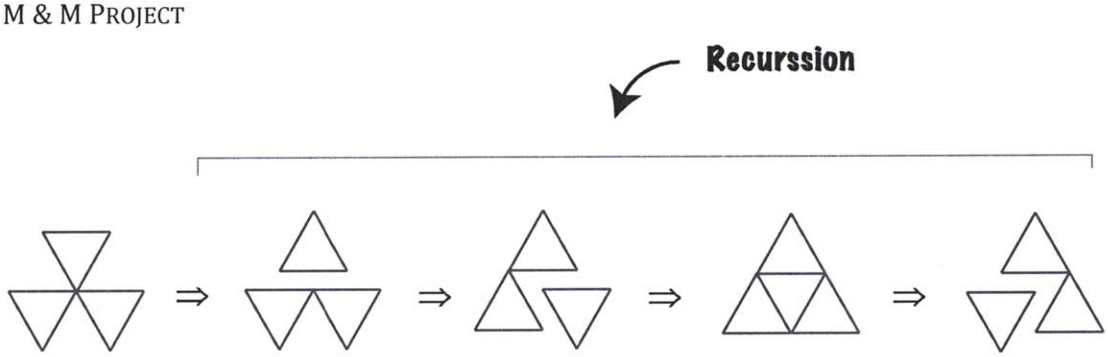
MUSIC VIDEO



Another group filmed a movie about M&Ms, but instead of moving through iterations, they refuted the Coach's feedback at multiple desk crits. Thus, the final project did not move through iterations at the level of other team's projects.

STUDIO 4

M & M PROJECT



Adapting to the Studio Culture

The greatest challenge for both Coaches, particularly those who are not from a design background, and students is to adapt to the studio culture. In the initial phase, neither the students nor the coaches had an existing community to learn from. Typically, new architectural students learn from the upper class that already navigated the studio culture. Similarly, studio instructors understand the particular learning styles of students and help other instructors customize critical feedback according to those needs. In this way, NuVu must have a clear procedure to help people adapt to the studio culture. Because the program is only for three months, it is essential to acclimate those into the program quickly. The following themes emerged from the NuVu pilot phase requiring further attention.

Critique Culture

Initially, students did not feel comfortable in the studio environment with its ambiguity and open-endedness. Shifting from a learning context in which clear tasks were defined and projects were identifiable required openness to critiques. Oftentimes a student completed a prototype and seemingly crossed of a 'check' on the assignment list. Students struggled with the studio's critique culture, especially in the first two studios. Students resisted criticism thinking that one solution exists to every problem and an instructor's role is to give them a grade based on the accuracy of their answers. Generally, we were unsuccessful with establishing a productive critique culture. Students felt very protective every time we attempted to critique their work.

Reflecting

In the first studio, we realized that students were unable to reflect on their projects during the final review. Each student spoke for 2 minutes only without mentioning details about the process or the decisions they made throughout.

To get students to be more reflective about their work, we asked them to shoot a short video of their work every day. These videos proved to be a great tool to increase students' awareness about their work. During the filming session, students shot many takes in which they experimented with different ways to convey the concept and progress of their project.

This was helpful during the final review. They were able to trace back the whole design process and the struggles they had to overcome.

As the students grew more comfortable working with each other in teams, they felt empowered to express their ideas and creativity, and became more reflective about their work. For the final review at the last studio, students talked for about 20 minutes about their work.

Customizing Expectations and Evaluations

Because NuVu operates within a multidisciplinary environment, we accommodate students' differences of interests, skills and learning abilities. We learned that some students preferred a rigid structure and felt their production suffered without looming deadlines. Other students needed greater flexibility to express their concepts. For example, one student seemed to be struggling due to what we saw as a lack of interest in the topic. However, two days prior to the final review, she explained that she wanted to present the gathered data in an art project. She felt pressure to use Vensim for modeling subsystems overshadowed additional options to express ideas. After this experience, we shifted towards increasingly more individualized expectations.

Chapter 5

Conclusion

This dissertation is an investigation into the effectiveness of the design studio pedagogy for teaching creativity. After exploring mindful learning and defining creativity as a balance between seeing and applying rules, I looked at how the design studio operates. Then, I created NuVu to implement an educational program modeled after the design studio.
So, how successful was NuVu? How do we even begin to measure our success since we do not have a single standard against which we can measure it?

We were very lucky to have BCDS extend our program beyond the pilot phase. That, for us, is a huge success. We are currently planning our official launch of the program with twenty-five students. But beyond that, how do we assess the effectiveness of the studio pedagogy in teaching creativity? Ultimately, we aimed to immerse students in a creative process in which many iterations are produced, tested, modified, and tested again; to integrate mindfulness into the learning process; to balance seeing and applying rules; to bridge the gap between art and science in multidisciplinary projects. To a varying degree, we were successful at that. In the first studio, students learned that by knowing the rules, they could build a complex system. In the second studio, students learned the importance of quick prototyping. By the third studio, most students were able to balance seeing and applying rules. The fourth studio generated an intense creative energy in which students embraced the studio culture; students even stayed at school late into the evening working on their projects.

The dissertation has argued that the design studio is an effective model for teaching creativity. The NuVu pilot phase evidences that the model can be implemented outside of the architectural context into a multidisciplinary high school environment. In addition to the design studio's successes and challenges indicated in chapter 2, the NuVu case highlights additional lessons. In moving forward, I explain the parameters in which the design studio successfully brings seeing or creativity into learning.

Integration into Studio Culture

To integrate students faster into the studio culture, the content of the Genius Camp needs revision. It is much more important to change students' mindsets rather than teaching tools. The Genius Camp should facilitate the integration of students into the studio culture. The program will be based on short projects and challenges, which instill the studio culture. Each challenge will run for the entire day and conclude with a final presentation. One of the challenges for instance is to figure out a plan to live on $2 per day. First, students will gather data about their own daily lives and track their own spending. After publicly sharing the data between all the students, we will form teams made out of 3 students. Teams will start devising different plans and strategies to survive on $2 a day. Students will be encouraged to prototype many ideas before they reach a final plan. The judging criteria will be based on the nutritional value and cost of the food. Different coaches will advise teams and help them to modify ideas.

It is important in these challenges that students learn the importance of process learning and to explain their ideas according to the process from which they began. Iterations become normalized while mindlessly moving through checklists is stymied.

Training (Studio) Coaches

In the pilot phase, we intentionally left much freedom to the coaches to conduct their studios. We wanted to see how students responded to the different teaching styles and studio projects. Moving forward, we want to work more closely with coaches to design their studios. We will also hold a coach training session before the beginning of every trimester. The training session seeks to integrate the coaches into the studio environment with its ambiguity and critique culture.

A key factor in a studio's success is whether coaches establish their "intellectual" authority early on in the studio. Students are more open to receiving feedback from their coaches if their expertise is understood. The Coach of the Filmmaking studio managed to assert herself in a very short time as an authority over the material that she taught. As such, students were more open to receiving her feedback and criticism. At the same time, she gave ample room to students to express their ideas and opinions.

Finally, it is imperative for every coach to have a clear understanding of all students in the studio. This understanding will allow coaches to tailor their instruction and critiques based on students' individual needs and challenges.

Embracing Difference

A recurring theme during the pilot was that the more perspectives we had on an issue, the better results we received. This goes against the status quo in which students are grouped based on age and sometimes on academic abilities. Difference in backgrounds enriches the whole creative process because more people are looking at the same issue differently.

In the Interactive Music studio two younger students joined the NuVu group. We watched to see whether the dynamic of the studio would change and to see how the younger students would integrate into the studio culture. Although these two students did not attend the Genius Camp, they adapted quickly to the studio culture, evident by the quantity and quality of the prototypes they produced. Interestingly, more than other students, they were able to quickly generate ideas, prototype them, and test them and then move to the next iteration. When they hit a technical bottleneck, our in-house technical expert joined their team to build the vision system.

During the final review, they were extremely vibrant and reflective. They loved to be on stage talking about the amazing things they built. Because these two students were younger and more playful, they created a more relaxed environment. Ultimately, they brought a different perspective to the studio and that enriched the culture of the studio.

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