

First Year Experience for Digital-native Students

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Session: First year experience

This paper discusses undergraduate freshmen experience in the core studio design course in the professionally accredited architectural program. The studio curriculum focuses on teaching digital and traditional tools in the design context while considering the level of knowledge and the nature of a student body. Design studio curriculum introduces students to traditional modes of creativity such as sketching and physical models. This preliminary stage is paralleled by an introduction of digital skills, which while visually familiar to students, often require broader conceptual and methodological underpinnings.

Later in the semester students focus on digital design tools with particular pursuit of design explorations that are digitally-native, such as performance analysis, physically-based lighting and material studies. The focus on performance and materiality exemplifies a particularly effective use of digital tools that takes an advantage of an intrinsic ability of computers to substitute or modify already existing data with a minimal knowledge requirement to how the data (in this case three-dimensional digital architectural model) is created. This facilitates investigative and speculative approach to design while providing student with an interactive validation mechanism. Furthermore, it allows students to focus on “what and why” they are doing, while continuing development of the “how” knowledge in the context of their designs.

This paper considers experience-based learning as such an effective method in student education that crosses various toolsets and discipline boundaries. While experience-based learning is a time-honored approach, there are also opportunities emerging specifically from digital tools that can further improve students’ educational experience and ability to learn unfamiliar material.

“Learning by doing” philosophy

Learning by doing, often called experiential learning, is about acquiring skills and knowledge through activity, which is often contrasted with the traditional didactic and passive-style learning referred to by Paulo Freire as “banking education.”[1]

There is ample precedence and philosophical backing for the learning-by-doing approach. Some trace it as far as Confucius, with his memorable adage from around 450 BC: “Tell me, and I will forget. Show me, and I may remember. Involve me, and I will understand.” In more recent times, David Kolb defined the concept of Experiential Learning Theory (ELT)[2] using two continuum axes: active experimentation–reflective observation and abstract conceptualization–concrete experience. Each of four learning types consists of experimentation, experience, or reflection as an active component of the learning process. These components can be used as building blocks of computationally facilitated design education.

Kolb credits philosopher John Dewey[3] as one of the influences on his theory. He also links his theory to ideas from Jean Piaget, Kurt Lewin, and others writers of the experiential learning paradigm. Another “learning by doing” contributor, Roger Schank [4], defines multiple

aspects of experiential learning that directly correspond to methodologies that can be applied in teaching entry-level architecture students, particularly in the context of digital tools. These methodologies are based on the five “teaching architectures”: Simulation-Based Learning by Doing, Incidental Learning, Learning by Reflection, Case-Based Teaching, and Learning by Exploring. Each of the above teaching architectures applies directly to computational design teaching and is illustrated later in this paper.

Curricular case studies

The basis for defining a successful program for first-year students is not whether it is digital or analog based, but rather how the curriculum connects to the students’ already possessed knowledge and their ability to build on this knowledge. That said, more and more incoming freshmen are digitally native, with ways of accessing, interacting, and processing knowledge that increasingly conform to a digital media mindset. A successful curriculum should acknowledge this asset and use it for further strengthening students’ knowledge. At the same time, it should continue to reference everyday experiences and provide students alternative ways to codify their experiences.

In their first ever project done during architectural education, students are asked to develop a cantilevered structure made of toothpicks and glue that would be able to support a brick. Interestingly, there are hardly any questions asked regarding the project in the initial stages of assignment. Students feel it is self-explanatory and expect it to be an easy assignment until they start working on it. This seemingly simple project exposes students to a wide range of issues ranging from basic modeling techniques to understanding of structural behavior and material characteristics.

Some students start the project by immediately building study models and follow the designing-while-doing approach. Others feel the need to sketch and pre-conceptualize an idea before building it. Either way they choose, a haptic approach characterized by tactile feedback and thinking or a rationalized approach facilitated by sketching and visual aids, students can follow their inner creative logic without being pushed into modes of creativity that are foreign to them. This is an important quality of successful design education, since creativity is often channeled through individual capabilities that may be difficult for a student to change or replicate in a different context. This dual quality of learning is still present in computational environments; however, tactility is achieved through direct manipulation of a designed object.

While working on the project, testing designs and often looking for the ways to reinforce their structures, students become familiar with phenomena such as tension, compression, and bending. They are also exposed to ideas of bracing, lateral stability, and material properties. Students learn not only from their own observations and the experiences of their classmates, but also from readings and lectures that give them theoretical foundations for their design work. The final presentation includes strength tests of their structures, with students overloading them and observing the weakest links emerging in their designs.

Losing the ground under one’s feet

Teaching creativity is particularly difficult and usually requires multiple strategies that consider individual students’ capabilities and past experiences. It involves encouraging students to look at a problem in new ways as well as questioning their original assumptions and motivations for

their designs. It requires placing students outside their design comfort zone and later facilitating their struggle to regain the balance or control of their design. In the process of regaining their comfort zone, students establish a new conceptual framework that lies outside their past experiences, thus broadening their creative vocabulary. A variation of this approach is to combine two distinctly different or contradictory ideas. Through the process of reconciliation and mutual influences, a new design emerges that is not reminiscent of the originally referenced ideas.



Figure 1, Painting analyses (images: Leland Greenfield)

A design teaching approach that allows for pattern breaking, putting students in a situation where they have to think in a different way, is the “painting/landscape composition” project. For this project, students were given as a starting point an abstract painting from a late 19th or early 20th century period and were asked to develop landscape designs inspired by each painting. Students started with painting analyses [fig.1], extracting the painting’s primary compositional framework and interpreting it into a landscape design. [fig.2] They used both hand media and digital tools to develop interpretive two-dimensional imagery that was later converted into a three-dimensional landscape model. An important part of this exercise was placing students into an unfamiliar conceptual context—abstract paintings—that was in most cases new to them and asking them to react to it. Painting served as the conceptual springboard for new designs. This allowed students to go outside their (comfort zone) default thinking and produce solutions that would not otherwise be possible. This example points to a delicate balance that needs to be continuously negotiated between keeping students within the “familiar” to allow them to connect to their work, and removing them from their immediate environment to make them aware of new possibilities that lie outside the horizon of the “familiar.”

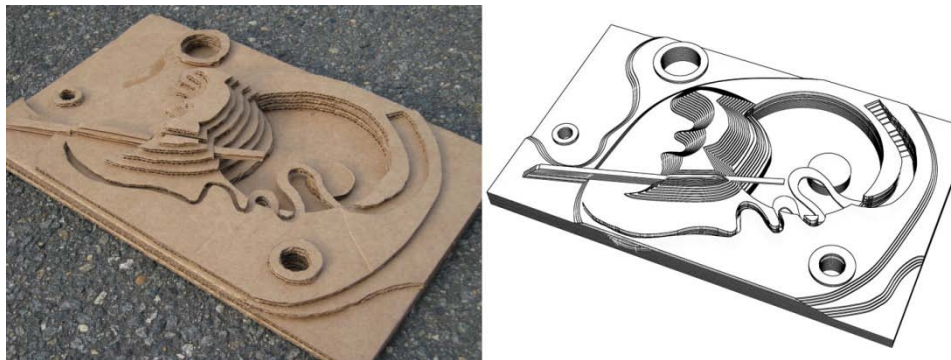


Figure 2, Painting translations into three-dimensional landscapes, analog and digital. (images: Leland Greenfield)

This approach allows for pattern breaking and helps to turn off the “autopilot” approach to problem solving. It promotes creativity and often results in qualitatively new solutions. However, this is not only about outcome, but also about teaching students the methodology for future problems. This methodology is applicable to both traditional and digital tools with portability to many creative disciplines. It is particularly effective in disciplines where one would use

unexpected combinations of elements or ideas to energize creative thinking. Through a reaction to these often unexpected circumstances, new ideas and solutions emerge. Digital tools effectively facilitate shifts in one's thinking and new perspectives on problem solving. In a similar way, the abstract painting project builds on the notion of surprise, placing students outside their comfort zone, and then facilitating their search for new ways to address a design problem.

Between analog and digital models

Analogous to the brick project, which was done with traditional materials and methods using physical models, are digital environments that utilize behavior and dynamics and consider material properties as an integral component of the design simulation. An example of such a project (shown in fig.3) was developed by student Mike Litus, in which he explored architectural forms that result in or mimic the tectonics of a drape, including facades similar to the artist Christo's wrapping of the Reichstag building in Berlin in 1995. To achieve Litus's design intent, the students started working with the standard three-dimensional modeling software package. Litus used a combination of NURB and loft surface that allowed for soft and veil-like forms. However, he quickly realized that these tools, while very effective for other applications, were not producing a natural-looking expression of a hung canvas. Furthermore, this continuous search for a perfect tectonic expression became a rather tedious and time-consuming exercise.

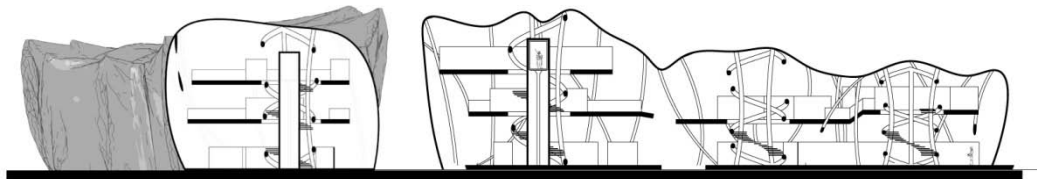


Figure 3, Model that follows a cloth geometry (image: Michael Litus)

Not only was the desired form hard to define, but even more importantly, the outcomes did not feel natural, like a real piece of cloth suspended and wrapped around an object. Consequently, we discussed how to overcome this impediment and looked for the ways to express cloth-like behavior in visually convincing and physically accurate ways. We started to investigate digital tools that employed dynamics and physically based behavior as form-making elements in design. We were looking for ways to simulate cloth-like behavior, producing a form that would result from physically defined characteristics, not something that was modeled outside the real-world behavior. We focused on dynamics-based tools that considered a modeled geometry not as a fixed spatial entity, but rather as a dynamic object that responded to external forces and displayed physically based material properties.

Litus switched to modelers that used soft-body dynamics, specifically a cloth engine. The results appeared very quickly. Soon, he was able to generate a number of preliminary design alternatives that visually communicated the design intent.

Exploring ideas that are not easily tested with traditional pedagogies

There are a number of design explorations that are specifically afforded by digital tools. These can be extensions of traditional functionalities, such as the use of virtual cameras or models to capture space in ways that traditional tools cannot due to their physical limitations or limitations

of physical matter. For example, the ability of a camera to selectively “see” parts of a digital model allows for developing imagery that is closer to human perception than that achieved through traditional photography. [fig.4] While both tools rely on a single point (eye) perspective, the field of view and the perception of space can be more easily achieved with a virtual camera. This is particularly evident in renditions of interior spaces.

Furthermore, explorations made possible by breaking apart models, assembling and disassembling design components in different ways, shifting them around, and substituting elements, all without a significant penalty in terms of time or effort, promote investigative thinking in architecture. Students gain their knowledge not by slow and tedious repetitive work that requires doing and redoing of a designed object, but rather by developing quick scenarios that test multiple design or performance criteria.

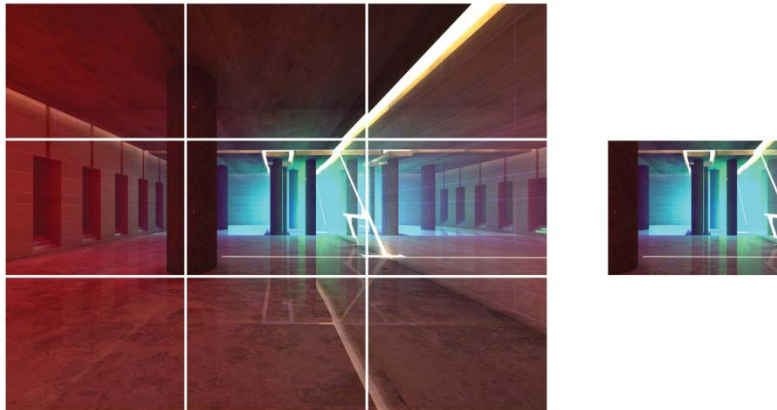


Figure 4, Left image represents recalculated traditional camera view from the right image.

Students can look at the models in a holistic way and adjust them globally with relatively low penalty. It is easy to copy digital models and alter them for further comparison of various design alternatives. This allows for evaluation of a number of scenarios in a short time when ideas are still fresh. Additionally, with digital tools it becomes easy to track changes, good or bad, and evaluate design decisions. Students invest more time in investigating the possibilities afforded by a particular design approach and less on developing foundations for their decision making in the form of tedious models of quantitative analyses. While the extended focus on the investigations may not necessarily lead to imaginative outcomes, the very process of explorations places creativity as a critical value in design.

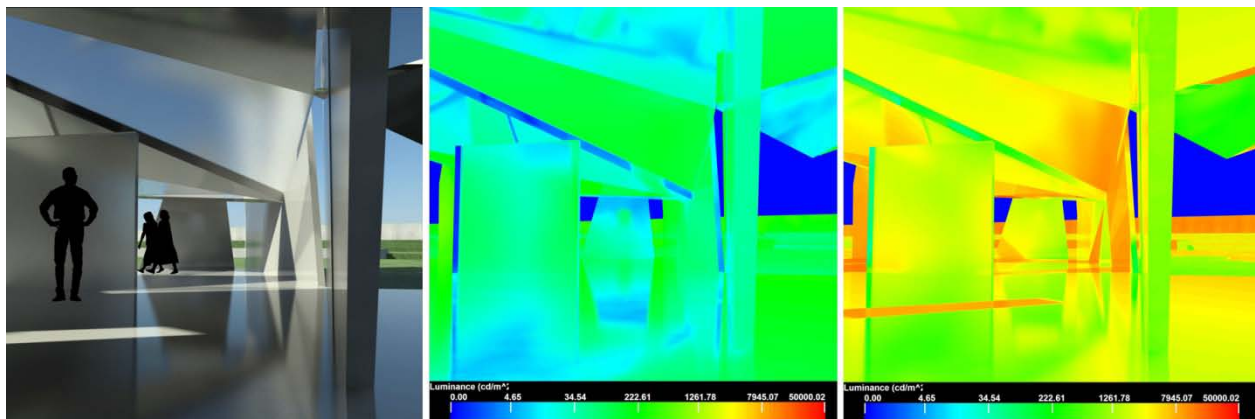


Figure 5, Visible light and the pseudo-color rendition showing the levels of illumination. (images: Travis New)

On other occasions, the introduction of digital tools makes it possible to introduce a new set of issues into academic curricula. Students are able to investigate design topics that up until very recently were exclusively part of professional discourse. Topics such as material and light behavior, or performance simulations, used to require specialized labs that can now be substituted with computational tools and performed on a personal computer. Consequently, a discussion of light can go beyond its purely visual character and touch on physical properties and quantities. With the introduction into physically based light analysis, students were able to combine photometric data (IES files) from the light manufacturer catalogs with actual light fixtures and consider their placement within an interior space. [fig.5] Students were asked to render a number of views, including floor plan projection with tabulated illumination numbers, in lux or foot-candle units, in order to further engage them with quantitative aspects of lighting design. This also became an opportunity to discuss various associated design issues, such as levels of illumination and human comfort. We went as far as discussing the color bleeding phenomenon and ways to account for it in design. As a result of this expanded light design discussion, students felt empowered not only by broadening their conceptual design framework with concepts of building performance, but also by its scientific and tangible dimension underwritten by physically based values and behaviors.[fig.6]

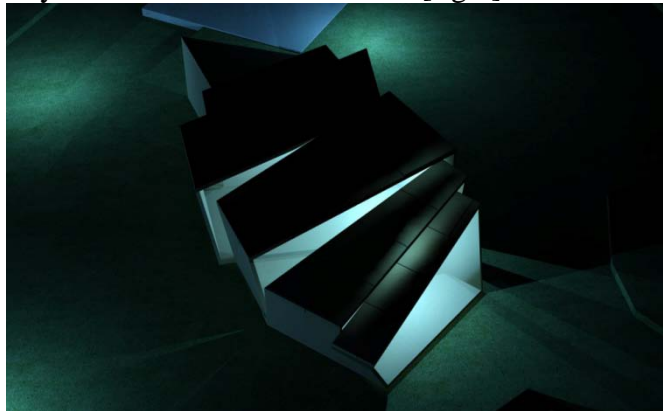


Figure 6, Digital model utilizes IES light definitions. (image: Sylvester Agyei)

The next step on the path to better design is a study of material and textural qualities of space. In a traditional design process paradigm, we would use physical models and handmade rendition done with color pencils or in watercolor. Physical models would be made of chipboard, balsa wood, or other materials chosen for design abstraction or symbolism rather than a simulation of materiality and perceptual qualities associated with design. Similarly, the pencil or watercolor images, while usually very effective in engaging a client through their visual appeal, did little to address material qualities of the design to an extent that would validate them as effective tools for a competent discussion on design alternatives. With digital models, we can overcome this limitation and are able to develop fully textured models that feel and behave realistically. The educational value of material studies lies not only in the ability to accurately visualize them, but also in developing quick alternatives and competing design scenarios. As a result, students start considering the materiality of their designs, and discuss material and textural alternatives. [fig.7]

These explorations can stay within narrow, rational material exploration using a palette of available materials, but they can also cross the normative boundaries and pursue broader speculative designs. They can be used as experimental design pursuits that question usual ways of thinking, approaches, and expectations from design. In these situations they can follow the “What if...” questioning to set expectation toward visual and physical properties of construction

materials. This speculative quality of digital design tools is particularly critical in developing students' attitude toward innovative thinking.



Figure 7, Material studies. (images: Sylvester Agyei)

Each of the discussed studies, light and materiality, can be seen as a separate design exercise framed independently from each other. However, they can also be brought together and discussed holistically as two qualities that mutually inform each other's perception and the role they play in defining design. The color, materials, and textural properties of a surface are intricately connected to the light qualities of a space. This interdependency of various design aspect can be used further to discuss broader influences on our perception and visual judgment.

Furthermore, the relationship between material color and light color is usually not understood intuitively by students. Color of materials, as pigments, relates to the subtractive color mixing rule, while light color mixing is additive. For example, a white wall would read as red when illuminated by red light, and it would look the same as a red wall illuminated by white or red light. This shifting and not always intuitive perception of color in relationship to light can be interactively studied with digital tools. Through these studies, students are able to develop understanding of these issues.

Virtual hands-on experience

As discussed earlier in the context of experiential learning, the primary concern is not to transfer the teacher's knowledge but to expose students to situations where they can experiment with tools, develop design propositions, and later to evaluate their designs themselves, through a group discussion or the instructor's feedback.

On numerous occasions, students showed a great deal of enthusiasm whenever they were introduced to various aspects of simulations within a design studio context. Their enthusiasm went beyond the "coolness" of used tools or their outcomes, and often addressed students' need to feel as much as to understand discussed topics. This concept of feeling the knowledge as much as understanding it is critical in development of intuitive thinking and deeper, holistic understanding of a given subject.

As a result of this exercise, students felt empowered not only by broadening their design framework with concepts of building performance, but also, or perhaps primarily, by its scientific and tangible dimension underwritten by physically based behaviors. I feel that the ability to reconnect theoretical concepts with hands-on explorations helped students to comprehensively understand their designs and to solidify their technical knowledge. This pedagogic approach builds on the notion postulated by Eduardo Torroja⁵ in *Philosophy of Structures*, where he emphasized the priority of qualitative over quantitative structural thinking. Computationally based digital simulations address Torroja's postulate of qualitative structural thinking by emphasizing a structural model with calculations being a critical determinant, but not

a primary visual communication component. Torroja's approach, while referred to structural teaching, can be broadened to any area of engineering or design, and predates work on experiential learning by D. Kolb.

Conclusions

A number of opportunities emerge from the use of digital simulations. These opportunities can enhance students' educational experience by grounding knowledge gained through everyday experiences in theoretical concepts taught in the lecture hall. They also can help to develop an intuitive knowledge that may to some extent compensate for a lack of real-life experience, experience that freshman students understandably lack. In this meaning, intuitive knowledge (or primary process knowledge—we all have sensations before the verbalization or organization of a thought) is an unprocessed comprehension of an idea or a process that can be relied upon in preliminary decision making. This pedagogical approach responds to Michael Polanyi's "Theory of Personal Knowledge," where the author observes that knowing is an art form in which the knower understands significantly more than he or she can articulate. This comprehension of external facts without being aware of them specifically, called "tacit knowledge," accounts for the human ability to function in the world. "[T]acit knowledge forms an indispensable part of all knowledge"⁶, and this part of knowledge allows us to process meaning and reach goals beyond our verbalized or processed thinking. What we often call experience is closely related to such defined, tacit knowledge.

This connection suggests that experience can be reinforced or partially substituted by other forms of learning. Simulations and explorations discussed in this paper are examples of those alternative learning modes. Additionally, an ability to ground a student in a physically based knowledge of architecture through digitally based simulations helps to relate complex ideas from materials and methods or building technology courses by introducing physical properties and dimensionality to abstract designs.

Bio

Andrzej Zarzycki is a designer and educator who employs digital tools to create experiential architectural spaces. Andrzej brings over 15 years of professional practice combined with design and technology teaching into the New Jersey Institute of Technology (NJIT). His research focuses on media based environments as well as validation methodologies of generative designs through building performance analysis and simulation tools. Andrzej Zarzycki earned his M.Arch from the Technical University of Gdansk, Poland, and S.M.Arch.S from Massachusetts Institute of Technology, Cambridge, MA. Contact: andrzej.zarzycki@njit.edu

References

¹ "Education is thus seen as a process of depositing knowledge into passive students. Teachers are the epistemological authority in this system; students' pre-existing knowledge is ignored, aside from what was expected to be 'deposited' into them earlier." [Freire, Paulo; *Pedagogy of the Oppressed*, p. 60]

² Kolb, D. A. *Experiential Learning; Experience as the Source of Learning and Development*, Prentice Hall, 1984

³ Learning by doing, or experiential learning, concepts and terminology were discussed and formalized by John Dewey in his book *Experience and Education*, Macmillan 1938/1997,

⁴ Schank, Roger and Cleary, Chip; *Engines For Education*, Lawrence Erlbaum Associates, Inc. 1995 also, <http://www.engines4ed.org/hyperbook/nodes/NODE-36-pg.html> The Five Teaching Architectures, 2/28/2010;

⁵ Torroja, E. *Philosophy of Structures*. Trans. J. J. Polivka and Milos Polivka. Berkeley: U of California P, 1958. 1-3.

⁶ Polanyi, Michael 1983, *The Tacit Dimension*; Peter Smith, Gloucester, MA, p. 20