Teaching Design in the Wake of Artificial Intelligence

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Abstract
In order to maintain its relevance and pertinence throughout history, Design Teaching has been pushed to regularly evaluate its adequacy in the face of cutting-edge technologies and constantly renewed tools. In that respect, the new paradigm of Generative Artificial Intelligence pushes once more the territorial limits of Educational Research and Pedagogy. In this study, we describe the implementation of Educational Methodologies to teach Design to Architecture Students in a Professional Degree Program in Mexico. This Methodology makes students acquainted with Design Fundamentals and later incorporates internet technologies as a support tool that grants them access to an expanding database of form and geometry configurations. The incorporation of 3D Modeling Digital Tools complements a process that aims to endow students with the capacity to understand and create space from within the manipulation of form and geometry and promotes the burst of new formal configurations within the student´s creative process. We base this process on the notions of Systems Theory and claim Design Teaching is a cohesive cluster of interrelated components. It is under this premise that we also claim that the new possibilities granted by Artificial Intelligence can be seen as another component within this system. Beyond the initial reluctance to incorporate AI to its Design Methodologies, the Design Disciplines should see AI as a tool that generates variations with radical speed, and therefore invaluable in its role as an aid to the Design process but nevertheless, incapable of generating new formal configurations by itself.

Keywords: Design Pedagogy, Systems Theory, Generative Artificial Intelligence

Introduction

Like many of its foundational principles, the Bauhaus' visionary design curriculum remains to this date an undisputed reference, whether by emulation or by opposition, to most Design School's curriculum in the world. Its core pedagogy principles are taken from the 1919 manifesto written by Walter Gropius which was later integrated in the famous concentric ring stages diagram that defined studies through the Bauhaus' four and a half year courses.

The Bauhaus remained active from 1919 to 1933 and started its operations in the city of Weimar with Gropius acting as its first director. Gropius was profoundly influenced by the theoretical foundations of the *Deutscher Werkbund* founded by Herman Muthesius.[1] He was also deeply aware of the work and the discussions prompted by his contemporaries in other parts of Europe and America like Peter Behrens, Henry van de Velde, Josef Hoffmann, Joseph Maria Olbrich or Louis Sullivan.[2] His understanding of the *zeitgeist* and the fundamental change of paradigm within the new machine age has proven to be foretelling given the 100-year-old longevity of his ideas and pedagogical principles instilled in the Bauhaus.

One of the core principles embedded within the Bauhaus curriculum is the pedagogical strategy of immersing its students in a compulsory one-and-a-half-year Preliminary Course. Regardless of the final output of the following three-year workshop studies, the Preliminary Course was considered essential in the Bauhaus curriculum due to its emphasis on Basic Formal Studies. These were regarded as foundational within all design disciplines and considered a methodological bridge to the following stage of Spatial, Color and Composition Studies.

The Bauhaus curriculum tried to respond to the need of *"a new and powerful working correlation of all processes of creation"* (Bayer, 1938, p.30). Prioritizing an abstract level of Formal control and Geometric manipulation at the Preliminary Course proved then to be a revolutionary teaching strategy and it is still the basis of many contemporary Educational Methodologies. Despite one hundred years of technical developments within the realm of representation tools its core Pedagogical method remains practically intact in many Design Schools around the world.

[1] Being the youngest of the *Deutsche Werkbund* leaders (Bayer, 1938, p.13), Gropius can be considered an important link between this association's ideas of seeking a synthesis between the "machine style" and the "arts and crafts" movement, and the development of the objectives and theoretical fundaments of Modern Movement of architecture.

[2] These architects are the most direct representatives of the avant-garde movements, preceding the Modern architecture. Their work was parallel regarding ideas despite they were located in distinct geographical contexts such as Germany, Belgium, Austria and the United States.

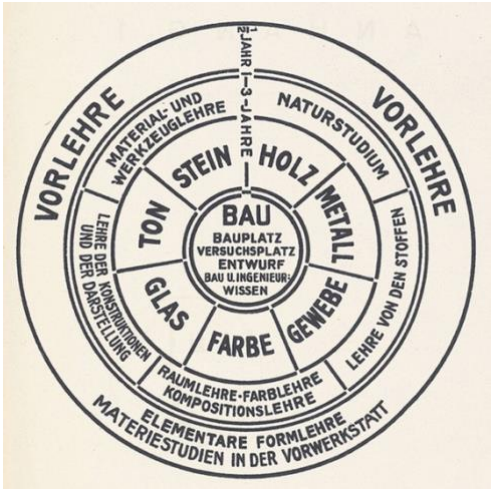

Figure 1: Diagram of the Bauhaus curriculum.
Walter Gropius, 1922. Lithograph. 20.2 x 29.3 cm. Satzungen Staatliches Bauhaus in Weimar (Statutes of the State Bauhaus in Weimar), July 1922. Bauhaus Typography Collection, 1919–1937. The Getty Research Institute, 850513.

The strength of this pedagogical system relies on the initial approach to Form, Matter and Space from a conceptual and abstract departure point in order to develop the following stages of figurative and technical development in parallel with the growth of the student´s level of technical knowledge. This system also allows a critical and analytical awareness to develop within the students' own process while releasing his or her creative input.

> Practical and theoretical studies are carried on simultaneously in order to release the creative powers of the student, to help him grasp the physical nature of materials and the basic laws of design. Concentration on any particular stylistic movement is obviously avoided. Observation and representation -with the intention of showing the desired identity of Form and Content- define the limits of the preliminary course. (Bayer, 1938, p.26)

Like many Design Schools founded during the second half of the XX century, the School of Habitat at the UASLP in Mexico, was founded owing a great degree of influence to the Bauhaus system.

The School opened in 1972 offering the Architecture degree program and its educational platform grew to offer degrees in Graphic Design and Industrial Design a couple of years later. The combination of these three degrees presented an ideal scenario for the implementation of a common Preliminary Course during their first year of training and a structured curriculum strategy that shared many common departmentalized courses the following years. The basic structure of the Architecture curriculum at the UASLP assimilated the three stages present in the Bauhaus curriculum: Conceptual, Instrumental and Specification.

One crucial difference between the two systems is the output in the UASLP curriculum final stage. Given the role of public professional education in Mexico, the capacity of granting a professional degree at the end of a six-year curriculum was considered of the utter most importance. The UASLP curriculum leads to a legal license to practice in the professional field. This third stage in the Bauhaus system was embedded from the beginning with a certain degree

of uncertainty. Its duration, level of academic and practical achievement defined by individual *"special circumstances"* (Bayer, 1938, p.26).

The above is mentioned to highlight the natural inclination in the UASLP system and its faculty to overstate the importance of the Specification stage and introduce knowledge based on technical and constructive skills from early conceptual stages. This, historically represented the risk of undermining the importance of the progressive evolution from conceptual to figurative in its educational system.

It is in this context where a recent interest among the School of Habitat faculty has risen to address the need to update and strengthen the transition between the Conceptual and Instrumental stages. This interest revolves around informing its Bauhaus methodology *vis-a-vis* contemporary theoretical developments, new lines of pedagogical inquiry and research as well as the undeniable presence of digital tools and new representation techniques.

The Theory of Form

A student enrolled in the Architecture program at the UASLP receives a practical course of Design Fundamentals during his/her first semester. This sets a practical foundation to understand the rules of form, composition, rhythm, proportion and scale. The following three semesters belong to the Conceptual stage which is developed through Design Studios that teach a consolidated methodology across project-based design exercises. This stage develops the skill to create architectural concepts capable to respond to any given programmatic needs and apply them to any imaginable site or context. And more importantly, do so while answering to the need of creating relevant form, space and geometrical configurations while responding to specific perceptual, existential and functional requirements. It is across the three levels that comprehend the Conceptual stage that an alternative methodology has been implemented. This strategy has been applied over the last six semesters at the Architecture program at the UASLP and its initial results are presented here.

A recurrent concern within this proposed Methodology is how to introduce and guide students properly into the world of Abstract Form and manipulation of Geometry as the steering Pedagogical strategy. In many ways, students enrolled to the Architecture program, whether they are aware of it or not, arrive with the natural expectation of understanding Architecture through the experiences occurred inside buildings they have inhabited. This implies that their understanding of Space, Form and Matter, previous to their arrival to the Architecture program is mediated by, or understood as, a confusing agglomeration of building components. It is very common to find students within the initial semester of the Preliminary Course eager to address Design, Architecture and Space as a consequence of hierarchizing very specific construction components such as walls, windows, doors, columns, ceilings, facades, stairs or hallways.

The strategy proposed here assumes that, at least during the initial stages of the student´s education, Architecture is not understood as a combination of construction components. It relies on the process taking place within the thematic progression from conceptual to instrumental stages proposed in the program curriculum. That process starts with an understanding of Geometry as a container of Space and with the students' abilities to develop, manipulate and control Abstract Form. At that point, it becomes crucial to make implicit the connection of subjects and skills developed by previous courses like Descriptive Geometry and the essential role they are about to play in the proposed Design Studio Methodology.

In this way, the initial tools given to the students within Design Studio are expected to be recognized as tools already present in their skill set. Among these are notions already studied as pure Geometry Typologies or as result of Geometrical Operations. It is expected that through the lens of design exercises the students understand these as Formal typologies used in the development of three-dimensional space: Orthogonal, Pyramidal, Polyhedral, Spherical, Curvilinear. In parallel, the students receive two more notions crucial to manipulate form: Formal Configurations of three-dimensional space (Solids, laminars, frames, voids) and Material Configurations of three-dimensional space (Transparency, translucency, shininess, texture, color). As mentioned before, these notions evolve from topics addressed in Geometry courses into Design Studio Tools through applied design exercises and, in most cases, these exercises imply the creation of physical models and formal archetypes already capable of responding to function, context or perceptual requirements.

A second crucial aspect of this Methodology is the conflict faced by the student *vis-à-vis* the need of creating variations of geometrical operations, iterations of physical models or recursive formal compositions given their early control over Geometry and Form. Here the question is how to introduce the students to grasp the myriad of possible configurations capable to emerge from manipulating Form at conceptual and abstract levels.

The proposed solution to this problem has been taken from the theoretical work of the German philosopher Niklas Luhman and his contribution to the field of Systems Theory. Luhman's work represents an approachable theoretical background to the challenge of developing new formal configurations within preexisting formal typologies. As explained before, this is an essential concern given the speculative nature of the work developed by students in the Design Studio exercises.

Luhman claims (2000, p.26-28) that the emergence (creation) of new Forms is done on the basis of processing its qualities within a Social System. He identifies the participation of perception and communication within this System and claims that these are principles active within the process of creating Art Forms. He explains that Art is, in its modern sense, a functional equivalent of language: its purpose is to launch a specific type of communication that uses the capacity of perception (or imagination) of Forms to undertake the "search of meaning". New Form is introduced into the environment of the System, differentiating itself from the rest and provoking communication that occurs from its perceived differences. The triggering effect of the specific difference launches a specific type of communication, a form that, by modifying the state of the system, becomes information: as a "difference that makes a difference."[3]

N. Luhmann deepens into the Theory of Form based on difference and claims that it is the operation of distinction which introduces Form into the world and makes it observable. Being able to observe one's difference from the rest becomes necessary to recognize one's own form and therefore, the specifics of Form are only possible to recognize in relation, in comparison, to everything else that exists in the world.

On the other hand, N. Luhmann also explains that when distinctions are marked as Forms two things are ensured: they can be distinguished and they can be reproduced. This is important because, while perception works with unformed distinctions, communication presupposes (is

[3] Although, in the field of social sciences, this phrase is usually attributed to Luhman, he actually mentioned to have taken it from the biologist, anthropologist, social scientist and linguist Gregory Bateson (2000, p.26).

based on) the elaboration of new Forms. This happens in two ways: First, as a condition within the concurrence of various psychic systems (the consciousness that perceives them) who notice the Forms due to their specific difference. Second, to guarantee the linking capacity of communication. Communication resorts to what has already been communicated and anticipates other possible communications, that is, the presence of *recursiveness* at the time of any communicative operation. This must be understood for all communication, and especially for the communication of Art that relies on self-produced Forms in the realm of the perceptible. It can also be deduced that the meaning of Art Forms is to make themselves available for subsequent operations within the communication system.

The way in which Luhman's theory gets inserted within this Pedagogic strategy relates directly to the aesthetic component within the Forms of Architecture. A component that has to do with its perception and what they communicate or contribute to us. Therefore, there are two elements directly related to this Methodology; the communicative quality within the aesthetic condition of the Forms of Architecture and the *recursiveness* of new Forms implicit in the creation of communication.

Thus, its application presupposes that the qualities of the Architectural Form are recognized and processed in the environment of the System of Architecture. Within this System each Form's contribution relates directly to its specific difference or to its own configuration characteristics.

It is possible to deduce then, that initial Formal configurations based on Geometrical qualities are already recognized typologies. Therefore, the knowledge of the already achieved Formal typologies becomes instrumental to the student's immersion in the System of Architecture. Hence the importance of providing from the early stages of this Methodology a documented or collected storage of Formal typologies.

Pinterest Database

Given the *recursiveness* necessary for operating and processing new Forms within the System of Architecture, it is important to remember that the storage of Architectural Forms and their qualities has historically occurred in archives, books and specialized magazines. However, digital resources and web-based digital archives offer new possibilities to the dynamics of processing and storing Formal typologies.

With this in mind, the use of the Pinterest platform has been integrated into this Methodology and into the workflow of Design Studio exercises of the first four semesters of the Architecture program. This promotes the student´s immersion into the management of Form and Space at an abstract level while offering tools that facilitate the student´s knowledge of existing Formal Typologies and configuration possibilities.

Pinterest ("All about Pinterest," 2023) is a platform that allows users to create and manage collections of images on themed personal boards. Its interface follows a structure of canvas or boards on which photos of the topics of interest are pinned.

Unlike other social network platforms, Pinterest´s workflow is not based on the possibility of users expressing themselves through texts and images of their exclusive authorship but rather through the selection of images already existing on the platform. This ability to search, select

and collect images on thematic boards is what represents a great technological advantage in the learning process described previously.
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Pinterest stands out for its ability to store, classify and order images in thematic boards. The platform generates and offers a series of similar images to follow the search process based on its user's preferences. Therefore, its constant use implies an enrichment between the user and the image suggestions.

The automatic update recommends a personalized feed, so that the following search is carried out in relation to the user's specific interests. This is not unlike the implemented algorithms in entertainment streaming platforms, web search sites or even the basic logic behind Artificial Intelligence.

The platform also offers the possibility of working on collective boards. This implies that several users deposit selected images which implies that the level of specificity and accuracy of the topic is enriched with a much greater speed.

Boards can be formed in advance by instructors and teachers who present a selection of images as a guideline to introduce purposes or objectives to be tackled on any given Design Studio exercise.

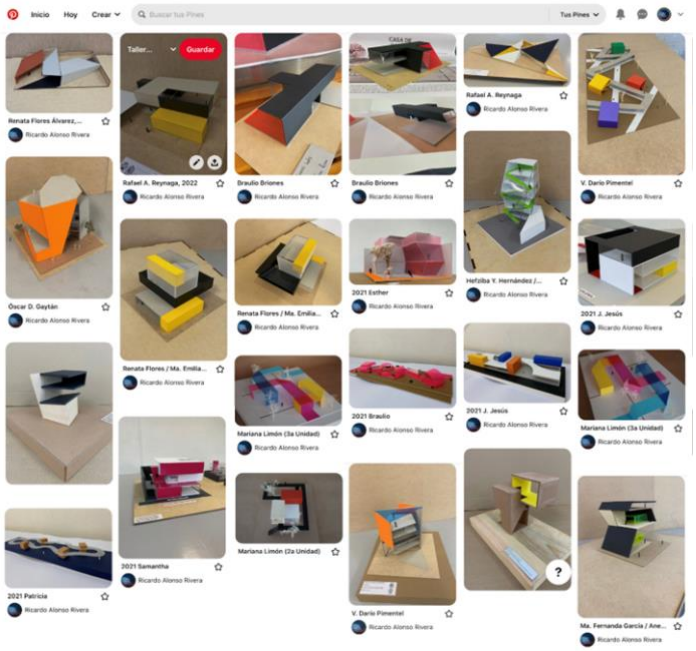

Figure 2: Student work display on a Pinterest board.

3D Digital Tools

It is important to highlight that beyond traditional media such as drawing or physical models, the technology behind architectural representation has also moved towards very advanced digital resources in the generation and manipulation of three-dimensional Form.

In the traditional sense of the discipline, Form along with its configurations and iterations have usually been worked on sketches or scale models. But since the 1980s, digital tools that enhance

the possibilities of this process have made an important mark in the field. It is important to emphasize that these tools, propelled by the speed of digital processes, are also inscribed within the mechanisms of communication, self-production and generation of recursion described by N. Luhmann.

Under this logic, digital tools cover the role of accelerated facilitators of these processes and become fundamental pieces of this teaching Methodology in line with the technological possibilities of our time. Just as the Pinterest platform becomes an accelerated mechanism to document, archive and document graphic collections, digital 3D tools generate accelerated processes to project, manipulate and visualize Geometry and Form and it becomes an invaluable tool to generate Formal *recursiveness* at an accelerated speed.

The specific interest in recognizing digital tools as a fundamental piece of this Methodology responds, in part, to the indisputable hegemony that digital media professes in every aspect of the production, representation and dissemination of Architectural Design and Discourse. It also responds to the need to explore and define the still emerging role that digital tools must play as part of the comprehensive learning process described here.

With this in mind, the following steps in this Methodology are grounded in the use of specific digital applications: Autodesk 3ds Max (formerly 3D Studio Max) and Rhinoceros from the company Robert McNeel & Associates (Rhino). This is presented as a progressive link within the process described so far and as a logical continuation to the process of learning through physical or analogue models.

One of the main challenges of this strategy lies in transcending and eliminating bad practices assimilated over more than 40 years of the popularization of 2D digital vector drawing software. Despite incorporating from its first version the possibility of constructing and manipulating 3D geometry, CAD software is still known primarily as a 2D drawing tool.

Therefore, the insertion of digital media as an integral part of Architectural Design has historically represented a challenge and has confined it to the territory of two-dimensional representation and production.

Which in turn, meant a tacit disconnection with what we have called here the System of Architecture, following the theoretical guidelines of N. Luhmann. To the extent that the limited operability of CAD as a two-dimensional representation tool grew, the gap that separated it from the Systems of Architecture grew as well.

In this context, it is important to point out the value of academic forums of Architectural speculation,[4] which have contributed enormously to the exploration and expansion of the capabilities of digital tools as mechanisms of formal/spatial manipulation. Today, academic forums around the world continue to concentrate Pedagogical discussions regarding a critical stance *vis-a-vis* innovative teaching tools and methodologies.

One of the guiding interests in the incorporation of digital tools into this Methodology, is to ensure that the student's formal repertoire is as abundant as possible, as well as to generate

[4] The paperless studios, an experiment conducted in in the mid-1990s at the Graduate School of Architecture, Planning and Preservation at Columbia University (GSAPP), is a particular example that illustrates the attention drawn by digital tools as means to expand discursive and disciplinary discussions regarding speculative experimentation with form and space.

recursive iterations as fast as possible. In order to create a clear evolution within the students´ learning process it is also important to translate the first approaches of physical models to digital interfaces in a coherent way. From this perspective, the 3ds Max software and its implicit functionality to manipulate basic solid objects offers an ideal link to achieve this purpose.

However, it is important to note that operations in 3ds Max exclusively contemplate manipulation of solids and, as we will see later, understanding the Geometric relationship between solids and surfaces is an essential notion of the Pedagogical approach of this Methodology.

It is important to remember that in Geometric terms solids are three-dimensional figures, which have length, width and height, occupy a place in space and define volume. Their faces are surfaces that can be flat, as in the case of polyhedra (cubes, pyramids) or surfaces with curvature, as in the case of solids of revolution (cylinder, cone, sphere). It is of particular importance to specify that the faces of a geometric solid enclose a finite interior space. The result of manipulating one or more of the surfaces that define a solid leave it exposed to the infinite volume of outside space.

This methodology tries to make evident the recognition of the interior space inscribed in the Form (finite), the perception of Geometric totality, its perception from the outside and its relationship with the context (infinite). This distinction seeks to highlight the interior/exterior relationship inherent to any Geometry, extending that relationship beyond its utilitarian and operational understanding (function) to also include its perceptual dimension and its contextual relationship.[5]

Because it is a software based on the creation of surfaces, Rhino becomes an essential piece within the progressive sequence of this Methodology. The level of precision and geometric rigor in its modelling processes make it the logical step after initially setting up Geometry in 3ds Max, which is a much more intuitive and flexible software.

At the same time, Rhino is a tool that efficiently incorporates the stages of development of a design project in a seamless way. First, Rhino has efficient and clear processes for extracting 2D information from a 3D digital model. Various attributes in its interface make these processes intuitive and very evident. This helps to emphasize the idea that any two-dimensional vector drawing (plans, sections, facades) is a mechanism to represent a three-dimensional object.

[5] In this stage, the understanding and control of concepts such as finite and infinite volume is essential. So are the different mechanisms to induce its perception and the way in which Form and Space relate with the context where architecture is immersed.

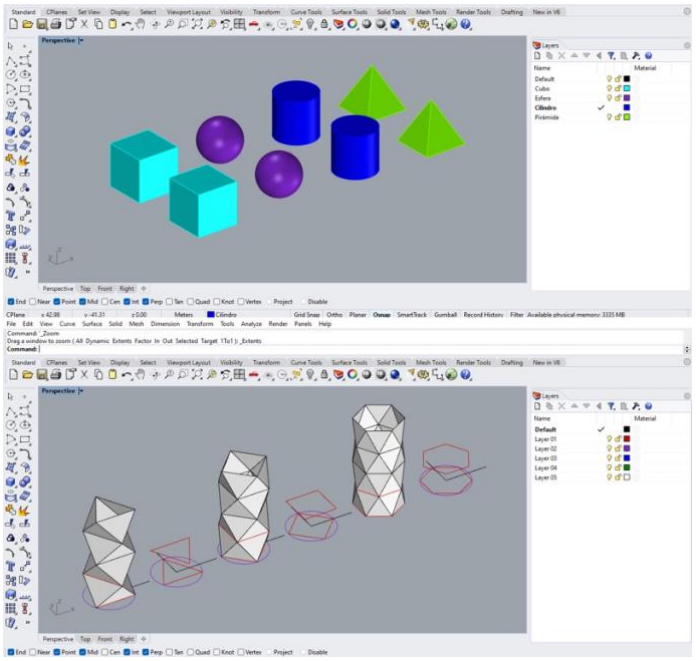

Figure 3: Rhinoceros software interface

Furthermore, by reinforcing basic principles of Descriptive Geometry, which are the foundations on which these representation tools are based, this Methodology helps create in the student the notion of progressive knowledge, essential in his/her training as a Design professional. The feedback capacity in the modelling process implicit in Rhino makes it a particularly versatile tool. The decisions that are made as the project progresses at any time can lead to rethinking assumptions made in the initial stages of the process.

Finally, it is important to mention that Rhino has a practically unlimited capacity to operate through different units of measurement, which emphasizes in the student the idea of Design as a tool to order the material world, regardless of its scale. This means that the qualities of the tool promote the understanding of Architecture in correlation with its context. And at the same time its coexistence and interrelation with its physical, material and constructive foundation.

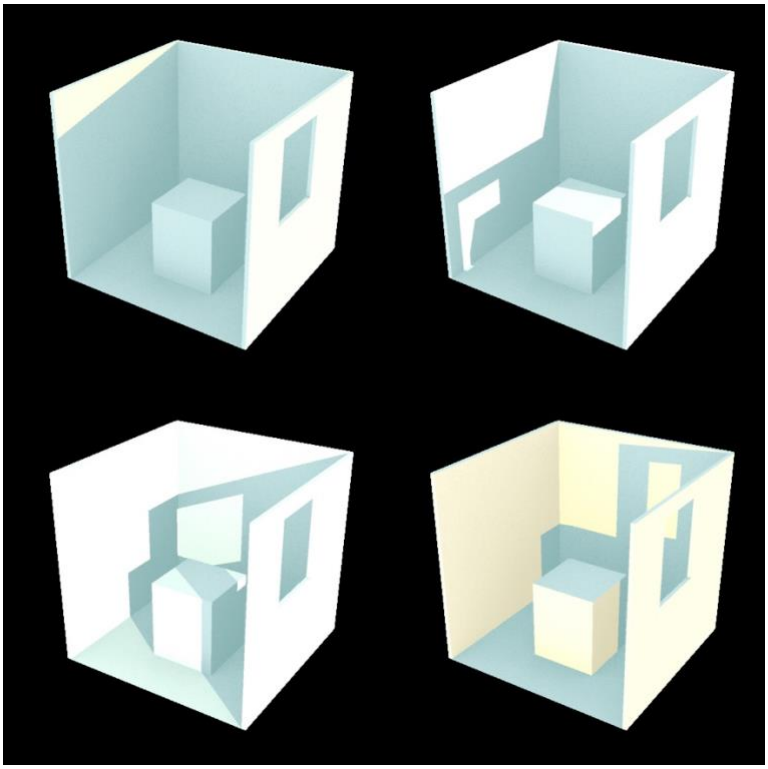

Figure 4: Geometry under a solar incidence time lapse

Generative Artificial Intelligence

What has been described up to now is the recount of a process already taking place within the Pedagogic system of a limited number of Design Studios at the School of Habitat at the UASLP. As mentioned before, its implementation relies on the structure of the Architecture program curriculum and its courses. It has been tested with students enrolled up to the midpoint of the Instrumental stage where courses on Digital Modelling become available and thus, the Methodology reaches a limit where these tools can be applied. However, in the face of emerging digital tools that rely on a higher level of sophistication this document tries to speculate their role in key aspects that will affect Educational Methodologies in the future.

Artificial Intelligence is a reality already embedded in many aspects of contemporary life. Its most used applications so far are based on the fields of web search engines, recommendation systems or recognition of human speech. Recent breakthroughs on the core structure of its programming and the incursion into innovative neural architectures have opened up many fields previously thought unreachable to Artificial Intelligence.

Among these are the fields of the Arts and the creative (Design) disciplines. What we know today as Generative Artificial Intelligence and Computational creativity has started to create outputs showing puzzling levels of intelligence and creativity. So far, the core structure of deep learning programming for Generative AI has been made available through the platforms of three main field players: Stable Diffusion, Dall-E and Midjourney. Such is the impact of its early manifestations, that in many disciplinary forums serious discussions are taking place regarding authorship, creative validity or originality.

Leaving those really important discussions aside, we propose here to address its potential functionality within the field of Architectural Design and its insertion into the Pedagogical Methodology described previously.

Despite its initial appearance, Generative AI doesn't offer much beyond a very effective tool to generate repetition and variation. But neither difference nor *recursiveness*. Therefore, we claim that the use of Generative AI by itself is incapable of inserting itself into what we have called the System of Architecture.[6]

Nevertheless, used in a strategic and critical way, Generative AI could become an important asset along the process to generate *recursiveness*. If 3D digital tools offer an accelerated way to project, manipulate and visualize Geometry and Form, then Generative AI offers a hyper acceleration of that process.

A promising connection between the programming architecture of Generative AI and the Methodology described is the reliance of Generative AI on meaningful semantical prompts. These prompts keep an interesting relationship between query, key and value inputs at the programming level of the software.

If conduced properly these prompts could potentially draw parallels and unleash meaningful implications for keywords embodying perceptual, existential, functional or contextual requirements. And therefore, offer valuable insights into how recursive iterations of Form could respond to the complexities surrounding a project.

However, the risk of using Generative AI resides in its potential uncritical and simpleminded use. Disconnected from a proper Methodology, an analytical approach or a strategical insertion into the workflow of Architectural Design, it is easy to see Generative AI falling into the generation of irrelevant, superfluous or unnecessary visual information.

Conclusions

The main goal behind the Methodology presented here is to prioritize the use of Architectural Form at a conceptual level as the guiding strategy behind Architectural Pedagogy. The process described here, implemented across three years of practical exercises within the Design Studios of the Architectural degree at UASLP shows results where students are capable of driving Spatial, Functional, Perceptual and Existential requirements through the development of Formal typologies, manipulation of Geometric variations and improvisation of compositional iterations.

The work of Niklas Luhman is present along different stances across this Methodology. The definition of the qualities of Form or its insertion into a Social System of communication are logic and direct interpretations of his work. However, this Methodology owes a great debt to Luhman for laying the foundations of the concept of *recursiveness*. The employment of 3d digital tools as an accelerated strategy for creating *recursiveness* is a development result of this Methodology. This line of thought goes as far as claiming that the potential implementation of Generative Artificial Intelligence in Design Pedagogy could be seen as a manifestation of a hyper acceleration of *recursiveness*.

[6] Here, it is important to remember the quote attributed to Luhman regarding the importance of difference in order to trigger significant communication and the creation of Form.

The importance and constant awareness of archives of existing configurations of Architectural Form is also a direct reference to the work of Luhman, its practical application in this Methodology is carried out through digital means on the web-based platform of Pinterest. The results presented here confirm this strategy has achieved optimal results in the students' design process.

As an integral and evolutionary piece of this process, we also present the idea that the generation of Form is a central piece in Design Pedagogy. To this end, in addition to the traditional resources of sketching and physical models, modeling on digital platforms such as Rhino or 3dMax, constitute ideal means for the creation and manipulation of Form, with an increased speed to generate automatic variations and unlimited configurations. It has also been mentioned its limited use as two-dimensional representation tools has been harmful to the advancement of these objectives.

It has also been speculated that, as Generative Artificial Intelligence becomes more advanced and its availability and use become wider spread, its potential application in this Methodology could offer great advantages. However, as with any new technology, there are also latent risks implicit. Therefore, further practical application within this Methodology is strongly suggested before claiming Generative AI an integral part of the process.

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