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Education, Design and Practice

Understanding skills in a Complex World

AMPS CONFERENCE 17.2

Education, Design and Practice – Understanding skills in a Complex World.

Stevens Institute of Technology, AMPS, PARADE, Architecture_MPS.
17—19 June, 2019

Education, Design and Practice – Understanding skills in a Complex World.

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INTRODUCTION

This publication is the product of the conference *Education, Design and Practice – Understanding skills in a Complex World* held at Stevens Institute of Technology in 2019. The keynote speaker was Peggy Deamer, Yale University. The call upon which the conference and this publication are based argues that:

> The relationship between education and practice in any discipline is complex. In an ever changing world, it is also in flux. In a context such as the built environment, it is also interdisciplinary. Today, educators in the liberal arts still identify learning as an end unto itself, and designers still draw on ideas about intuitive knowledge. By contrast, the businesses behind urban development or city and regional growth call for graduates armed with the skills required in practice from day one. At the same time local government and cultural or city management firms need creative thinkers capable of continual adaptation. In the industries and sectors such as construction, transport and engineering, managers focus on a foundational baseline and value engineers and designers as both pragmatic problem solvers and visionaries.
>
> These alternative perspectives have been reflected in multiple changes to the practice and structure of the education sector. One such example was the Boyer-Mitgang report which restructured architectural education in the US to reflect other professions. As in other areas, it resulted in a 'degree arms race', with MAs and doctoral programs multiplying more rapidly than the research and teaching methods they required. At the same time, the 'widening participation' agenda produced an explosion of research and funding for new pedagogical approaches and initiatives. Attempts to fuse education with the creative arts, industry and business through university led partnership schemes also proliferated. More recently, changes in the financing of the HE sector in places like the UK, mean universities now stress educational efficiency and guarantees of graduate jobs.
>
> Working within this context, educators in sectors connected with the design, management and construction of the built environment have developed new and innovative ways to teach, they have embedded collaborative practices into their pedagogy, have forged unique partnerships across disciplines and outside the academy, and much more. However, research into best practice learning and teaching in the classroom is still evolving and educational initiatives can sometimes be seen as contradicting on-the-job realities in practice. The *Education, Design and Practice* conference publication explores this complex and contradictory scenario from multiple perspectives.

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REVIEW OF MASTER SEMINAR "RESEARCH-PROJECT" WITHIN A PROJECT AND PRACTICED ORIENTED INSTITUTION

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INTRODUCTION

On reading the call for papers, it struck us as crucial to share a pedagogical format conducted during the course of a master in Management of Design and Innovation training program students wishing to specialize in Health and Social Innovation in the Care Design Lab at L'École de design Nantes Atlantique, associated with Université de Nantes. Since the conference has the title of *Education, Design and Practice – Understanding skills in a Complex World*, it is proposed here to study the link between educational programs in design and the preparation for future jobs in a changing world, where designers are called on to do more than using only the conceptual skills, tools and technics taught in undergraduate school. The call of the conference requesting to envision new pedagogical approaches more participative and interdisciplinary resonated as well as the integration of the question of educational efficiency and the guarantee of executive jobs for fresh graduates from Master programs. This is precisely the very DNA of L'Ecole de Design Nantes Atlantique. Founded 30 years ago, the then Art School [l'École d'Arts plastiques des Pays de la Loire][i] cultivated close partnerships within the industry and business community of the region. When Christian Guellerin[ii], in the mid-90s, back from working in the United States of America, took the leadership of L'Ecole, he stressed even more on the necessity to train under-graduate students in partnership projects and to develop Bachelor [BDes] and Master in Design [MDes] according to the trade, industry and service needs expressed locally as well as nationally.

The importance of matching the current and future needs of industries is fully incorporated within this project and practice oriented institution. Indeed each students enrolled in a MDes has at least 2 industry-based projects a year. Being director of studies then and emeritus scientific director now, Jocelyne Le Bœuf, emeritus scientific director of the Design Labs[iii], stressed a research-led model to ensure a reflexive approach to design as a professional practice. The aim is to pursue a reflective and forward-looking teaching approach at L'École de design de Nantes Atlantique, from partnership projects, as it is developed by Nigan Bayazit in his paper "Investigating Design : A review of Forty Years of Design Research", "*design research is a systematic search and acquisition of knowledge related to design and design activity*"[iv]. In the ongoing debate on Design Research, Design Methods, Design Education, scholars and practitioners aimed at establishing language and concept, methods and tools, to consolidate design, "*as a discipline*"[v], after being a "*trade*" and a consolidation of tradition of practices, to ensure its development[vi]. The aim being to guarantee undergraduate, graduate students and alumni to continue growing in a trade, which has been rapidly impacted with the utilization of tools, such as ICT, 3D printing and more and developing transformation within the fields. As proposed

by Schön in his *Reflexive Practitioner*, several methods have been developed to help transformation and adaptation of practices.
The professional practice of designers during the twentieth century have continued to diversify, and this trend is only supposed to keep growing during the current century. There is a need to anchor research and promote innovation in the pedagogy and the content of design education in order to "[anticipate] *the future direction of professional practice*"[vii]. There has been a rapid change in the fields where a formalization of approach and methods of service design has initiated a turn in design education practices. Indeed, the L'Ecole de design education program of all four design labs are made of partnerships with private, public and non-profit services in the fabric of Nantes and of Pays de la Loire region. Care Design Lab has been favoring partnership with non-profit and public institutions, as to fit its own research program "Design and Innovative Public Action". Therefore, pedagogy at Care Design lab is made to deliver "*genuinely innovative proposals",* affecting the medical world and public institutions, by involving professionals *"in health and design*", experts and students[viii]. Teaching at Master's level is to train future professionals for a complex world. More than teaching skills, which is what is ensured at both BDes and MDes level with different techniques, activity and methods of teaching, and a strong will to develop a wide spectrum of knowledge of current fields in which design is implemented.
In this contribution to the conference on educational issues, a project based research and innovation seminar having been part of the Master's training program in spring semester 2019 at L'École de design Nantes Atlantique shall be critically reviewed. During the first year of the program, in the "research-project seminar", students are familiarized with social design methods, aside from two industry-based design project. The methodology of this paper is to study one project through an evaluating grid to assess the approach, the objectives and the results. This is part of the yearly evaluation of pedagogical process, in order to improve, correct and adjust skills, methods and knowledge. We will alternatively explore internal and external assessment of previously successful projects with participatory tools to include users in the conception. In a previous design and innovation in education, a thorough evaluation of participative workshop has been done (Montagne and Boussard, 2019), this iteration on a research and innovation seminar aims at elaborating a renewed theoretical approach, methodological framework and adaptive set of tools to support further research by design on public action and public services fields.

PUBLIC SERVICE, INNOVATIVE ACTION, DESIGNERS

Design, designers, actors for change, for public change?

When introducing design very often, one immediately come to product design, visual communication, interaction, user experiences. Currently in France, a shift has been made to introduce design and its methods within the public services managements (27 Region). Indeed, a decade ago, in the aftermath of 2008 economic crisis, the French State started an intense modernization of its public services, choosing mostly to digitalize as much as possible in order to ease process and procedure in administration. This digitalization has also been done with a diminution of face-to-face services with citizens and users. One must also not forget that a reduction of 3% per year of the civil servants community has also diminished the available workforce to ensure these face to face services. As recent years demonstrations in France have proved, there is an increasing question mark over the public services quality and quantity when compared with a constant increase of taxations.

Practices of design, design methods, "design of co-design"

Designer is defined as "*a cross-disciplinary profession which uses creativity to resolve problems and co-create solutions*", by the former International Council of Societies of Industrial Design (2002), which became the *World Design Organization* in 2015. ICSID's definition of design emphasizes its creative nature: "*whose aim is to establish the multi-faceted qualities of objects, processes, services and their systems in whole life cycles. Therefore, design is the central factor of innovative humanization of technologies and the crucial factor of cultural and economic exchange".*
It contributes to the construction of a theoretical framework and of tools for innovative public action design. The empirical research for the project in the workshops supplements and facilitates curricular innovation. But it also contributes to and calls into question the design-led research carried out in the Design Lab.
The emphasis is on the exploratory and collaborative aspects of the workshop time, which make it possible to pool the participants' specific and qualitative knowledge. This aspect must be distinguished from the project development time which requires a long conception period and a dedicated follow-up. The methodology for this workshop is qualitative and is based on active participant observation. Having drafted the design brief, measured the renderings that the partner could expect from the students, accompanied the project organizer's preparation, attended the workshop and the restitution session, the collaborators were involved in analyzing and assessing the results. A series of co-design activities with the participants (all of whom took part willingly in the workshop) were organized: "*The activity of co-design requires the active participation of the user and of the other stakeholders in the process*" (Guilloux, Le Bœuf, 2017:34).

CASE STUDIES

Research-Project Seminar: a combination of research, design and innovation seminars

Context

This public design project, initiated in February 2015, is an articulation of three learning seminars, the research seminar, the innovation seminar and the Care seminar. Instead of three different disconnected topics, a decision was made to work on a public service and on public policy on a renamed seminar "research-project". This expression is borrowed from Alain Findeli, a researcher in Design, who participated in revival, in 2000, of French design research with the famous "*design without research in only reproduction*" (Beaubourg Conference). Its primarily objectives were to articulate and make coherence of the research, specific and innovation seminars, which were already planned in the program approved framework. The aim of this seminar is to develop a social design project over a period of more than non-consecutive 6 weeks. This seminar benefits from being indeed non-partnership based, and totally free of result constraints, allowing total freedom to choose adequately a problem or a partner that could be a local urban body or a regional institution. Students also remained totally in control of their designs productions. During spring 2019, the research project seminar focused on the redesigning of the geriatric hospital room, having in mind the upcoming renovation of a floor in the Hospital of Tours, and a new building to be designed and built in the Hospital of Angers.
The research project seminar is made as such :

- Phase 1
  - Class seminar to define problems on the topic 'geriatric services, how to improve a room in 2020 and how to reimagine it for 2030
  - 3 days of fieldwork, interviews, focus group, observations of rooms, floors, services, shadowing of nurses, helpers and doctors of two different services – short stay and long rehabilitation stay

- Definition of problems after the field work inputs
    - Phase 2
- Work on the design answers to these problems
- Presentation in front of a panel made of administrative, nurses and doctors of these 2 hospitals
    - Phase 3
- Reshuffling, from 7 to 4 groups, Students going through innovation part, communication strategies, environmental impacts, financial feasibility
- Presentation of 4 projects in the Hospital of Angers to the steering committee of Tours, Rennes, Brest, Nantes and Angers hospitals.
-

Brief

Every project has to have a brief, on which both the Design Lab and the partner agrees on a term of reference guidelines for a context, what to achieve and means to be allocated to meet targets. For the research project seminar, separate from financial counterparts, the Design Lab team, both Director, Course Leader are free from financial obligations. Here it was proposed to design new rooms to answer public health issues around the ageing French population, with increasing chronic and neurodegenerative diseases patients, which raises the costs of in-house treatment, degradation of well-being of care-givers, as well as care of patients.

Practice-oriented outputs

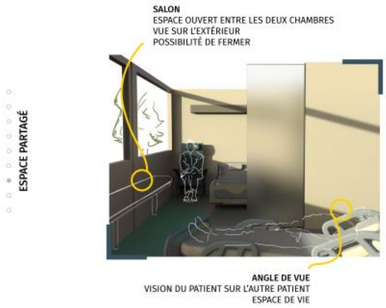
This research project seminar focused on the social design research methods, allowing three days of benchmark and review of currents problems, 3 days on the fieldwork and 4 days of formalization of the design problem. In this project, students are developing answers to questions which have been phrased during or after the fieldwork. They are preparing and conducting with communities of users of the hospital, focus groups, observations and shadowing of helpers during their daily work. They are then asked to formalize their problems into design project.

Phase 1 : Feedback from fieldwork information, formulation of main problem question

RETOUR TERRAIN :

PROBLÈMES OBSERVÉS	SOLUTIONS PROPOSÉES
Isolement : ennui / autonomie	Signalétique / Automatisme / intuitif
Diminution de la vue ou troubles cognitifs	Faciliter la perception sensorielle
Pas de **repère** ou reconnaissance intuitive	Jouer sur les contrastes
Perte des **repères temporels** Les troubles du comportement (soir et nuit)	Repères temporels visibles depuis le lit. Lumière et éclairage naturel : marquer le temps, favoriser l'endormissement.
Besoin d'**intimité**, présence du rideau (pas suffisant + augmente l'isolement)	Plus de chambres individuelles, avec plus d'activités extérieures et lieux communs
Salle de bain : hauteur des éléments non adaptée aux différentes positions.	Adaptabilité, réglage des hauteurs et positions, modulable, automatisation
Barres de maintien : pas aux bons endroits	Cheminement lit / SDB / toilettes / douche / Lavabo accessible quand on est assis
Soin et toilette : espace pour la manutention du patient + équipements	Accès PMR + accès autour du patient, position assise sur la chaise de douche: accès au frein

Phase 2 : First design proposition



Phase 3 : An innovation project with a business model to be implemented in hospital

The last phase of the project is not be realized by the students or the Care Design Lab, but by an architecture firm, AIA (https://www.aialifedesigners.fr/). Drawing from the students projects, a concept car of the geriatric room of the future will be built at the public hospital in Nantes in June 2020.

Design Education Outputs

The design phase framed around a systemic answer to a question: *How to ease care-givers daily work? How to help rehabilitation with introducing a safety walkway in corridor? How to help recovery by grasping daily, weekly and monthly timelines?* The students have appropriated a method of design, user-centered and field-based as well as the tools to transform concepts into scalable projects. They had the opportunity to implement design not only for the final users but with and by social actors and experts from ageing hospitalized people.

The ethical positioning of designers is to produce projects and "*desirable social change*" (Manzini, 2011), and so the importance given to the user in co-design has become a central question.

DESIGN EDUCATION IN A COMPLEX WORLD: INTRODUCING DESIGN METHODS INTO FRENCH PUBLIC SECTOR

Positioning markers evaluating Education design outputs for public service

New knowledge, skills and methods

The initial pedagogical goals were first focused on methods and tools oriented. Fieldwork and user-centered design relied on Ground Theory principles and design ethnography methods. This is knowledge offering students to diversify from the tools acquired during their undergraduate curriculum and practicing directly in social design methods, a tool kit from design ethnography. Most importantly, a major input would be the introduction to abductive research methods and in the self-criticism to reformulate design problems after fieldwork analysis.

The outputs of the projects were tangible propositions on how to implement design within not only product and space designed or service design but how to intertwine both service, space and product design to improve best health access to all users. The main ideas of the four projects were to be added in the guidelines for the design of the new geriatric services in Tours.

Fieldwork frictions, or why is it necessary for social designers?

As in any assessment, improvement feedback was taken into account, at first the students complained of the tiresomeness nature of the fieldwork, unaccustomed to this kind of intervention on site. Some students were close to a nervous breakdown at the end of the design phase. The adjunct faculty also abounded in criticism claiming that students are not ready in first year to go to the field. Lots of them were complaining during the observation times. The faculty have been stating a few notes for improvement, at first there is a lack of restitution to the whole community that participated to the fieldwork, we were particularly thinking of the caregivers of CHU de Tours (L'Hermitage, Bretonneau) and CHU d'Angers, who are reluctantly seeing the irruption of designers in their workplace. There is also a dear need of a way to restitute our proposition to the patients of the hospitals. Secondly, it was extremely interesting on the first day to see how typical tools such as *characters*, *timeline* and *sketches* were distorted, transformed and adapted to the students' methodologies, the user trajectories described and group dynamics (at times exhaustive, laconic, rigorous or unstructured).

CONCLUSION

There are few outputs of a case study of pedagogical format, the "Research-Project" Seminar. The challenges represented by collaborating with audiences who are not familiar with design were eventually overcome and proved to be a precious educational experience for the students. The students were able to try out "*a shift from the classic user-centered approach to a society-centered one*" (Tromp, Hekkert, Verbeek, 2011). Grounding their positioning in social design on immersion, observation, interview with the intelligence of rephrasing main questions is the red line of project-based pedagogy. The opportunity given by this call for papers has been a stimulating comparison of case studies, in order to reflect on the tools, techniques, methods and on a project-based education to emphasize a critical and reflexive practice as designers and educators. Design-led public innovation means not only putting users at the center of the process, but also the social issues and systems of actors which are central to the project.

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[i] The history of the creation of L'Ecole de design has been narrated recently by Jocelyne Le Boeuf, in her blog Design et Histoire : http://blogs.lecolededesign.com/designethistoires/2019/04/11/lecole-de-design-nantes-atlantique-30-ans-dhistoire-1/

[ii] Christian Guellerin, executive director of L'Ecole de Design Nantes Atlantique gave a conference during the Cumulus conference, organized by the University of Lapland, within the working group Business, Industry & Innovation on the specificities of the education curriculum offered within undergraduate (BDes) and graduate program (MDes)

[iii] The Care Design Lab is a design-led research laboratory. The research subjects focus on health and social and environmental quality of life. It brings together public and private stakeholders and research laboratories with the aim of creating, developing and testing innovative approaches, methods and tools in the domain of services, products and spaces. It oversees Master's programs and co-supervises scientific research with academic laboratories.

[iv] Bayazit, Nigan, 16, 2004

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[v] Findeli, Alain, « Rethinking Design Education for the 21st Century : Theoretical, Methodological, and Ethical Discussion », *Design Issues,* 17 (1) (2011)
[vi] Buchanan, 1998, Giard, 1990 : 27
[vii] Buchanan, 1998 : 65
[viii] The Master's programs for design students combine theoretical training with a very important application of the methods and tools in designing products, spaces and services. The exercise of the laboratory workshop at the Nantes Ecole de Design is not just about fulfilling the design brief stipulated by the public institution

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MEDIATING THE TRANSITION BETWEEN COLLEGE AND WORK

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BACKGROUND:

This study focuses on the transition from college to the workplace, and the implications for knowledge and skills that support that transition. Historically, the focus of educational institutions has been on knowledge organized in the form of subject matter, while workplaces organize knowledge in different ways, such as for production[i] resulting in discontinuities. This disparity can contribute to overall dissatisfaction with the college to work transition, and subsequent costly employee turnover.[ii]

Alternative instructional models have been developed in engineering programs intended to improve career readiness. One model is the widely adopted engineering capstone experience, a culminating project typically in the student's final year, and intended to represent the real-world practice of engineering. This study focuses on the consequences of such mediating models with the transition between college and work conceptualized as a boundary crossing between two activities.[iii]

THE PRACTICE OF ENGINEERING:

The professional education of engineers requires acquisition of specialized knowledge, development of problem-solving skills, and execution of good judgment in service to society. Ideally, higher education processes would serve as an apprenticeship to the profession.[iv]

Capstone design courses have been developed, in part, to represent this apprenticeship and help mediate the transition between college and work.[v] They are often industry sponsored, with a company identified opportunity or problem. Some universities have expanded the traditional 1- or 2-semester capstone project to incorporate a multi-disciplinary, multi-year approach intended to introduce a real-world context. One such example at Michigan Tech University is an optional undergraduate curriculum called The Enterprise Program, designed to support the needs of students and industry, and allow students from varied disciplines to work in an industry-like setting. Within the Enterprise framework engineering/business entities are established and students join an enterprise to work with other students and faculty to make it a successful ongoing venture.[vi]

THEORETICAL FRAMEWORK:

Activity Theory was originally developed by Vygotsky[vii], with subsequent refinements added by Leont'ev[viii] and Engeström[ix] to help explain the interactive nature of human activities. The theory is most commonly used in educational research as a conceptual lens through which data can be interpreted.[x] The application of this lens is aimed at interventions that can enhance and even transform learning. The theory serves as a descriptive meta-theory or framework and the constituent elements of an activity system are shown in Figure 1.

The term *object* is used to refer to the goals of the activity and while with interacting systems it is not expected that goals be completely shared, when the college experience is viewed as preparation for work, the two activity systems can be considered an interactive system that could potentially generate shared goals and outcomes. Figure 2 represents two interacting activity systems, with the interaction tied to the object of the activity. Contradictions are a key principle of Activity Theory and represent tensions within or between elements of an activity system or between different activity systems.[xi]

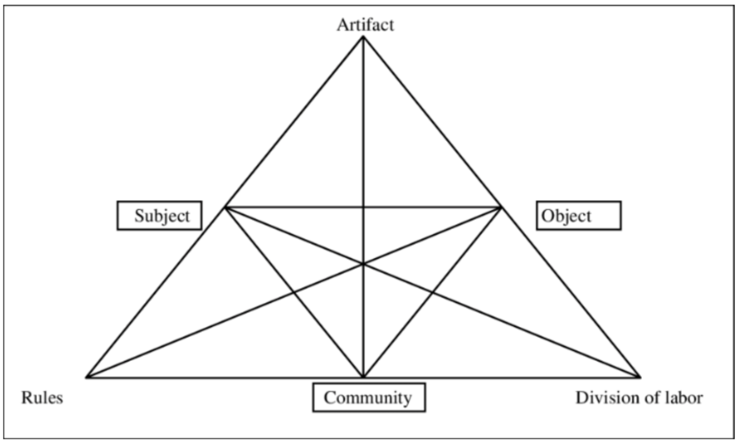

Figure 1. Activity System Diagram[xii]

Activity Theory has been used to study a variety of systems using six related elements[xiii]. In this study, academic settings and work settings are considered to be two different activity systems and are analyzed separately using the elements defined as follows:

1. Subject or participant in the activity. For the purpose of this study, the subject is represented by undergraduate engineering students participating in the senior design or enterprise program or post-graduates who have been working in an engineering-related field for 2+ years.
2. Object or objective/goal of the activity where the supposed object here is the practice of engineering. Some activities have multiple objects, which may be in tension. For example, within healthcare systems, the objects of patient wellness and generating profits are often in tension. Similarly, academic goals in engineering programs may be in tension with work practices.
3. Community is the collective of individuals and their roles in the activity system such as team members, advisors, supervisors, co-workers, and customers who interact with the subject.
4. Instruments and mediating artifacts are tools or resources such as physical resources (computers, machine tools, etc.), intellectual knowledge and work processes used by subjects to help mediate the object and assist in its transformation to an outcome.
5. Division of Labor is the division of activities among participants in the system, the structure of which may be hierarchical.
6. Rules are the guidelines and policies regulating activities which may be explicit or implicit and include norms, conventions and social relations.

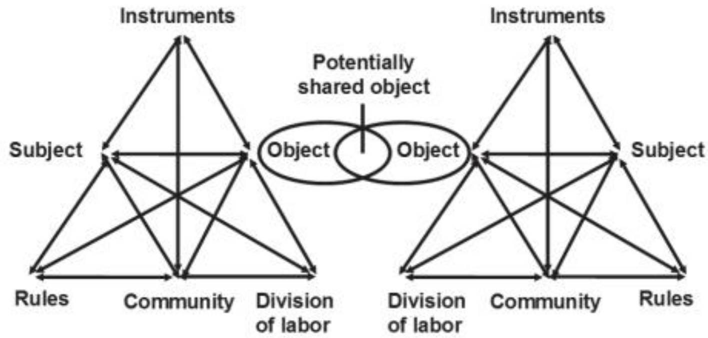

Figure 2. Interacting activity systems (Engeström, 2001)[xiv]

METHODOLOGY:

Research informed by activity theory is typically conducted using qualitative approaches informed by the phenomenological perspective. Phenomenographic research utilizes interviewing as the primary source of data. Most such studies include 20-30 interviewees with a goal of understanding their perspectives and experiences.[xv]

For this study, interviews were conducted with students fulfilling their required capstone through either the traditional senior design program or the more contextual Enterprise Program described above. Interviewees were within one month of completing their capstone project and most were expected to graduate at the end of the semester. Approximately ten of these students were subsequently re-interviewed after working professionally in an engineering-related field for two or more years.

Interviews were recorded and transcribed verbatim for analysis. Interview questions were open-ended in nature and intended to elicit the interviewee's understanding of, and experiences with, the practice of engineering in university and workplace settings. Analysis of the interview data consisted of a careful review of the data using Activity Theory as a lens through which the student and graduate perceptions of the practice of engineering could be examined.

RESULTS:

A comparative analysis of interview data from the Senior Design and Enterprise programs, and from those employed in industry was conducted for each element of Engeström's activity system (see Figure 1). Key themes generated from the interviews, as related to the elements of the activity system are summarized below:

Object:

As expected, the object of the activity differs for students in an academic setting as compared to engineers in the workplace. Students were largely focused on gaining practical experience in the application of technical knowledge, as well as a desire to complete the required course components for graduation. Most also noted a desire to please their sponsor/client by achieving a product design that met expectations. In comparison, the object for working engineers was a product or process that satisfied customer (internal and/or external) requirements. This was viewed as essential to creating opportunities for career advancement. Assessment of the work shifted from a focus on proper application of the process of engineering in the academic setting to a stronger focus on the actual resulting product.

Students often noted feeling conflicted about the object of the activity, where departmental requirements felt constrictive and non-essential to completing the project and in some cases where the assigned project didn't match their career objectives as noted by one senior design student who said: *"My project was to develop a new program to do pretty much what the old one did. I felt really let down by my department because my project didn't have anything to do with the field I was interested in working in."*
Students additionally noted that a secondary object of the capstone project was to develop professional and interpersonal skills such as team and communication skills, as indicated by this Enterprise student who said "*my primary goal was to not disappoint my project sponsor, but I also wanted to produce a great presentation and report at the end. I think communication is very important. What's the point of doing something new if you can explain it to people?"*

Instruments and Mediating Artifacts:

Prior to the workplace experience, most students described having sufficient tools to use in their projects. Once they were able to see workplace resources, they indicated the college resources, by comparison, were dated and in some cases not readily available. They also indicated capstone projects followed a strict schedule and format of deliverables that often differed from what they experienced in the workplace. They described some of the college required project management and engineering tools as "busy" work having little relevance to the development of the project, but rather required artifacts dictated by their department. One senior design student shared that "*when we told our sponsor that we were required to use the House of Quality tool, he laughed at us*." By comparison, once in the workplace, they felt that had freedom to adapt deliverables to best fit the needs of the customer and project, and reported limited examples of "busy" work. They further noted that while major milestones were generally prescribed and couldn't be adjusted, they had considerable flexibility in scheduling their work to meet those milestones. As noted by a former Enterprise student now employed as a research engineer: *"In my college classes, there was a text book to read, practice problems, homework assignments, exams. Now the work is more fluid and dynamic, with multiple projects, each with tasks and priorities that change from day-to-day that I need to figure out how to manage".*
Several graduates also noted the importance of industry standards in their day-to-day work, such as ISO and ASME quality and process standards. They had a vague recollection of being introduced to these tools while in college, but didn't realize until entering the workplace the significant role these tools would play in completing their engineering tasks.

Community:

With Community, Enterprise students generally reported feeling a greater sense of responsibility to their team than did Senior Design students. Senior Design students felt accountable to their department and its imposed requirements, but also wanted to satisfy the client's needs. Enterprise students by comparison felt accountable to their Enterprise team first, and also wanted to please the client.
Most graduates interviewed rarely engaged with the external client (or end user), and treated the direct recipient of their part of the project, the internal client, as their customer. A former Enterprise student now employed as a manufacturing line supervisor noted this when he said, *"I'm leading a team of technical trades employees, and I'm also part of the larger plant team. I don't want to let the second- and third-shift people down by leaving a mess from my shift."* Workplace employees noted feeling primarily accountable to their project team and company, and less so to the client, except in cases where the employee had regular direct contact with the client.

Also, those in the workplace noted having access to a wide range of internal experts whom they could go to for help and mentorship. Most had access to a strong network of advisors and peers, and also experienced significant support through on-the-job training during their first 6-12 months. By comparison, students often felt there wasn't anyone with the requisite expertise available to them when needed and some noted spending a great deal of time struggling to figure out where to go for help. Enterprise students did note however that they found value in the peer-to-peer mentoring that occurs within the multi-year team structure.

Division of Labor:

A larger distinction was noted between the senior design and Enterprise students with regard to division of labor. Senior Design students generally took on tasks they felt most comfortable with and often didn't involve any actual engineering work, but were instead focused on project management and team organization. Within the Enterprise program, students noted taking on tasks that were assigned by a project manager and aligned with their level/year on the team as well as expertise and interests. The division of labor on an Enterprise project team was more consistent with that seen in industry where work was largely assigned within the highly specialized roles for which they were hired. Additionally, Enterprise teams, by design, have hierarchical organizational structures which more closely reflected those seen in the workplace. Several senior design students indicated perceptions of inequitable distribution of labor where some team members carried the bulk of the workload. They also noted high variability in skill levels across the team where some members were viewed as lacking the necessary skills for their assigned tasks. Enterprise students expressed less dissatisfaction with workload inequities, but both senior design and Enterprise students noted inconsistencies across teams and departments in the complexity of projects assigned.

The level of autonomy experienced by the industry professionals was largely determined by their level of experience. Industry teams were well coordinated with respect to roles and it was clearly understood where each person's work ended and the hand-off to another part of the team began. For example, one design engineering shared *"I work on R&D for hydraulic tools. Others on my team work on other types of tools (plumbing, electrical, etc.). Then the design engineers take the "lego" pieces we've developed and build a new tool design, and then manufacturing takes it the rest of the way."*

This clear division of roles was also seen, but to a lesser extent, on Enterprise teams, and much less so on senior design teams, in part due to the smaller size of the team and the mono-disciplinary nature of the senior design program.

Rules:

Senior design students noted they were required to follow processes and deliverables as assigned by their department, with little discretion or flexibility. Many expressed frustrations over constrained timelines that prevented moving forward at a natural pace. There were feelings of spending too much time doing "busy" work on tasks that didn't advance their knowledge or the project in a meaningful way. In comparison, many of the Enterprise processes were designed by the team and intended to mimic the requirements of the industry client as much as possible, leading to feelings of autonomy. For the engineering professionals, required processes were dictated by the company or client, but all noted having some level of discretion in deciding which processes and deliverables were necessary and which could be deemed unnecessary and therefore not acted upon.

With regard to time and project management, senior design students appeared to feel most constrained by the submission deadlines of deliverables. One senior design student noted "*I wish we had less hoops to jump through. As a student it feels like we wasted a lot of time on these hoops that no one was going to look at.*" Another senior design student noted that "*we wanted to be able to go at the speed and pace of our customer, but the department told us we had to go by their speed, not the customer's speed*." Enterprise students indicated having the flexibility to adjust schedules and key deliverables within the overall client milestones, and that assignments generally reflected real-world requirements. Some indicated having the opportunity to propose eliminating unnecessary deliverables, and were generally supported by the team's faculty advisor, an approach closer to that experienced by the engineering professionals who all noted having freedom to manage their time and deliverables within the constraints of the overall customer milestones and deadlines.

In summary, results suggest that while the capstone system represents a reasonable approximation of a professional engineering system, there are many elements of the capstone activity system that conflict with those in a professional setting and represent opportunities for improvement. This suggests a need to review the overall object of the activity, especially for the senior design option, which is the more school-like of the two capstone programs discussed here. This would also entail review the significant tensions that have been shown to exist within Rules, Community and Division of Labor. Moderate adjustments to the departmental imposed requirements could allow for better aligned capstone and industry activity systems.

CONCLUSION:

In conclusion, the following opportunities for improvement in the execution and management of undergraduate engineering capstone programs are indicated and would be worthy of additional study:

- Consider allowing the students more flexibility and autonomy in choosing deliverables that advance their project in some way rather, as well as the ability to adjust timelines and delivery of assignments within a prescribed set of key milestones.
- Provide opportunities for students to engage with experts and mentors throughout the project to help them develop just-in-time learning and reflection skills.
- Help students to clarify goals and objectives that are more reflective of those seen in industry, rather than just meeting a set of deliverables needed to pass the course and graduate.
- Facilitate role identity and development of each student within their capstone project teams to allow them to align themselves to specific areas of knowledge and expertise and make a unique contribution to the overall project.

It is further noted that the activity system elements within the contextual Enterprise Program represent a closer approximation to those in industry which would suggest the potential for an easier transition to the workplace. Overall, this study is intended to contribute knowledge about the differences between academic capstone and engineering workplace activity systems and findings from this study suggest key gap areas which can inform areas of improvement to the capstone experience.

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USING BIM TO ACHIEVE ARCHITECTURAL ENGINEERING UNDERGRADUATE LEARNING OUTCOMES

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INTRODUCTION:

BIM is now a requirement in architectural education. The profession is driven by the construction industry which is facing new complexities and challenges. One major challenge is the issue of global warming. We need to construct buildings which meet the requirements and needs of human activities. Yet we need to achieve this using less material resources and consumption of energy. This applies at both the CAPEX and OPEX stages. There is a need to reduce C02 emissions. In order to limit these emissions, it is essential to predict the impact of the building on the environment through specialized models and assessment. The technology of BIM offers a solution in designing a more efficient building that takes into account sustainability requirements and promotes for buildings with less impact on the environment especially during the energy intensive operation and maintenance phase. The challenge here falls on the architectural engineer. Their role is to ensure that the design of the building combines art, science and BIM methodology based on numerical values and data that allows him to explore energy efficient architectural solutions.

"No job can be done well without the right tools – regardless of profession."

(Valance et al 2018)

The development of building designs and production information has predominantly moved to one which utilizes digital tools and technologies. Emerging tools and technologies raise new questions how the design student of today can develop the skills necessary to work in todays industry and the emerging industry of tomorrow.

This paper specifically looks at how architectural engineering undergraduates in the UK can develop the necessary skill to achieve the benefit of working in a BIM environment and also be able to integrate collaboratively their contribution with other in the building design and development professions.

The professional body for Architects and Architectural Engineers in the UK is the RIBA.

The RIBA was founded in 1834 for 'the general advancement of Civil Architecture, and for promoting and facilitating the acquirement of the knowledge of the various arts and sciences connected therewith'.

RIBA (2016)

As a professional body the RIBA has a responsibility to ensure member are trained with the necessary skill to provide an appropriate product to the client or customer.
Two questions arise as part of the pedagogical discussion what should be taught and what is the most effective way for it to be taught.
The reason for the use of tools is that they augment are capabilities either in a physical sense or a cognitive sense. (Engelbart 1962) characterized the component of digital cognitive tools as artifacts, language, methodology and training. Building Information Modelling is the current emerging system being adopted by the UK design and construction industries.
"As we move towards a digitized built environment we are rapidly having to reassess education against the backdrop of a digital future."

(Philp 2015)

ARCHITECTURAL ENGINEERING AND ARCHITECTURAL EDUCATION, THE SIMILARITIES AND DIFFERENCES

An abundance of architectural engineering courses exist around the world, often with diverse and sometimes even conflicting meaning. Architectural Engineering courses for example in the US, typically refer to courses with a strong emphasis on the environmental and mechanical services of buildings. They revolve around the integration of appropriate techniques of servicing buildings and achieving comfortable environmental solutions and the integration with the design and interiors of a building is what attributes to them the "architectural engineering" title. Similarly, in the UK, there are also similar courses of BSc Architectural Engineering, that focus on building services, such as the BSc Architectural Engineering course of Nottingham University. However, most Architectural Engineering UK courses, refer to a heavy integration with Structural Engineering, making them essentially an engineering course, with a strong emphasis on structural engineering. These courses in the UK will be typically be attributed the BEng title, to signify their strong engineering aspect, sometimes their accreditation by the Institute of structural engineers and clearly distinguish themselves from the BSc Architectural Engineering courses.
An entirely different approach to Architectural Engineering curricula is seen in courses of the Middle east. In the MEA context, it is an umbrella term to include Architecture related courses, which have anyway a stronger engineering understanding than typical UK and US courses. This paper will use the term Architectural Engineering to refer to the course currently delivered by University of Salford. The philosophy of Salford's Architectural Engineering course is to create a graduate "*with robust knowledge of building structures and the capability to lead a multidisciplinary approach to building design",* as also mentioned on the programme's website.

ARCHITECTURE IN DIGITAL AGE

The programs of the AEC industry are limited in their courses when it comes to performing modifications because to keep up with the standards of accreditation, they have to maintain a certain level. (Sharag-Eldin et al, 2010). With BIM, new skills and opportunities are required especially that in architectural education the system is aligned to these requirements. It is also critical to utilize the features of BIM in order to achieve the architectural learning objectives that shall enhance the performance on the educational level and the career level. The architectural education of parts 1 and 2 has a criteria that is set out by the Architects Registration Board UK .

A lot of changes are taking over the 21st century which have a great impact on the learning styles that are being adopted. One of the most major changes is the reflection of new technologies on the educational level where universities are competing with non-traditional education associations. This shall enhance the teaching methods and enforce universities to understand how students learn best. Aspects of current trends include distance learning, mobility, modularization, globalization, flexible learning and work based learning (Ashworth et al, 2004).

The new technologies that are being adopted encourage the idea of independent learning and requires students to develop new skills. This implies a gradual shift from traditional teaching and learning forms into new ones where the information does no longer require the physical interaction between teachers and students but rather focuses on the self of the student (Knowles, 1975). One example for this approach is the problem based learning where the learner needs to be independently responsible for his own learning.

The impact of the digital age will continue to grow whilst having economic and social impacts on society. The tools and methods for self-learning are becoming more available for learners where they can now learn and work from home without the physical need to attend on campus. Moreover, the act of increasing modularization allows students to learn at their own pace and according to the time that best suits them (Ashworth et al, 2004).

STATUS OF BIM WITHIN THE EDUCATION

The topic of BIM education in response to the demands of the industry have been the focus of previous studies. Surveys that investigated this area were concerned with:

1. BIM implementation within the AEC curriculum and its existing status
2. The expected outcomes of BIM education by the participants of the industry
3. The future perception of BIM education regarding AEC modules.

Reviews in the literature have always involved debates about whether or not BIM technical skills are dominant in their importance than BIM conceptual knowledge in AEC education. According to a study carried out by Wu and Issa (2014), the skills of BIM software are considered the most desired learning objective in BIM education within universities. Yet, other researchers considered that the conceptual knowledge of BIM is of higher importance than the software skills. Since BIM technology is still evolving and mastering the skill through a single course might not be effective in the long term implementation strategy (Dossik et al., 2014, Ku and Taiebat, 2011). Although there are two opposing views concerning the importance of BIM, BIM instructors are highly advised to cover both, the conceptual and the technical skills in the learning modules (Dossick et al., 2014).

The outcomes of the performed surveys reveal gaps that exists in BIM education. These deficiencies are mainly concerned with the lack of understanding towards the importance of collaboration between different disciplines, the lack of BIM experience and the lack of

communication between sharing work and communication (Wu and Issa, 2014). However, other surveys show that inter-disciplinary BIM processes are well attained in internships and professional practice more than the AEC programs (Sacks and Pikas, 2013).
Studies also highlight on the fact that there is no defined strategy in AEC programs which deals with how BIM should be integrated within the curriculum, while some studies suggest how to introduce the concepts of BIM (Becerik-Gerber et al. 2011). Several studies have also highlighted on the need to build technical and managerial skills for undergraduate students. Some studies suggest that the basic knowledge related to BIM should be covered in the early modules of the curriculum while more advanced BIM modules should occur on the advanced and senior levels (Lee et al., 2006).

BIM AND THE AUGMENTED ARCHITECTURAL ENGINEER

BIM is a type of intellectual augmentation that improves on CAD software, which at the time of computer adoption was a form of technological advancement. This transition from drafting concepts to modelling and simulation approaches have elevated representations in the form of a digital model.
The operation of the industry is significantly affected by the adoption of integrated digital methods in the delivery of buildings. BIM applies an information approach and develops collaborative practices across the whole building lifecycle (Macdonald 2011). From the architect's perspective, BIM gives the opportunity to view the building through a detailed and developed model where spaces are tested prior to the commencement of the construction phase. From the RIBA digital plan of work perspective, BIM defines what is to be created and communicated.
It is essential that BIM implementation is synchronized to achieve the objectives and values of the architectural process. From an architect's perspective, the main approach has always been how the design is represented conceptually in a model, how the design serves the function ideally and whether any innovative method is used. Others might have different objectives and areas of focus. Hence, different analysis and simulation tools need to be available (Liu et al 2005).

BIM as an Information Capturing Tool

The first step of a BIM process is to understand the context and project requirements. Capturing the project's information and implementing them into the BIM model acts as a basic step in understanding the surrounding and providing accurate data input for analysis (Coates 2013). BIM requirements capture tools such as Trilligence Affinity can be used. One powerful, accessible and affordable tool for capturing existing building is photogrammetry where measurements information are taken directly from the photographs that are captured for a building and then upload them to generate a BIM model (Tuttas et al., 2017). Laser scanning offers an alternative way of capturing a point cloud which can for the basis from which to create a BIM model of existing buildings.

BIM as an Authoring Tool

BIM offers the designer the ability to create the geometric components and spaces with associated descriptive data. Early stages may include the development of simple massing models. At further stages of the project, the added level of detail and information can aid in the structural and environmental analysis of the building (Ching, 1979). At times, the creation of the desired geometrical form might be complicated and require external algorithmic modelling before transferring the model into the BIM authoring tool.

BIM as an Analysis and Rapid Prototyping Tool

"Data and analytics are already shaking up multiple industries, and the effects will only become more pronounced as adoption reaches critical mass."

(McKinsey Global Institute 2016)

The model generated in BIM links graphical objects together with their respective data. Thus the model can be used to perform different forms of analysis such as energy analysis, GIS integration and the generation of schedules. These models may use different forms of data representation to provide insight and understanding. One of the most important forms is the building energy simulation model. This is of a great interest when considering global warming concerns (Hopfe et al 2017). The results of the analysis can provide the designer with concrete data on which to make decisions (Maver 2000). Moreover, BIM model offers a rapid prototyping tool especially for large scale manufacturing methods such as contour crafting and production of building components (Khoshenevis, 2012). The production of these models is done using CNC machines is reliable and feasible option (Kolarevic, 2005).

BIM as a Structural Analysis Tool

BIM has the ability to make structural concepts and enquiry visible. The architectural engineer is faced with multiple challenges of developing a structure which is effective, efficient, constructible and within project cost constraints. Analysis can involve both static and gravity analysis. The ability to switch between structural solutions allows greater understanding to be gained of structural solutions. Tekla Structural Designer is a BIM tool which allows for frames generated in steel to be reproduced in concrete and vice versa. There is a need to get the students using such tools in an enquiry driven approach.

BIM as a Sustainability Analysis Tool

Developing buildings which offers environmentally friendly solutions is a requirement and necessity. The main considerations are concerned with the indoor air quality, integrity in its different forms of acoustics, thermal, light and space. These are analyzed and imported to suitable programs depending on the type of analysis to be performed (Wong and Jan, 2003; Oyedele et al., 2012).

Placing a new building within the existing built environment requires sustainable thinking in order to meet the future challenges and expectations especially when it comes to the aspects of availability of material resources, energy consumption and land use.

BIM as an Output or Communication Tool

Communication and collaboration between different parties is important (Mitchell, 2005). BIM acts as a communication tool between the architect and other project stakeholders. BIM can be used for 3D visualization of the building and integrated with augmented and virtual reality prior to and during the construction phase. Stakeholders in the construction industry showed a great interest in the growing use of BIM and are therefore requesting BIM as a in the delivery of the project output. Considerations of accuracy and interoperability are also important aspects of BIM.

BIM as a Visualization Tool
Having the advantage to visualize the design from the initial phases to the final renders makes BIM a cutting edge tool in the revolution of visualization (Corke, 2017). BIM goes beyond any hidden lines in the interior space and provides a full view to the designers and to the users (Yakeley, 2000). Part of the skill of the architectural engineer is defining and creating appropriate visualizations related to providing insight the tasks in hand.

BIM to Manufacture
The changes imposed by BIM on the design have also been reflected in the manufacturing process (Mitchell, 2005). BIM offers students and engineers the chance to model and generate and actual demonstration of their model using machines (Lave et al. 1996). Buildings produced directly from the BIM model either by additive or subtractive manufacturing is a growing field in the creation of our built environment.

BIM in Professional Practice
The practices of BIM involves professional practice. The process of BIM involves the asset data which requires moving from the process of approval, authorization to verification (ISO 19650-1, 2018). The practice of BIM process resembles the professional practice one where the architect's efforts take place prior to the approval step which is fully clarified by the NBS BIM Toolkit (NBS BIM Toolkit 2018).

BIM Management
The implementation of BIM in the concept of construction project management offered project's stakeholders new advantages. On the level of management, BIM increases the value of the building, shortens the project duration, provides accurate quantities and estimate and optimizes the operation and maintenance process of the building (Eastman et al., 2011).

BIM Collaborative Tool
Since BIM involves different disciplines in a common environment, it is one form of a collaborative tool. The collaborative workflow process acts as the essence for the success of BIM. It is necessary that the project's participants collaborate together in order to deliver an effective product (Succar 2009).

The challenges that are encountered in the construction process are mainly cooperation, coordination and integration. With the use of BIM, a great solution to overcome these challenges is offered. BIM allows the exchange of information on one platform and highlights any clashes between different design disciplines. This ensures effective communication between all parties and provides accurate and updated information to better make a reliable decision and maximize their return on investment. Collaboration can only be achieved between all parties when it is aligned self-interest, the requirements of the requirement and project objective. Hence, BIM as a collaborative tool is achieved when the overall process is based on collaboration and when knowledge and technology are both considered.

DIFFERENT APPROACHES ADOPTED TO IMPLEMENT BIM IN EDUCATION

The adoption of digital technologies like BIM changes the how and what of architectural design. The questions of how we do and what we do are changing and are transformed to the way architecture is being taught today. The introduction of BIM into the education process requires innovative thinking (Cheng et al 2006).

Communication and representation conventions act as determining factors in the proposal of new architecture. In order for architectural education to embrace new design outputs, the design process must also be developed. The future of architecture in terms of concepts and practice are at crossroads between BIM and PM (project modelling). The architectural profession is shifting from traditional practice into a dynamic and model oriented digital practice (Abdirad et al 2016).

The design studio is the place where a model for the building design starts. The process of analyzing structural, electrical and mechanical systems can act as a basic agenda set for the design studio. One of the most potential present in the application of BIM is that the actual construction of products and components are directly derived from the design studio. BIM offers the possibility from starting from the whole building rather than ending up with one in the case of the traditional process (Abdirad et al 2016). This shall expose students to new possibilities and challenges in the comprehensive design studio.

The attempt to update existing modules should involve core courses that cover the full potential of BIM. Moreover, BIM rather than CAD, imposes additional cognitive skills for users in order to make the computer learning curve more significant (McLaren, 2008, Pikas et al., 2013). One of the strong examples of the efficiency of BIM adoption is in the case study of Pikas et al. (2013) where it was found that students who had BIM background in a cost estimation course, had improved learning experience. On the contrary, students who didn’t have basic BIM course faced difficulties in utilizing BIM tools.

When dealing with the limitations imposed by BIM as a standalone course or integration of BIM into modules implemented in AEC courses, it is advisable to combine strategies of learning general concepts of BIM and the skills to use the technology.

In spite of the two opposing views relative to the importance of BIM concepts and skills, it is highly recommended that BIM instructors cover both the technical and conceptual skills in their modules (Dossick et al., 2014). Outcomes of performed surveys detect existing deficiencies in BIM education which involves: lack of understanding towards the inter-disciplinary collaboration in BIM, the lack of BIM experience in related projects and the lack of understanding between work sharing and BIM based communication (Wu and Issa, 2014). Other surveys convey that inter-disciplinary BIM processes are well covered in internships and professional practice more than by AEC programs (Sacks and Pikas, 2013).

Some studies highlights the lack of existence of a clear and specific strategy in AEC programs concerning BIM integration within the curriculum, while other studies suggest how to merge BIM in education and introduce its concepts (Becerik-Gerber et al. 2011).
Several studies have highlighted on the need of building up technical and managerial skills for undergraduate students, however some suggest that basic knowledge and process should be covered in early modules of the curriculum while advanced and more specific BIM uses and integration should be concerned for senior level modules (Lee et al., 2013). Thus these questions require further investigation in this research.

RESEARCH PROBLEM

When investigating the status of BIM in AEC modules, studies showed that the implementation of BIM in undergraduate courses is more than in graduate ones (Becerik-Gerber et al., 2011). Yet studies which followed later (by a couple of years) highlighted a shift towards graduate programs (Dossick et al., 2014). These results supports the idea of the need to implement more BIM courses at undergraduate and graduate levels as a requirement for AEC degrees.
When it comes to BIM educational requirements, previous studies have analyzed the contents of BIM curriculums in relation to BIM job descriptions. The findings have focused on the importance of teamwork, communication and analytical thinking skills in using BIM tools, also the importance of the knowledge in BIM standards, process and coordination (Sacks and Pikas, 2013).
Summing up the areas of focus and previous research, the knowledge of BIM concepts, technical skills, BIM enabled collaboration and integration within the AEC industry are all complementary factors to one another. BIM competences should be aligned with the core topics of AEC curriculum to achieve best educational outcomes. Moreover, there is a need to see more BIM implementation in undergraduate and graduate levels (Abdirad et al 2016).

RESEARCH METHODOLOGY

The BIM modelling technology provides a smooth flow in the process of information from throughout the project’s lifecycle, from the design till the construction where it facilitates simultaneous work of different disciplines on one common building model (Smith 2014, Ajibade et al 2012, and Goucher et al 2012). Hence, BIM proves to stand as a digital modelling tool and an information management system which stores and transfers all data among users on one platform (Ajibade et al 2012, Underwood et al 2010).
The developments of BIM revolve around the process of innovative technology and information management which is affected by the demand for change by the market. When researching BIM as a technological development tool or as a new software for designers, a methodology is needed in order to evaluate the potential of this tool and its impact on the built environment upon its introduction (Kehily et al 2015).
This research aims to solve a technical social problem by developing a framework to embed the BIM within the architectural engineering curriculum. The Design Science Research is an appropriate method to solve the research problem.

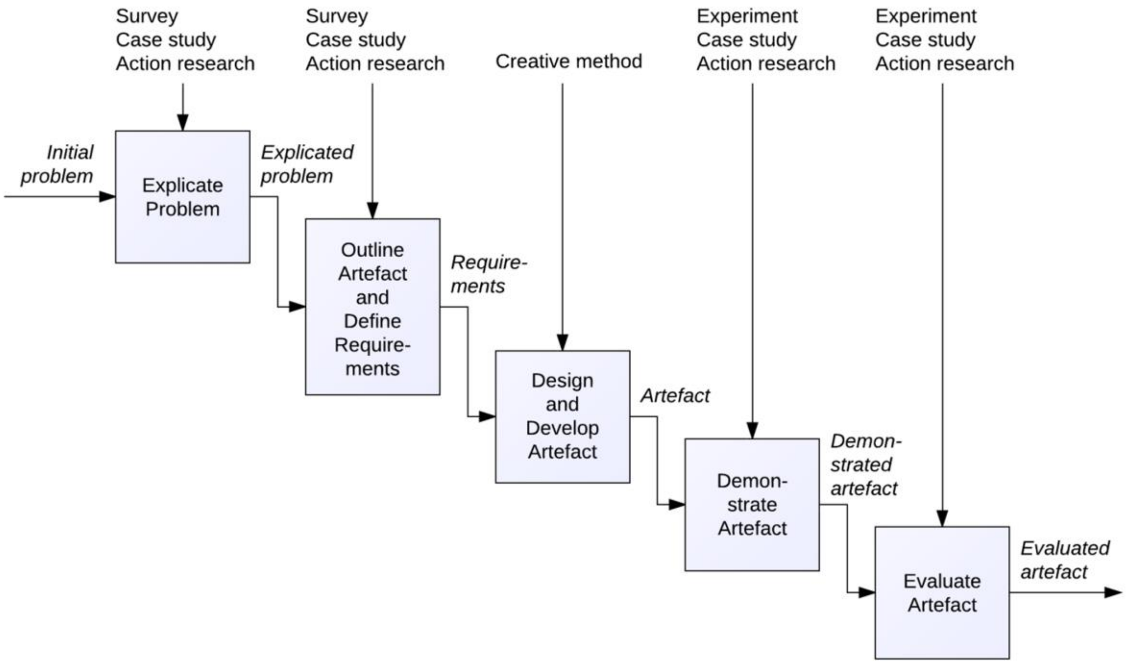

Figure 1 Suggested use of research strategies in the design science method (Johanesson 2012)

The methodology of the design research focuses on the design and development of artefacts and on the processes of evaluation and demonstration. The process of literature review leads to problem explication and the definition of the requirements of the solution. The developed artefacts are a result of efficient research approaches such as surveys, case studies and interviews. After these are undertaken the next step is designing and developing the artefacts which in turn lead to solving the explicated problem and therefore achieve the.requirements. The final activity is concerned in evaluating the developed artefact in order to determine if it fulfills the requirements and solves the problem.

In this research semi structured interviews aimed at making two contributions. The first aspect relies in gathering the answers to the questions and gaps formulated from the literature review and the second aspect relies in deducting a solution based on the responses of the interviewed BIM experts. For the purpose of achieving the objective, the selection of the interviewees was based on the criteria of achieving the previously mentioned goals where the participant's background had to be compatible for the interview questions asked. Out of an invitation for 37 personnel, only 11 responses were obtained. This varied between practitioners and professional academics. The professions of the 11 interviewers are listed in Table 3 below. The whole interview process followed a professional approach where the invitation took place via a formal email and official approvals were sent back and documented. The type of the interview was semi structured where it gives some freedom for the participant to express his opinion and opens up the discussion with the interviewer. The time frame of the interview was approximately half an hour, performed face to face or through video calls for international participants.

The primary goal of the interviews was to go in depth with the questions that were based on the identified gaps and outcomes derived from the literature review. The interview structures were divided into categorized questions which allows further filtration of answers under themes in the analysis process. The main themes are:

BIM advantages within the institutions

The first theme examines how BIM could serve the design related modules in the architectural curriculum. Responses agreed on the concept of implementing BIM at early stages gradually in order to reach the process of full implementation at more senior levels.

BIM disadvantages and limitations

- The first question discussed whether BIM limits the creativity and imagination of students. Responses were divided into a group who think that BIM actually does impose these limitations since they are not fully able to express their ideas, especially the complicated ones. The other group's view opposes the first where they consider that awareness is the most important aspect when introducing BIM where students tend to use the BIM tool to develop their skills.
- The second question aims to highlight the experienced disadvantages of BIM implementation. The main responses were concerned with the time required for students to learn the tool, and starts with practicing it shortly and with the associated cost for professional companies.
- The third question discusses the implementation of BIM in the curriculum. Responses agreed that the goal is to teach students how to learn and apply new tools since the technology is under evolution. Hence the student shall be prepared to stay updated with any new tool that rises in the market.

The third theme focuses on the implementation strategy and the required needs.

- The first questions examines which BIM method is more suitable for implementation: the standalone course or the multi-disciplinary course. The views came up varied between both options. Respondents believe that there is no right or wrong but the framework of implementation is the key for the success of the process.
- The second question inspects the possible ways to implement BIM within taught courses. Different criterias were suggested for the possible implementation but most responses agree that BIM should be introduced in the design related courses which allows the student to practice BIM on their own project and therefor ensures better understanding.
- The final question under this theme surveys whether interviewers support the need for a technician at the university to aid the students in the massing essential. Views were divided between the idea supporting the student is the best person capable in translating his own ideas and between supporting the presence of a technician to aid students.

The following fourth theme explores the status of BIM post-graduation.
The assessment was performed through interviews with 12 students in order to explore the challenges they face post-graduation.

- This discussion dealt with the level of BIM experience that students have at graduation level and which is nowadays a main requirement in the recruitment process. The idea of implementing a credited internship courses within the curriculum was favorable to most respondents.

SUGGESTED IMPLEMENTATION METHOD

Discussion and validation

The validation process for the suggested framework involved a presentation to RIBA professionals and experts followed by a discussion. The invitation was composed of a brief explanation about the topic and it was sent to around 30 possible participants. 11 respondents were interested in taking part of the study in a timeframe of 40 mins. The discussion explored 5 main areas in the process of validation. The first point tests whether the presentation is clear and easy to understand. Next, the discussion examines the willingness and interest of the interviewer to implement the framework and by how far they agree with the idea of internship practice as part of the curriculum assessment. Finally, suggestions about further improvements are deliberated. Responses came either supporting the framework or neutral with some suggestions for improvement and enhancement.

CONCLUSION

When explaining the concepts of BIM to students clarity is the key. It is important to introduce the technical terminology of the subject area slowly to allow effective assimilation to take place.
The process and product of design are in a radical state of change as a result of developing digital tools and applied informational systems. A changing world demands new smarter architectural products and associated forms of generation. BIM is not the only tool that is used word processing, photo editing, use of search engines are some of the many other examples of the tools also used. Perhaps we should be considering the task as one of integrating digital skills into the architectural curriculum as opposed to the integration of BIM.
The intention of the paper has been to discuss how BIM can be best integrated with undergraduate architectural programs but also to highlight the importance of digital changes that are taking place. The linking of research with teaching has a role to play in educating students. The theory of constructive alignment (Briggs 2003) would suggest the importance of including requirements within program and module learning outcomes.
BIM facilitates new methods of collaboration. Educators need to consider how inter-disciplinary, multi-disciplinary, trans-disciplinary learning related to BIM can be built into the curriculum.
Development of appropriate teaching and learning environments aligned to the development remain an important element in the integration of BIM into architectural programs.
Suggested levels of competency were developed for this paper but development of a more expansive competency index would form a better basis for integrating BIM education into undergraduate architectural programs.

Software developers also have the responsibility to work towards developing tools that are easier to learn and use. BIM tools themselves ideally should have the ability to act as vehicles for computer aided education.

Education aims to teach the architects of tomorrow. If we are to train the architect of tomorrow there is the question of what provision should be made for innovations that go beyond the traditional BIM paradigm.

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EARNING SKILLS AND EXPERIENCING COLLECTIVE VALUES THROUGH DESIGN-BASED UNIVERSITY-COMMUNITY PARTNERSHIPS

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INTRODUCTION

Contemporary societies risk inequality, disintegration and segregation due to a complex array of social, economic and political changes that have been occurring over the last few decades.[1] These changes include the loss of shared values, changes in how individuals interact and get together, and new practices relating to participation and decision-making.

In parallel to the evolution of contemporary societies, a complex array of changes are transforming the physical environment where these societies live and work.[2] These changes are affecting especially the disciplines that plan, design and transform the physical environment. New processes of transformation, new ways of interaction, new types of projects and new professional roles are deeply transforming the working environment of architectural disciplines.[3]

While these changes offer new opportunities for innovation, they also threaten to generate division in diverse and complex societies. Within this context, universities have the opportunity to expand their social responsibility by affirming that teaching and research can contribute to redressing social inequality, disintegration and segregation. This can be achieved through action,[4] exploring new ways of relating universities to their social context by working with *real* projects and *real* people, establishing links between academia and practice.

Educating citizens, not just students

Civic learning can be experienced if universities engage with communities.[5] Universities can empower diverse groups of individuals, facilitate collective experiences, develop self-management, and activate bottom-up approaches to decision making. Universities can facilitate learning new ways of understanding citizenship[6] by promoting participatory processes through partnerships[7]. By creating a collective project between communities, students and academics, new skills and new values can be learned through experience.

Shaping new professional identities

Partnerships expand teaching and research, enabling experience of practice-based education through the development of *real* projects.[8] Students can begin to develop skills relevant to practice and frame professional identities underpinned by civic engagement and social responsibility, whilst helping communities understand and improve their conditions. Collaborative and interdisciplinary work, participatory methods, or new professional roles such as facilitator, mediator, educator or builder, can be learned through the experience of a participatory project.

Earning skills and experiencing collective values

This research aims to assess the capacity of design-based partnerships to shape collective values and facilitate learning of civic skills when undertaking a change in a physical environment. From within the framework of an Action Research methodology, different partnerships have informed this paper. The projects were facilitated by communities and local governments in New Zealand and were developed within design courses of landscape architecture. Reflections show that partnerships enable civic engagement through participatory processes. They are useful instruments for helping communities transform their physical environment. But partnerships are also essential tools for experiencing civic learning and for creating a sense of empowerment – a feeling that when working together, independently of age, qualification, or beliefs, important changes can happen.

Figure 1 - Different partnerships: workshop, construction, opening event (from left to right)

THE METHOD

Partnerships as the medium

Partnerships between universities and communities are valuable personal and collective experiences where learning is maximized and economic interests either don't exist or tend to be secondary.[9] Partnerships are also useful instruments for generating shared ideas that can be carried down to implementation following participatory design methodologies.[10] By facilitating different and subsequent partnerships, the applied methodology was developed and adapted to different contexts, seeking to maximize the outcomes over time for communities, students and academics.

Working at local and community levels

In order to fully experience civic engagement, the university must engage with the social, cultural, and economic life of its city and region,[11] addressing issues of public concern through teaching and research[12]. Communities may be able to mobilize and self-organize, but what they can rarely achieve is to undertake complex projects by themselves. A partnership with a university can meet most community needs.[13] The developed methodology targeted two types of partners:

- Community groups that were politically disadvantaged and were interested in developing self-management practices.
- Local governments interested in developing a participatory process engaging with specific communities.

Develop the methodology through Participatory Action Research

Partnerships with different communities inform research and provide a substrate to critical reflection.[14] Action research is ideally suited to partnerships because the projects are often fluid and change over time, providing an ideal substrate for cycles of doing, reflecting, proposing action and doing.[15] The applied methodology was developed and adapted to different types of partners and projects. It enabled changes during and in-between partnerships. It also allowed to reach different ending stages: concept design, detailed design, construction and assessment of the implemented designs.

Understand design as a tool for change

To generate ideas through design is what universities are used to doing. But universities tend to struggle when they need to consider how those ideas can be implemented.[16] They often do not feel comfortable when the design process gets into stages where they need to develop roles associated to practice.[17]
In order to meaningfully change the physical environment of communities, the methodology progressively focused the interest of the partnerships – not just on the generation of shared ideas. By adopting roles associated to practice, the goal of the methodology became to explore how the shared ideas could be developed and implemented. Going a step further from construction, the applied methodology kept on evolving. In order to improve the reflection post partnerships, the assessment of the implemented designs was considered strategic and introduced as part of the methodology.

Figure 2 - Different partnerships: workshop, construction, implemented design (from left to right)

Table 1 – Different Case Studies (2014 – 2019)

CASE STUDY	PARTNERS	SCOPE	PROJECTS	LENGTH	ENDING PHASE	FUNDING
Featherston	2 postgraduate courses Community group Local government	Town, surroundings	Large Medium	5 months	Concept design	Community University Council
Wakefield	Undergraduate course Community group	Town, surroundings	Large Medium	6 months	Concept design	Community University Council
Otari Wilton's Bush	Undergraduate course Local government	Nursery	Medium Small	6 months	Concept design	Council

Carterton School	Undergraduate course School community	School	Small	9 months	Construction	Community University
Hurunui-o-RangiMarae	Undergraduate course Marae community	Marae	Small	10 months	Construction	Community University
Tory Street	Undergraduate course Local government	Street	Temporary	15 months	Assessment post-implementation	Council
Paekakariki School	Undergraduate course School community	School	Small	15 months	Assessment post-implementation	Community

LEARNING BY DOING

Trying to maximize their impact, progressive changes were introduced in the consecutive partnerships. These were related to:

- types of partners, facilitating experimentation, adaptability and improvement of the methodology
- types of projects, reducing complexity and increasing feasibility
- ending goals of the partnerships, from the concept design stage to the assessment of the implemented designs
- internal organization of the partnerships, extending their length and improving the participatory process.

The evolution of the partnerships comprised three stages: from concept design to construction to post-implementation.

The traditional way: end at concept design stage

The initial partnerships followed the traditional approach. This means they used design courses for developing large and medium size projects down to the concept design stage. In order to maximize the experience of civic learning and the outcomes of the partnerships, several strategies were followed:

Partnering with politically disadvantaged communities

Community groups from small towns located on the outer fringe of metropolitan areas were targeted. These towns are politically disadvantaged compared to larger towns of their districts and their population is in the process of change due to the arrival of new commuters. The communities were aiming to get their own projects, and use the generated designs as a base for finding resources and partners for developing the projects. The roles of the different district councils differed depending on the partnership: from no support at all, to external support, to a third partner.

Merging different approaches to design

Following participatory design methodologies, no specific site or programme was given to students, who needed to build their own design propositions responding to the social and physical context. In order to build a shared approach to design, interaction between the university and communities was maximized. Cohabitation, events and workshops were programmed for developing a real participatory process. Partnerships ended with final exhibitions, where communities voted for their favourite designs and students received awards.

Failing to change the physical environment

Partnerships ended at the concept design stage and communities were left with a collection of projects to be developed. Communities mostly failed to meaningfully change their environment due to technical, legal, economic and political complexities. As a consequence, communities lost the empowerment that the partnerships provided and dissolved. This resulted in the communities returning back to their original situation of political dependency and marginalization. The process revealed the need to explore new approaches to design based partnerships, seeking implementation and a real change in the community.

Figure 3 – final exhibition of big and complex projects (from left to right: C. Isaacs, S. Lousich)

Implementing small and feasible interventions

Maintaining the idea of using design courses for developing shared projects with politically disadvantaged communities, different goals were targeted to facilitate implementation:

Facilitate decision making

In order to improve community organization, leaderships and decision making, it became strategic to work with smaller and more cohesive community groups. Public schools and Marae [18] communities were targeted as partners. Both types of communities tend to be politically marginalised and struggle to fund maintenance and construction of new facilities in their properties. Therefore, they tend to be interested in developing self-management skills and design-based partnerships.

Reduce design complexity, funding needs and legal requirements

By working within the boundaries of the property of a community, all legal disputes are avoided and all legal requirements for construction get eliminated or at least minimized, facilitating implementation. At the same time, to target small interventions facilitates design development and makes change economically feasible by reducing funding requirements. In order to facilitate implementation further, these small interventions were designed at low cost.

Extend and accelerate the design process

Design research was extended beyond the concept design stage, which was simplified. Strategic sites were pre-selected by communities and the concept design stage was compressed within three weeks.

Designs were presented and exhibited as a design competition between different teams of students. The communities voted for their favourite proposal. The winning proposal was developed by the university down to construction documentation.

Transform the physical environment through small interventions

The design goal of the partnerships generated a framework for small and feasible interventions that would be implemented over time depending on the available resources. At the same time, one of these small interventions was developed down to construction documentation by the university. Construction was planned when university courses were over and developed mostly through volunteering, enhancing the civic learning of the projects. Communities funded construction, but sponsorships played an essential role in reducing costs and facilitating implementation.

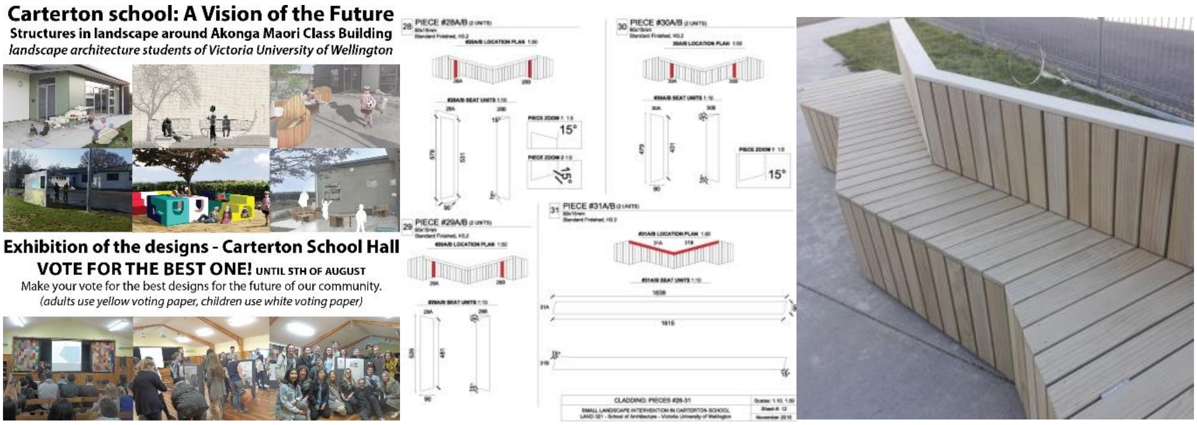

Figure 4 – From concept design to construction (VUW-LAND321 2016 class)

Developing practice-based research

Findings of the second group of partnerships showed that it was necessary to better organize the development of the agreed design down to construction documentation as well as better manage the construction process. At the same time, the opportunity to develop specific research around the impact of the implemented designs became apparent. In order to improve the outcomes and outputs of the projects, several strategies were followed:

Extending the length of the partnerships

Partnerships were extended both before and after the university course. To extend the partnerships before the university course facilitated better organization, planning and better options to seek for funding. This guaranteed a more functional and adaptable process. On the other hand, by extending the partnerships after the university course, extra time was allowed for developing better documentation, planning and management of construction.

Improving the design outputs with extra funding

In order to improve the outputs, included in the agreement of the partnerships was funding for student scholarships, which were funded equally by the university and community. The goals of this extra stage were to finish the design process, prepare specific documentation and manage construction. Construction continued to be managed by the university and funded by communities, with the support of volunteering and sponsorships.

Assessment of the implemented designs
Findings showed the opportunity to gather knowledge around the performance of the implemented designs. Specific research post-implementation was developed and funded by the university. The main goal of these research projects was to assess the impact on communities of the implemented designs. Furthermore, to gain typological knowledge and contribute to the research environment by assessing specific aspects of the implemented designs.

Figure 5 – Construction and research post-implementation (VUW-LAND321 2017 class)

FINDINGS

Civic learning
The case studies demonstrated that being part of a collective project enables the experience of civic learning for students, communities and faculty. A design-based project promotes learning of new methods of transforming the physical environment linked to participation, democratic citizenship and civic action. At the same time, facilitates communities to understand and improve their conditions while students experience practice-based education and faculty practice-based research.
Partnerships train individuals about participatory design methodologies, building capacity for active participation in future projects. The developed partnerships demonstrated to be valuable personal and collective experiences where learning was maximized and economic interests either did not exist or were secondary. The collective action of developing a partnership created a sense of empowerment –a sense that when working together, big things can happen.

Earning self-management skills
In parallel to understanding and improving their environment while experiencing civic learning, communities earned self-management skills. This means they were able to build a capacity for developing projects by themselves or with other partners. Findings showed that communities learned about internal organization, communication and leadership. They experienced how to make collective decisions as part of projects that are developed over time and face many complexities.

The acquiring of self-management skills was also related to tangible aspects learned mostly by the community leaders. These were related to project organization and planning, technical aspects and legal requirements of a design process, or funding opportunities and applications. At the same time, community leaders earned skills around how to interact with key stakeholders, or how to organize events such as workshops, seminars, exhibitions or collaborative construction.

Shaping new professional identities

The case studies revealed that experiencing practice-based education gives students a chance to learn skills relevant in practice. They practice the development of a design from preliminary to detailed design stages. They also have the chance to participate in the construction process: they learn how to take a hands-on approach to design. This practical aspect challenges the traditional way in which design disciplines are usually taught (solely based on intellectual capacities).

Practice-based education allows students to learn about processes of collaborative work with colleagues and communities. They explore links between speculative and pragmatic approaches to design at the same time that practice how to communicate their ideas to non-technical audiences. Finally, partnerships allow students to learn about new professional identities related to civic engagement. New roles that are emerging and starting to be relevant such as facilitator, educator, mediator, collaborator, activist or builder, can be experienced through these types of projects.

The academic as facilitator

By linking teaching with civic engagement through partnerships, academics act as facilitators of participatory processes and civic learning. Practice-based education opens up the boundaries of teaching and research to socio-political and professional environments. To work with subsequent partnerships allows building knowledge around action research, participatory processes and practice-based education. In parallel to this core research, these types of projects facilitate further research depending on the interests of the academic, what types of communities are approached and what type of projects are developed. Therefore, partnerships facilitate parallel research projects depending on the particularities and outcomes of the projects.

Findings also showed that developing partnerships and doing real projects adds a substantial amount of work on the top of the regular responsibilities that academics have. If universities want to favour the development of civic engagement and practice-based education, academics need to have more support from universities.

Figure 6 – Different partnerships and temporary collectives

CONCLUDING REMARKS

With contemporary societies experiencing many disruptions, universities have the opportunity to expand their social responsibility by affirming that teaching and research can contribute to redressing social inequality, disintegration and segregation. This contribution can be achieved through action, by partnering with *real* people for developing *real* projects.

Universities have traditionally approached design education through speculative thinking and studio-based courses. Current research shows that universities need more practice as well as practice needs more research. In order to normalize practice-based education, new knowledge needs to be generated from the experience of design-based partnerships. Universities, communities, governments, practitioners and industry can benefit from these. By adapting roles associated with practice, universities have the opportunity to complement practice and contribute to the discipline by developing specific research that practitioners usually cannot do due to knowledge, time or funding constraints.

Design-based partnerships provide the opportunity to rethink, transform and improve the physical environment. But also non-physical outputs are achieved. Values and skills related to participation, democratic citizenship and civic action can be attained by being part of a temporary collective. In a time when university funding is based on the assessment of traditional academic outputs, it becomes strategic to raise knowledge of the non-material assets of practice-based education. This is particularly relevant in design-based disciplines, where developing practice-based education increases workload and hinders academic recognition. New ways of assessing the impact of research in design-based disciplines needs to be developed, facilitating the implementation of practice-based education and the development of non-traditional research outputs.

This research aims to contribute to knowledge around the importance of developing practice-based research underpinned by civic engagement and social responsibility. As the presented case studies demonstrate, design-based partnerships offer many opportunities. But at the same time, they showcase that partnerships are complex constructs that require the development of further research in order to become an effective tool within contemporary societies.

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[18] Marae are fenced-in complexes of different buildings and grounds that belong to a particular iwi (tribe), hapū (sub tribe) or whānau (family). Marae are used for meetings, celebrations, funerals, educational workshops and other important tribal events. Maori communities tend to be socially and economically deprived in New Zealand. Maori culture is trying to be raised in NZ in order to build a real bicultural country.

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IMPROVING SKILLS ON ARCHITECTURE STUDENTS TO UNDERSTAND AN URBAN ENVIRONMENT OF CONSTANT CHANGE THROUGH DATA VISUALIZATION

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INTRODUCTION

Exploring the idea of urban environment led us to the study of the theory of the good city form that was described by Kevin Lynch in the sixties. In his world famous book, *The Idea of the City*,[1] 1 he argued that to understand the city's complexity it was necessary to create mental maps based on the inhabitants' perceptions and feelings. Urban morphology was only a part of the complex environment in which cities had become and new concepts should be considered to describe non-tangible connections beyond the physical evidence. Identity, structure, meaning, transparency, congruence, legibility, fit, vitality, accessibility, control, immediacy, legibility, imageability or way-finding were new motives to be used for understanding this complexity. Following these ideas, the paper proposes an approach to urban data visualization as a discipline to deal, not only with the representation of the morphology of the city, but with the city sense,[2] uncovering all these hidden layers of information. Our aim is to propose urban data visualization as a powerful discipline to develop diagrammatic representations using a variety of tools as charts, graphs, plots, maps, images, 3D surfaces, 3D solids, isosurfaces and animations to rearrange information data of any kind, such as numeric, symbolic, scalar, vectorial, discrete, continuous, binary, enumerated or multidimensional.

A HISTORICAL PERSPECTIVE OF DATA VISUALIZATION

Looking for best ways of visualizing complex urban data, the paper starts offering a historical approach to data visualization, not presenting an exhaustive study of the history of the discipline,[3] but selecting some illustrative and representative examples. Dating back to the history, the first map known in the world history is a mural found on the Lascaux Cave,[4] located in south-western France. Over six thousand wall paintings cover the interior walls and ceilings of the cave, representing local fauna and hidden within the paintings, the stars constellations can also be read. However, the first map of an urban city was found during an excavation in 1963, in Ankara, Turkey. There, the British archaeologist James Mellaart unearthed one of the earliest known maps. (Figure 1) The wall painting was radiocarbon-dated back to 7.000 BCE and it is considered one of the earliest known cities.[5] According to Mellaart's interpretation, the foreground shows the Neolithic city of Çatalhöyük, with the eruption, in the background, of the twin-peaked volcano known as Hasan Dağ.

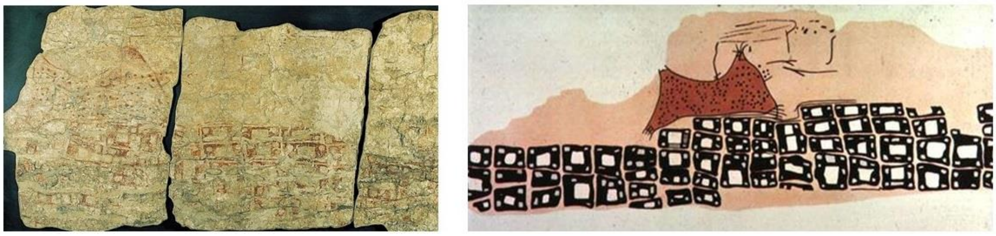

Figure 1. Neolithic mural of Çatalhöyük in Turkey (left) and Mellaart's interpretive drawing of the wall painting (right). Museum of Anatolian Civilizations, Ankara.

Moving on to sometime in the 13th Century, it is worth to mention the Ebstorf *mappa mundi* (Figure 2) that shows the Christian world view within the body of a crucified Christ.[6] Christ's head is in the East (the direction of the Paradise), his hands point north and south, and Jerusalem is in the middle. Asia is placed in the upper half, Europe in the bottom left and Africa in the bottom right. Landmarks are placed following an order, but not under the rules of Cartesian accuracy.[7] It is an idealized description that has more to do with an ideal than with the representation of a geographical area. Another example that graphically visualizes theoretical ideas dated on the 16th Century is the Bünting's clover-leaf map (See figure 2) contained in the *Itinearium Sacrae Scripturae*,[8] a book that was first published in 1581. A world map is represented within the shape of a clover-leaf to possibly represent the Trinity, including the three classical continents (Europe, Asia and Africa), Jerusalem at the centre and additional indication of Great Britain, Scandinavia and America, the New World.

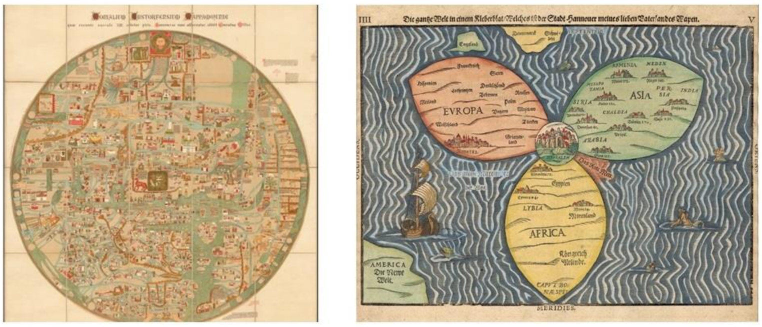

Figure 2. Reproduction of the Ebstorf's world map. Leuphana Universität Lüneburg (left). Bünting's map. Jewish National & University Library, Eran Laor Cartographic Collection (right).

Moving on more than a step forward, it is worth noting William Playfair,[9] a Scottish engineer and political economist who is considered the founder of graphical methods of statistics used for communication purposes. Playfair invented four types of diagrams: line graphs and bar charts, for economic data, and pie charts and circle graphs, both used to show part-whole relationships. (Figure 3) Another pioneer in many respects was Charles Joseph Minard, a cartographer that invented the flow diagrams. His famous flow map on the subject of Napoleon's disastrous Russian campaign of 1812 (See figure 3) displays several variables in a single two-dimensional image: the direction that the army was traveling, both in advance and in retreat; the size of the army on both directions; the location of the army with respect to certain places, and the weather temperature along the path of the retreat. The graph provides a strong visual representation of human suffering emphasizing the decrease of the army's size at the end of the campaign and after crossing the Berezina River on the retreat. Even the graph containing information about the temperature allows guessing the terrible conditions.

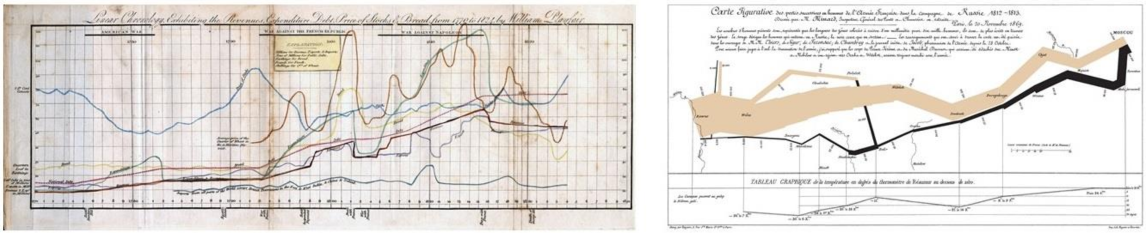

Figure 3. A 1824 Playfair's line graph illustrating how war affect prices Image: William Playfair (left). Minard's graphic of Napoleon's 1812 march on Moscow. Princeton Architectural Press (right).

A combination of maps with line graphs, bar charts, pie charts and circle graphs was used by Antonín Götz in the *Atlas Ceskoslovenske Socialisticke Republiky* (Atlas of the Czechoslovakian Socialist Republic)[10] in 1966, (Figure 4) that went beyond the representation of the land to cover different layers of information, not only geography but also hydrology, climate and economic statistics.

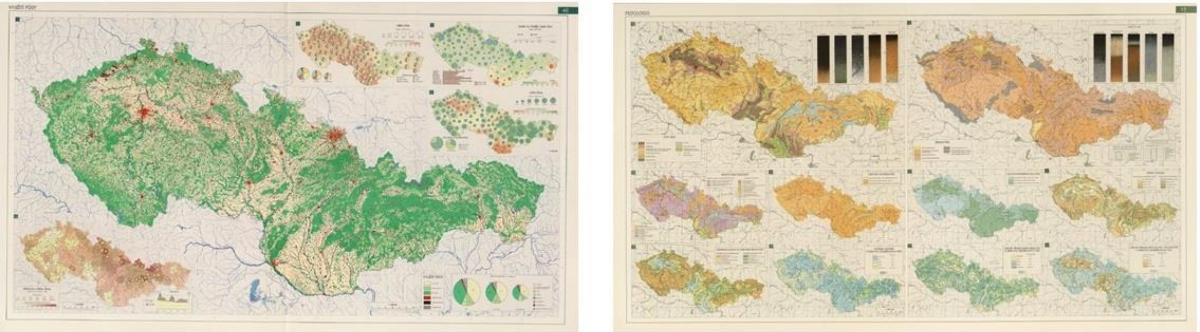

Figure 4. Antonín Götz's maps extracted from the Atlas of the Czechoslovakian Socialist Republic. David Rumsey Historical Map Collection.

A completely different approach can be found on the diagrams made by the Austro-Hungarian sociologist and political economist Otto Neurath, who rejected histograms with numerical scales, pie charts and continuous line charts for a method that displayed facts in a more easily understandable form. Numbers were represented by a series of identical pictorial elements, or signs, each of them associated to a defined quantity. In his *Atlas of Society and Economy,*[11] he uses Isotype's[12] combinations of maps and diagrams to visualize data, overlapping symbols to maps to compare urban areas in different cities analysing their growth in space and population. (Figure 5) The Isotype symbols' simple beauty has had an enormous influence on graphic design nowadays. In this regard, it is worth to mention the work of Nigel Holmes, who has repeatedly declared the influence that Neurath's principles and graphics has had on his infographics. Holmes' is known for using figurative illustrations, icons and pictograms, as in his widely known *New York Times* op-ed page on the progress in New Orleans after Hurricane Katrina (See figure 5).

Figure 5. Two Neurath's maps and diagrams from The Atlas of Society and Economy (left). Holmes' New York Times *page on the progress in New Orleans after Hurricane Katrina (right).*

AN OVERVIEW OF CONTEMPORARY METHODS OF DATA VISUALIZATION

Nowadays, urban data visualization is considered a discipline that involves three main steps: discovering, analysing and designing. Discovering data is becoming easy nowadays; data can be found in official sources, such as open cartography databases (OpenStreetMap[13] or Google Earth[14]), the media or public databases and also, in non-official sources, such as social media and even gathering data through innovative devices, as digital cameras, smartphones, laser scans, GPSs, total stations or Arduino platforms and sensors. Analysing and designing this data is possible through a variety of open source and proprietary software.[15] To better approach data visualization tools and show their impact in urban design, some representative examples are shown below.

The first example (Figure 6) combines maps, pie charts and graphics, showing the internet fiber-optic submarine cable system under the earth oceans. It displays information about the internet users affected by the Alexandria accident,[16] the world cable capacity and the largest submarine cables, becoming a powerful visualization that explains how vulnerable is the system in which we rely on. The second example (See figure 6) is an interactive map that visualize the worldwide remittance flows of money sent back home by immigrants. The visualization combines a map and a line graph showing information about the remittances in different countries, allowing interaction to explore data results. Selecting each country and sliding along the time axis on the line graph, it is possible to visualize how remittances have developed since 1970 and where most of the country's migrants live.

*Figure 6. The internet's undersea world. The Guardian. (left)
Worldwide remittance flows. http://remittances.herokuapp.com/?en (right).*

The combination of social media data and geodata available to the public was used by Eric Fischer in a series of maps linking interesting places around the world, that are grouped under the *Geotaggers' World Atlas*. *Local and Tourist*.[17] (Figure 7) The interactive world maps show the most-photographed places on Earth and the routes connecting them. On the map of each city, pictures taken by local inhabitants are shown in blue, photos by tourists in red and the rest in yellow, allowing identifying areas of interest for locals and foreigners. A geolocation API was used to get the photo locations from Flickr; OpenStreetMap was the main source for the geographic information and urban data, and finally, some scripts were written by Fischer to identify the clusters of the locations. Other Fischer's visualizations are the ethnical maps included in the series *Race and Ethnicity*,[18] (See figure 7) where races are represented attending to a colour[19] and each dot is associated with twenty-five people.

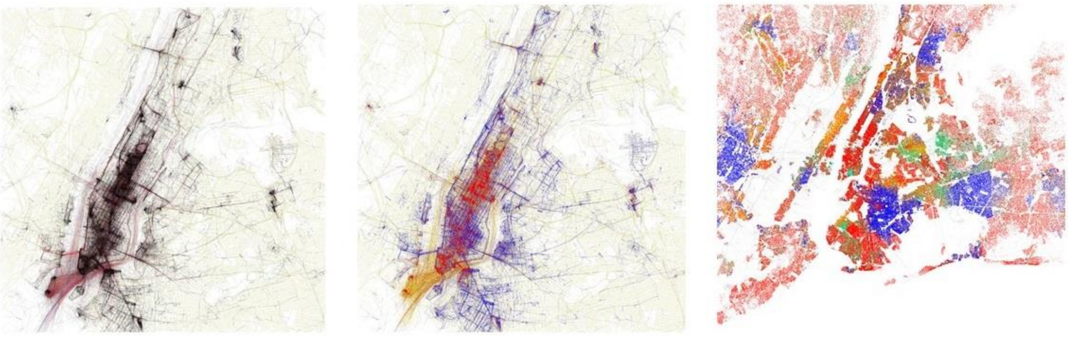

Figure 7. Fischer's New York maps from Geotaggers' World Atlas (left) and Race and Ethnicity (right).

The last examples (Figure 8) are focused on transportation. The first one was designed by Lewis Lehe when he was a Berkeley PhD student in transportation engineering. *Stop to Stop*[20] combines an interactive map of the location of transport stations and a chord diagram showing their names and the possible connections among them. Selecting any station, the total entries of riderships appears in the map and the chord shows the connections with other stations. A JavaScript library and a vector tiled map were used for designing the visualization and in addition to the usual cartography from OpenStreetMap, Polymaps[21] provided various visualization techniques to present the data.

The second example, *Transit Quality & Equity*[22] was developed by Raymon Sutedjo and Sandra Lee and uses a JavaScript library for the interactive visualization and the open software R. The interactive map shows the transit of San Francisco, not in terms of speed and efficiency but overlapping transit data with income levels of the population. The income levels for each area of the city are shown in the map, as well as the percentages of people living under the poverty level. The blue line is the route of the bus; the size of the nodes represents the frequency of the stops on that spot and the shade indicates the delay. The map allows to compare prosperity and transit quality visualizing flows and variations.

The last visualization, *San Francisco Pavement Quality*,[23] represents the pavement quality of San Francisco streets overlapping two data sets: paving scores and street center lines. High quality pavements are shown in green while those in the worst are red. The map background is an image layer from CloudMade[24] and to merge the two data sets of the street into GeoJSON[25] it was used a Python script. It was also used a data visualization library called Protovis for color interpolation.

Figure 8. Lehe's interactive Stop to Stop map (left), Sutedjo & Lee's Transit Quality & Equity map (center) and San Francisco Pavement Quality map (right).

As we have already seen, data visualization is a powerful tool that allows representing all kind of information related to the urban environment (visible and invisible) and the interaction of citizens among them and with the city. Thanks to it, a better design of our cities could be possible, but Architects and Urban Planners will have to learn how to use these new tools if they want to better shape the future of our cities. The next paragraph explores the tools that are being used in a university's project-based learning approach that raises architectural students to create maps using available data and free and open-source software to analyse and understand the urban environment.

IMPROVING SKILLS ON UNIVERSITY STUDENTS THROUGH DATA VISUALIZATION

Looking for improving skills on our architecture students through data visualization, we started a project-based teaching initiative that provided instruction on these new tools for understanding the urban environment. The initiative started as part of one of the educational programs offered at the Fab Lab Madrid CEU (the digital fabrication laboratory based at CEU University), which is an advance diploma in Digital Fabrication for Architectural Design and offers students new tools and skills to improve their knowledge in this field to be applied in their architectural projects.

The course covers three fundamental matters. First of all, it starts with a brief introduction to data visualization applied to urban design. Then, using a project based approach, shows how to use available databases in Madrid. More specifically, we used the Open Data Portal of the Madrid City Council,[26] the Territorial Information System of the Statistics Institute of the Community of Madrid,[27] the IDEE (the Spatial Data Infrastructure of Spain),[28] the CNIG (National Center of Geographical Information)[29] and Datos Gob.[30] Finally, the third part of the course introduces students to open software tools to map the database, such as QGIS[31] to map, export and print data; Free Office[32] to clean the data; RAWgraphs[33] to design graphics and Inkscape[34] as final tool for layout.

The examples included below (Figure 9) have been made by architecture students and show how urban data is addressed to the available level via data visualization. The aim is to arrange information data using QGIS, adding layer by layer all the files containing the data, which includes vector maps of the Madrid city's districts combined with information of the neighbourhoods, urban land uses or information related with different topics of interest selected by students, as well as vector data. Overlapping layers of different kind of information and editing the visualization of each layer it is possible to visualize and unveil some challenges that is facing our city. Using this workflow, students made visualizations that analysed, for instance, the public and private schools and institutes by districts and neighbourhoods in relation to the transportation system; types of infrastructure in relation with nearby Wi-Fi points; markets and transport routes by district; cultural and representative buildings related to streets and roads; Airbnb[35] houses by districts; landmarks and nearby public restrooms or hospitals and nearby pharmacies.

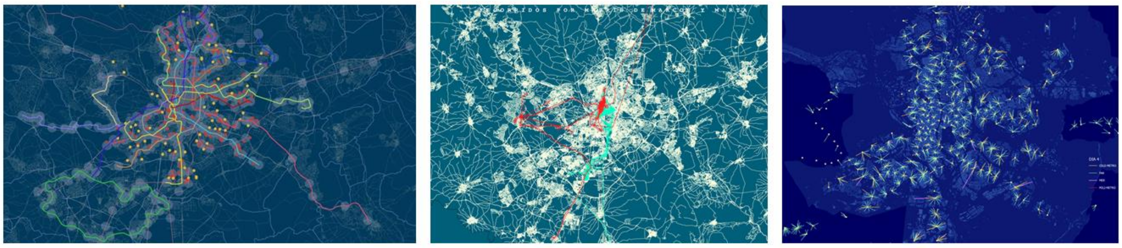

Figure 9. Maps created by university students under the instruction of Irene Rodríguez Vara. Maps by Marco A. Morales (left), Rafael Calero (center) and Javier Esparza (right).

The course also focuses on the visualization of not geolocated data through graphics using RAWgraph using various kinds of diagrams, (Figure 10) such as dendrograms[36] to visualize information about neighbourhoods and districts; sunburst diagrams[37] to show urban cleaning actions by districts or alluvial diagrams[38] to show the number of people involved in urban activities based on gender and age.

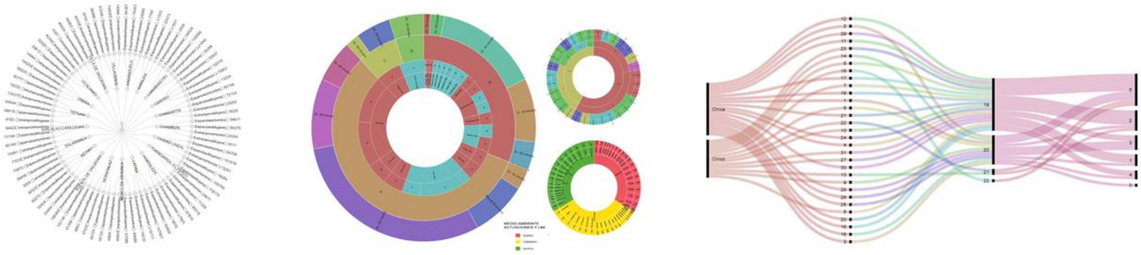

Figure 10. Maps created with RAWgraph by university students under the instruction of Irene Rodríguez Vara.

Encouraged by the potential of the data visualization tools, inspired by illustrative outstanding examples found out along the history and after a study of the new practices and tools developed nowadays to merge maps and graphs in visualizations, our program tries to offer students some intuitive and open access tools that allow them to create data visualizations of the urban environment. The program is still in an initial phase and therefore, it is soon to draw conclusions, but the experience seems to be promising and students, not only showed great interest on the use of these tools but they made interesting visualizations that have allowed them a deeper understanding of the city.

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[11] Otto Neurath, *Atlas Gesellschaft und Wirtschaft. Bildstatistisches Elementarwerk*. (Leipzig: Institute AG, 1930)
[12] Isotype (International system of typographic picture education) was the name of the method for assembling, configuring and disseminating information and statistics through pictorial means. Neurath described it as a 'language-like technique' characterized by consistency in the use of graphic elements.
[13] OpenStreetMap is a map of the world created by people and free to use under an open license. https://www.openstreetmap.org
[14] Google Earth is a free computer program from Google that renders a 3D representation of Earth based primarily on satellite imagery. The program maps the Earth by superimposing satellite images, aerial photography, and GIS data onto a 3D globe, allowing users to see cities and landscapes from various angles. https://www.google.com/intl/es-419/earth/
[15] Analyzing data is possible nowadays using Processing, Grasshopper, QGIS, Free Office or RAWgraphs, just to mention some of them. Designing the visualization is also intuitive today, thanks to a variety of design software such as Inkscape, Illustrator or Flash, among others.
[16] In 2013 naval forces in Egypt arrested three men alleged to have attempted to cut an undersea cable off the coast of Alexandria causing a sixty percent drop in internet speeds.
[17] Eric Fischer, *Geotaggers' World Atlas, Local and Tourists.* https://www.flickr.com/photos/walkingsf/sets/72157624209158632/detail/
[18] Eric Fischer, *Race and Ethnicity*. https://www.flickr.com/photos/walkingsf/sets/72157624812674967/
[19] The map shows the Caucasian in red, the Afro-American in blue, Asian people in green, Hispanos in orange and other races and ethnicities in yellow.
[20] Lewis Lehe, *Stop to Stop*. http://enjalot.github.io/bart/#chapter-05
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[22] Raymon Sutedjo and Sandra Lee. *Transit Quality & Equity*. http://ray-mon.com/urbandatachallenge/
[23] Polymaps, *San Francisco Pavement Quality*. http://polymaps.org/ex/streets.html
[24] CloudMade provides a platform for software developers to build geo-enabled applications making extensive use of OpenStreetMap data to provide mapping services. http://cloudmade.com.
[25] GeoJSON is an open standard format designed for representing simple geographical features, along with their non-spatial attributes. It is based on JSON, the JavaScript Object Notation. The GeoJSON format differs from other GIS standards in that it was written and is maintained not by a formal standards organization, but by an Internet working group of developers. https://geojson.org/
[26] The Open Data Portal of the Madrid City Council (Portal de Datos Abiertos del Ayuntamiento de Madrid) promotes access to government data as well as the development of creative tools to attract and serve the citizens of Madrid City. https://datos.madrid.es/portal/site/egob/

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[28] The Spatial Data Infrastructure (SDI) of Spain (IDDE) integrates data, metadata, services and geographic information through internet. https://www.idee.es/
[29] The CNIG (National Center of Geographical Information) offers geo-referenced geographic information, topographical data, transport networks, contour lines, photographs and orthophotographs of several years, satellite images and scanned ancient geographic documentation, which include maps and manuscripts. https://www.cnig.es/home
[30] Datos Gob that promotes the opening of public information to the citizens and it is supported by the Ministry of Economy and Business and the Ministry of Territorial Policy and Civil Service. https://datos.gob.es/
[31] QGIS is a free and open-source cross-platform that functions as a geographic information system (GIS) software, allowing users to analyze and edit spatial information, in addition to composing and exporting graphical maps. https://qgis.org/en/site/
[32] FreeOffice is a free complete Office suite with a word processor, a spreadsheet application and a presentation program. https://www.freeoffice.com/en/
[33] RAWGraphs is an open source data visualization framework created by the Density Design Research Lab (Politecnico di Milano) with the goal of making the visual representation of complex data easy for everyone. https://rawgraphs.io/about
[34] Inkscape is a free and open-source vector graphics editor that can be used to create or edit vector graphics such as illustrations, diagrams, line arts, charts, logos and complex paintings. https://inkscape.org/es/
[35] Airbnb is an online marketplace for arranging or offering shared lodging, primarily homestays.
[36] Dendograms are tree-like diagrams to show the distribution of a hierarchical clustering.
[37] Sunburst diagrams are similar to a tree-map, except it uses a radial layout.
[38] Alluvial diagrams allows to represent flows and to see relations between categorical dimensions.

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ARCHITECTURAL INVESTIGATIONS: INTEGRATIVE VISUALIZATION AND FABRICATION

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INTRODUCTION

Digital production and image making have now become mainstream in architecture. A new wave of inquiry into the future direction of the discipline is working to bring a more diverse set of tools and processes of making together into dialogue. New design methodologies encourage thinking across digital and analog media and creating a feedback loop between 2d and 3d forms of representation. Meanwhile, educators have called to change STEM to STEAM by adding art education to STEM programs. This new initiative has not yet been widely integrated into high school curricula. Digital literacy programs have not evolved to incorporate the art and making strategies needed for architecture and design coursework at the collegiate level. This paper presents the work of a k-12 course for scholarship students from underrepresented communities we developed at Pratt Institute that provides an approach to design education that integrates a variety of digital and analog methods, tools and materials to prepare students to work in a post digital era, where students are digital natives, digital tools are mainstream, and innovation comes from new ways of combining different types of making.

FROM DIGITAL TO POST-DIGITAL

The digital revolution of the 1990's brought new modeling, visualization, and fabrication software and tools to the discipline of architecture. Software such as Maya, Autocad, Rhino, and Vray were used to digitally model and visualize forms that were difficult and sometimes impossible to create by hand. Tools such as 3d powder printer, laser cutter, pla printer, computer numerically controlled (CNC) mill, and the robot mill directly translated digital models into physical form. According to theorist and historian Mario Carpo, the digital revolution was invented in architecture schools. In a 2015 *Metropolis Magazine* interview, he states,

> Think of digital mass customization, non-standard seriality, variability of market prices, the production of non-standard items, you name it—where do all these ideas come from? Who first started to formulate these ideas and to investigate them? It was a bunch of young architects in the early 1990s in a handful of architectural schools.

Digital production and image making have now become mainstream in architecture. In fact, awareness of digital tools is widespread throughout mainstream culture. The new generation of students are described as digital natives, with no experience with pre-digital culture. A new wave of inquiry into the future direction of the discipline is working to bring a more diverse set of tools and processes of making together into dialogue. This second wave of inquiry has been broadly labeled as the "Post-Digital." [1] Carpo, who calls this the "Second Digital Turn," states:

> Today, the digital turn, digital culture, and digital technologies are changing again, and in my opinion architects are still at the forefront, just as they were 20 years ago. To this day, the best laboratory, the best place to observe the next step in the digital turn is still in schools of architecture.[2]

This term has become broadly applied across a wide range of fields beyond the design disciplines to describe the new reality that has evolved out of the relentless pace and ever-expanding global reach of digital innovation. In the field of art, Jonathan Openshaw, author of *Postdigital Artisans*, describes the post-digital in his introduction, writing that we live in "a world that has been reformulated by the digital moment, and where a digital mindset is inextricably entangled with our existence, whether or not the digital *technology* [emphasis his] is actually present." [3] His book focuses on artists that combine digital technology with a return to craftsmanship and the handmade.
In February 2019, management consultant giant Accenture published a blog post on the post digital:

> In the post-Digital world, differentiation comes from applying digital in powerful new ways. The technologies needed to innovate and differentiate go beyond the foundational adoption of digital tools and concepts.[4]

For Accenture, the post digital is about new capabilities in mass-customization and a new accountability for the products that digital technologies enable one to create. For most, the post-digital is about hybridization that moves beyond "techno-positivist innovation narratives exemplified by media such as *Wired* magazine, Ray Kurzweil's Google-sponsored 'singularity' movement, and of course Silicon Valley. Consequently, 'post-digital' eradicates the distinction between 'old' and 'new' media, in theory as well as in practice."[5]

FROM STEM TO STEAM

In the field of K-12 education in the 1990'S, there were movements to bring technological, and later, digital literacy to young students. [6] The first use of the acronym STEM came from
CAHSEE (Center for the Advancement of Hispanics in Science and Engineering Education), who started a summer program for Latino precollege students in the Washington, DC area to enter science and engineering schools in 1992 called the STEM Institute, which stood for Science, Technology, Engineering and Math. The National Science Foundation (NSF) began to use the STEM acronym In 2005 the National Academies of Sciences, Engineering and Medicine published Rising Above the Gathering Storm, which outlined the need to increase the American talent pool by training high school students in science, engineering, technology and math to respond to competitors that the American workforce and economy faces as a result of globalization ("10,000 Teachers, 10 Million Minds, and K-12 Science and Mathematics Education).
STEM became mainstream after Barack Obama announced his STEM Initiative 2010. The president secured $1 billion in private investment for improving STEM education as part of the Educate to Innovate campaign. In his press release, Obama stated, "Reaffirming and strengthening America's role as the world's engine of scientific discovery and technological innovation is essential to meeting the

challenges of this century." "That's why I am committed to making the improvement of STEM education over the next decade a national priority."[7]

Since the Obama Initiative, STEM has been implemented across a broad range of programs. In 2018, the United States Department of Education charted a five year Federal strategy to bring STEM literacy to all youth populations., with a directive to invest $279 million in discretionary funds toward expanding STEM. Still, there remain many open questions about STEM. What is the definition of STEM? Is it a curriculum that is about promoting the fields as separate curricular trajectories, or is it about the integration of the four areas? In STEM programs, technology is often equated with computer science, though the term encompasses a much broader range of subject areas. Is the program merely to train students for STEM careers, or should it have a broader agenda?

In 2012, then-president of Rhode Island School of Design (RISD) John Maeda stated, "Indeed, we know that the challenges the next generation faces will demand creative solutions, but I would argue that STEM alone will *not* get us there. Innovation happens when convergent thinkers, those who march straight ahead toward their goal, combine forces with divergent thinkers – those who professionally wander, who are comfortable being uncomfortable, and who look for what is real." [8] He was referring to his RISD initiative to add Art to the STEM movement, effectively changing the acronym to STEAM. Maeda believes artists and designers will become the next great leaders. Art and design education, with its project-based approach, is the right environment for innovation. Creativity and innovation through art and the culture of physical making needs to be brought into the STEM subjects. [9]Maeda then outlines various initiatives undertaken at RISD where design students partner with engineering students from neighboring Brown University on interdisciplinary projects, including an NSF-funded grant bringing together "thinkers from the fields of Art + Design, Science, Creative IT, Engineering, and Mathematics to examine the ways educators and policy makers can bridge the gap between art and science."[10]

STEAM curriculums and conferences have since proliferated at various art and design schools, approaching the integration of the arts into the STEM subjects in different ways. RISD has partnered with Brown University in the Brown/RISD Dual Degree program to capitalize on the complementary strengths of both institutions. Columbia University Teachers College has a program called STEAM Garage, which focuses on computer programming. The Bartlett Global Center for Learning Environments in London held a conference on STEAM education in March 2019 which focused on the way learning environments might evolve in the wake of the STEAM movement.

PRATT YOUNG SCHOLARS AND GRADUATE ARCHITECTURE PROGRAMS

Our research project brings the latest post-digital tools and techniques of combinatorial and integrative digital-analog making taking place at the graduate and post-graduate architecture level at Pratt Institute into Pratt Institute's K-12 STEAM curriculum. Pratt has been educating children and teens since the school opened its doors in 1897.

According to its mission statement, Pratt Center for Art, Design and Community Engagement K-12 aims "to increase access to instruction in art and design for young people by leveraging the resources and expertise of the Institute to support school-age children, city-wide public schools, and youth-serving organizations."[11] Pratt's Graduate Architecture and Urban Design (GAUD)program was a leader in the development of digital software and digital fabrication tools in the early 2000's when the MARCH program was launched. Faculty worked with notable software developers on the development of design methodologies. Sponsored studios explored then-innovative digital fabrication techniques that established the school as a leader in digitally-driven design. The GAUD invested in 3d printers, laser cutters, and CNC mills including robot mills, and Pratt Institute established the Consortium for Research and Robotics in 2014, acquiring New York City's largest industrial robot that aims to engage designers, engineers, and researchers in a new experimental paradigm that is equal parts digital and physical.

Today, the GAUD continues to educate students at the forefront of the discipline with a focus on integrative, combinatorial and multi-modal approaches to making. In addition to digital tools, there is a renewed focus on woodshop and metal shop fabrication, mechanical tools such as the foam cutter and vacuum form machine and fine art techniques such as casting, painting, and hydrodipping. The first semester studio project for graduate architecture students introduces a broad cohort comprised of students with a wide range of backgrounds to principles of design. The exercises work between and sometimes combine digital and analog media, physical and digital outputs, and two and three-dimensional deliverables. Students began with a casting project, which was cut to form a sectional model. Students worked with simple household objects and placed them into a bounding box to create a mold into which casting material is poured. The objects are chosen for their relatively simple geometry that can be translated primarily into arcs and lines. The agenda for the object placement in the box is to partially erode the box volume shape through the addition of the objects as well as to create a void inside the volume, which could be formed through the placement of one or multiple clustered objects. The casting process has the effect of estranging the resulting output from the original inputs. The geometries of the objects and bounding box become fused into a new whole, one that is also the negative of the original objects. The formwork created by the students was cut on the bandsaw prior to casting to create a sectional model. Photos of the model were traced in Rhinoceros, a computer-aided drafting and modeling program. Linework from the sectional model was used to create new digital form. The digital model was cut into pieces to be fabricated through different media, including lasercutting, 3d printing, and more casting. New sectional linework was generated by the new digital model. In the second project, the new object generated in the first project was then used to create a ground into which the object would be sited. The digital object was used to carve or stamp into a digital volume that would become the ground. The digital model would be sectioned into different parts to be output in different ways. The same digital fabrication tools were again implemented with the addition of CNC milling. Paint and vacuum forming were used on the physical outputs to blur the boundaries between materials. Section drawings were produced to explore the relationships between the object and ground. In the final third of the semester site, program, and scale were introduced to inform the development of the object-ground pieces. The object and ground were reworked according to the new prompts. New horizontal and vertical sectional cuts were made to explore scale and inhabitation.

Figure 1. Exercise 1: Casting

This process was reworked for the high school tenth graders in the Pratt Young Scholars program. For this course, which takes place in ten two-hour sessions in the fall and another ten in the spring with no assignments outside class time, the exercises were simplified and condensed. The first assignment introduces the concept of architectural massing. The work shifts to a digital 2d exercise in the second assignment and returns to a physical 2-1/2 d, or relief, in the third assignment. The first exercise of casting familiar objects using multiple mediums to construct three-dimensional form replicates the MARCH first assignment. The students explored how creating formwork and casting individual elements together with layers of Rockite, a quick-curing cement and wax would create new combinations of solid and void conditions. The students were shown collage work of the Dada movement, combinatorial readymade sculptures by Duchamp, Greg Lynn's work on aggregating common industrial objects into new forms, Rachel Whiteread's work in casting, and OMA's Prada Transformer which combines basic geometric forms into a new whole.

Figure 2. Exercise 1: Cast model elevations

The second assignment introduced students to the concept of section in buildings and drawings, and looked at section drawings of local New York City Landmarks, including the Statue of Liberty, the Guggenheim Museum, and the transit hub in Lower Manhattan. The students traced the photographs of the sectional models in Rhino and were directed to create linework that aggregated the outlines from the original objects and cast lines in new combinatorial ways. The students used the tracings to create tone drawings, where they reimagined areas of solid and void.

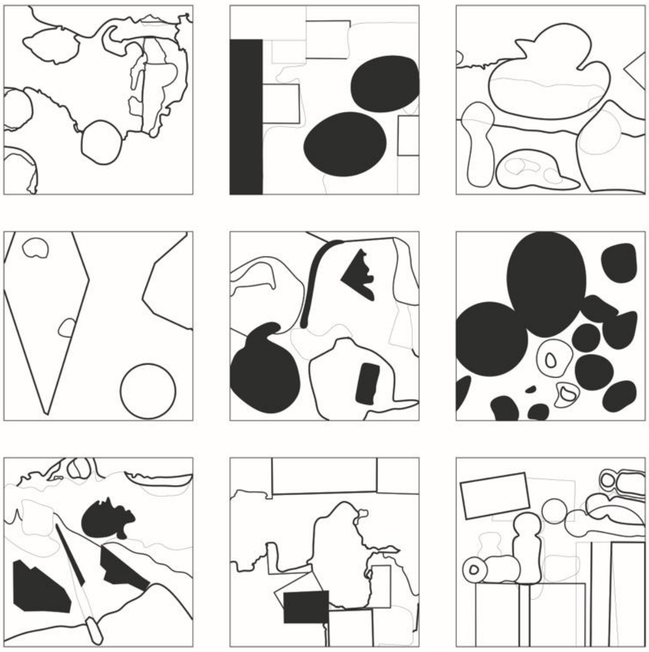

Figure 3. Exercise 2: Linework from cast model photos

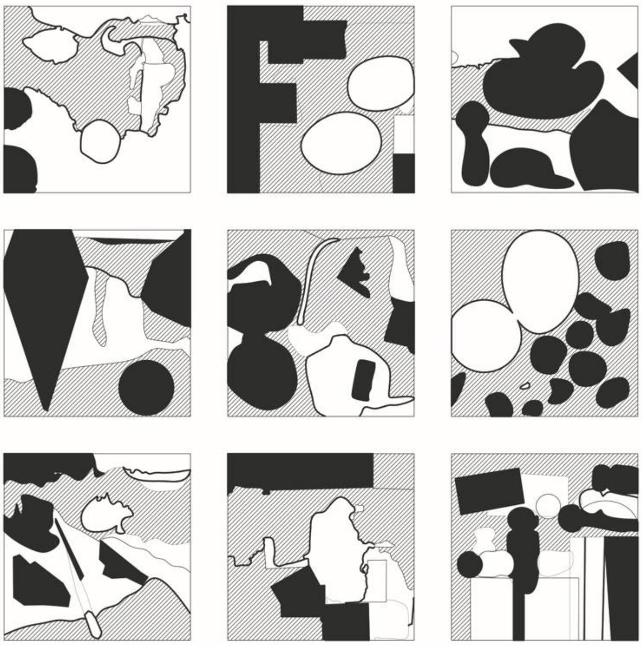

Figure 4. Exercise 2: Tone Drawings

The final fall assignment brought the digital work back into physical output. Students were introduced to the concept of creating *relief*, or 2½ dimensional space from two-dimensional digital linework. The 2D linework from Assignment 2 was extruded at different levels to create new spatial organizations that are distinct from the original cast objects. These reliefs were contoured into layers in Rhino that were then cut out from paper using a laser cutter and assembled into physical form. The students were introduced to the history of relief sculpture and the interplay of two-dimensional pictorial or drawing space and three-dimensional sculptural space spanning from ancient Roman, Greek, and Egyptian works to the Renaissance to 20th Century works like Mount Rushmore as well as to the concept of relief in mapping topographies.

Figure 5. Exercise 3: Laser-cut Reliefs

In the spring, the students revisited the concepts of massing and relief through the lens of different media, with the final project to combine the massing and relief elements together. The fourth assignment returned to the 2D linework from Assignment 2. Students used the 2D line drawings from to create new spatial organizations that are distinct from the original cast objects and from the lasercut reliefs. This time the students extruded linework to create a digital 3D object or massing within a bounding box of 4x4x4". The resulting massing composition was duplicated to be processed into two different physical 3D outputs. The first was again to section the object into contoured layers to be laser cut, assembled, and glued together. The duplicate model was prepared for 3D printing using PLA filament. Prior to preparing for output, the digital objects were cut into two pieces so the different types of physical outputs could be combined to create composite models. The laser cut contour models produce a lower-resolution quality to the object, while the 3D print is a faithful high-resolution replication of the digital model. Combining low resolution and high resolution together creates novel formal properties. The two object halves could also be combined in such a way that they do not replicate the original object but rather create another new condition.

Figure 6. Exercise 4: Contour massing models

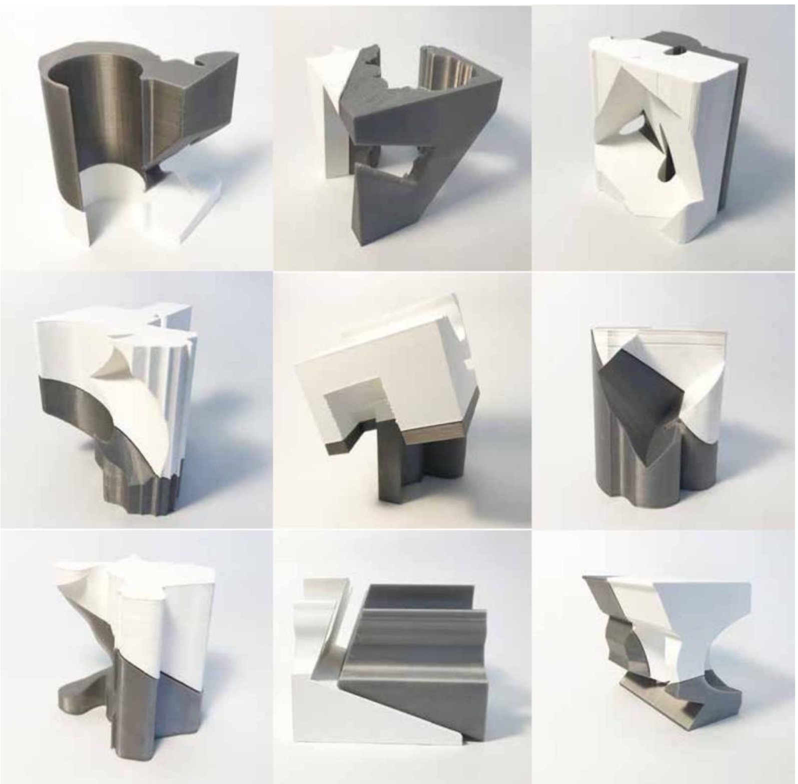

Figure 7. Exercise 4: 3d print massing models

The fifth assignment was to take the relief generated in the fall and prepare it to be milled on the CNC mill. The subtractive quality of the milling process and the tool paths produce a lower resolution and contrasting texture to the contoured mat board reliefs.

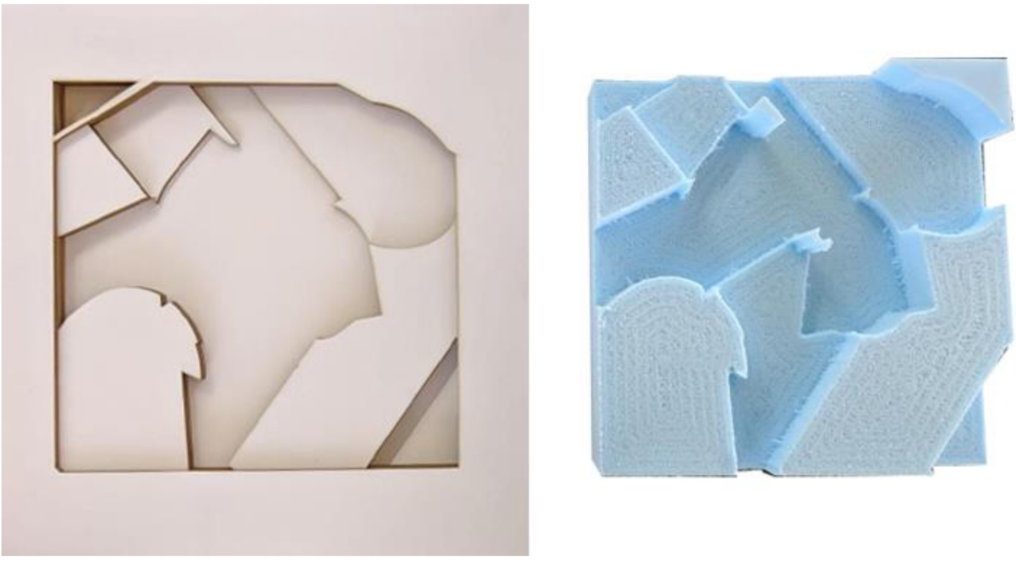

Figure 8. Exercise 5: Laser-cut and CNC mill reliefs

In the final assignment, students assembled combinations of massing objects and reliefs into new composite pieces. Students were instructed to place the objects in such a way as to make alignments with edges and curves shared by the different types of output. They were also encouraged to create void spaces between the assembled object pieces as well as between object and relief. The waste material from the laser cut assignment was used as a stencil to map profiles from the objects onto the new composites as a way to connect object and relief through color and shape.

Figure 9. Exercise 6: Composite models

CONCLUSION

Digital modeling, visualization and fabrication tools have revolutionized the field of architecture. New design and fabrication techniques developed in architecture schools have produced work that has a sophistication that was not previously possible. Digital design, fabrication and digitally-driven project delivery has brought incredible new capabilities to the profession. Digital technology has also revolutionized society at large. Every developed country has access to digital tools, and the current generation has grown up in the digital age, learning to use digital tools in parallel with their cognitive, social and motor development skills. In this context, US government recognized the need to refocus education on STEM subjects. Art institutions subsequently recognized the need to bring a creative approach, or "design thinking" to STEM subjects. The implementation of STEAM curricula that prepare students for careers in a post-digital world is still in its nascent stage.

Our pedagogical approach at Pratt Young Scholars outlined above proposes a way to situate digital tools in a broader context of different types of making so that the spatial and material qualities produced by different outputs can produce new composite qualities not achievable by digital output alone. Fine art techniques and manufacturing tools allow a post processing of digital outputs that extends the design process beyond the initial digital-to-physical output and allows for the potential of post-output adaptability to local conditions.

It is our hope that this project promotes knowledge exchange of post-digital design methodologies that continue to push the boundaries of formal and material exploration at all levels of design education. Architecture can continue to lead the way in the evolving trajectory of digitally-informed design and making.

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LEARNING DESIGN BY MAKING: AN ALTERNATE PRACTICAL PEDAGOGICAL APPROACH FOR DESIGN EDUCATION IN THE UNITED ARAB EMIRATES

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INTRODUCTION

Model making methods have for centuries years accompanied the drawings medium, with both being well-known tools of inquiry and representation in the architectural discourse. In 1970, Marcial Enchenique described the physical models as “a representation of reality, where representation is the expression of certain relevant characteristics of the observed reality, and where the reality consists of the objects or systems that exist, have existed, or may exist”.[1] The language of architectural and design representation have evolved over time, and have always been influenced by the era’s technology and design trends. Societies across the globe, at different time intervals, have witnessed drastic changes and driving waves as trends evolved from craft-making to mass production to digital culture and mass customization to today’s computer power and personalization. Today, we repeatedly witness the computer power being cultivated and placed at our fingertips.[2] Within the architectural design discourse, computer aided design (CAD) and computer aided manufacturing (CAM) technologies have significantly altered tools, techniques, design approach and representation. Digital fabrication has enabled us to program the physical world and introduced the notion of personalized manufacturing; a paradigm movement towards global knowledge and local production.[3]

The paper reflects upon an implemented case study across three semesters. It presents the implementation of an alternate pedagogical approach that utilizes ‘prototypes’ as means of inquiry, investigation, process and final realization. It also challenges the linear sequential mode of education and adopts a based-on need learning approach. Using the fabrications tool as means and utilizing design and build approach, it adopts an interdisciplinary, vertical, based on need learning approach. The presented case study has two folds; conducted with three cohorts of design students and one cohort of non-designers. Acknowledging that the followed pedagogical approach (Design and built) is a well-documented and tried methodology in many design schools worldwide, the conducted pedagogical experiment’s uniqueness stems from its social context and unique participants’ background.

CONTEXTUALIZATION

The introduction of robotics and computer programming into educational settings can be traced back to Seymour Papert initiatives in 1960[4], through which he assessed constructionist learning process in a number of schools across the United States.[5] The constructionist learning theory calls for learner-centered approach. It encourages knowledge acquirement from direct interaction with surrounding environment.[6] This formed the foundations for the Maker/DIY movement in which learning is based on direct experience, hands-on involvements, projects’ building and tinkering.[7] Powered by the rapid advancement in computing power, the past decade have witnessed the spread of many fabrication laboratories and makerspaces; a paradigm shift towards personalized fabrication predicted by Gershenfeld in 2005.[8]

TechShop; a maker facility, was initiated in 2006 in Menlo Park, California. It offered public access to high-end manufacturing machinery in exchange for a membership fee.[9] In March 2016, Abu Dhabi Department of Education and Knowledge opened TechShop Abu Dhabi[10], considered to be the first maker facility in the Gulf Cooperation Council area. The aim was to support and encourage innovation within Abu Dhabi community, and nurture "a pool of future innovators whose job will be to increase the diversity of the economy".[11]

Spearheaded by the authors, Zayed University signed an MOU (Memorandum of Understanding) with August 2016. This enabled the authors to develop a design and build elective course at the College of Arts and Creative Enterprises at Zayed University Abu Dhabi campus. The course was successfully conducted in Fall 2016, Fall 2017, Spring 2018 and Fall 2019.

Participants backgrounds

Zayed university, established as 1998, is a federal gender segregated institution for higher education that follows the American liberal arts college system. It is located in the United Arab Emirates (UAE) and has two campuses in Abu Dhabi and Dubai.[12] Zayed University is accredited by the Middle States Commission on Higher Education, and the College of Arts and Creative Enterprises (CACE) holds a substantial equivalence accreditation from the National Association of Schools of Art and Design. The college offers a Bachelor of Fine Arts with majors in Interior Design, Graphic Design, Visual Art and Animation Design, in addition to a joint degree a Bachelor in Multimedia with the College of Communication and Media Sciences and the College of Technological Innovation.[13] 80% of the students' demographics are female Emiratis.

UAE is amongst the few nations that have experienced rapid and far-reaching social change and economic growth.[14] The fast transformation was prompted by gas and oil commercial exploitation, drawing to it various working groups in the late 70's early 80's. 2014 / 2015 statistic data shows the UAE populate to encompass approximately 11% Emiratis to 88% Arab and non-Arab expatriates.[15] Modernization and globalization brought with it increased levels of comfort. It majorly altered the people's life transforming a society that was dependent on fishing and pearl diving into a consumer-based society with one of the highest world's per capita GDPs.[16] "Decades ago, women would weave tents, camel bags and carpets. But after Sheikh Zayed provided all the residents of the Western Region with houses in the mid-1970s, the craft became less of a necessity."[17]

PEDAGOGICAL PERSPECTIVE

Experiential education within the Bauhaus school setting is one the earliest examples of design and build pedagogy connected to its time emerging technology and social context.[18] Kolb defined it to "the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience."[19] More recently, Blikstein described through three main attributes: 1. Enhancing existing practices and expertise, 2. Accelerating invention and design cycles, and 3. Long term projects and deep collaboration.[20] It is seen to offer "a pedagogical alternative to the theoretical, desk-based and media-driven (drawings, digital models) design process"[21] It has been known to "supplants drawings, models, and all forms of representations"[22] for the direct interaction with material and manufacturing processes.[23] The described methodology was further applied and extensively explored in many architectural schools across the globe.[24]

Methodology and Process

The working methodology commences with researching and identifying a problem in the immediate community, and working towards devising, designing and making a spatial response. The process is foreseen to be a recursive one where participants skills advance and grow more sophisticated with increased time. When the course was initiated, the authors foresaw the process going through three main phases:
Phase I: Individual self-empowerment where knowledge is gained on how to use and appropriate the various fabrication tools to come up with design-built solutions.
Phase II: Mastering the used tools, thus moving to the stage of being able to generate creative innovative solutions to identified problems.
Phase III: Ownership where the needed tools are invented and appropriated from the identified problem parameter towards a devised solution.

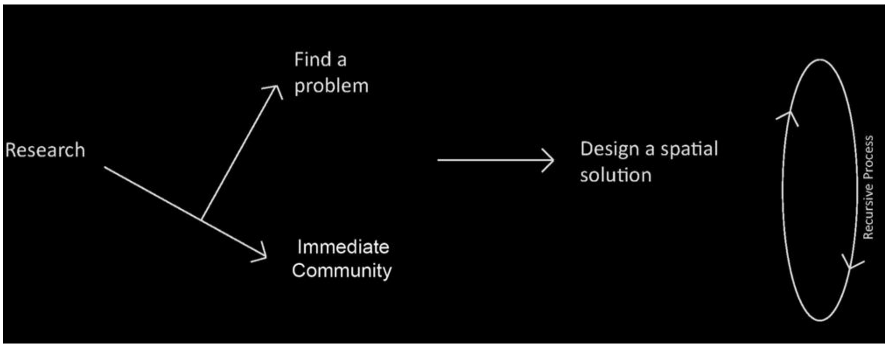

Figure 1. Process overview

Course Overview

The course stemmed from the authors' interest in fabrication, and belief in the necessity to diversify the mainly traditional representations techniques, design processes and methodologies followed at the institution. The intention was to overcome three main limitations currently present on the institutions Abu Dhabi campus:

1. Operational hours; Students are unable to access the design students on weekends and after 5:00pm on weekdays.
2. Limited availability of manual and digital fabrication machinery.
3. The absence of a dedicated lab technician which presents an immense with faculty having to supervise their own students.

Teachshop provided the students with daily late access 7 days a week with dedicated technicians who conducted the health and safety session for the students, supervised the students work, maintained the equipment and trouble all rising technical issues. This allowed faculty to turn their focus and attention to the learning process which embodied four main characteristics that distinguished it from all the other classes conducted within the college on campus premises:

1. Interdisciplinary learning; the course catered to the five college disciplines; Interior Design, Graphic Design, Visual Art, Animation and Multimedia. This immediately altered their conversation, widen

their horizons and forced them to consider the different skills and visions that each major has; thus, created interesting varied approach to the same presented brief.

2. Vertical learning; as oppose to the academic course progression through the university years, the offered elective course had no prerequisites. This allowed students from the different academic years to enroll, creating an interesting working setting where junior, intermediate and senior students worked alongside.
3. Based on need learning; rather than having a defined curriculum, students learnt techniques and methods in response to the immediate need presented by their selected project approach. The became expert in the tools and techniques they chose to utilize and had an overview of the ones used by their colleagues.

The authors opted to negate the drawings which is the main medium they are taught to work with in the university. Scaled mock-ups replaced the traditional technical drawings. In addition, as a result of the makerspace location and setting, the students informally interacted with other TechShop members on a daily basis. This opened their horizons to different views and altered visions, an attribution that is difficult to attain in the traditional university setting.
The above characteristics and condition immediately put the participating students out of their comfort zone, thus creating an invaluable prospect for growth and skill embellishment.

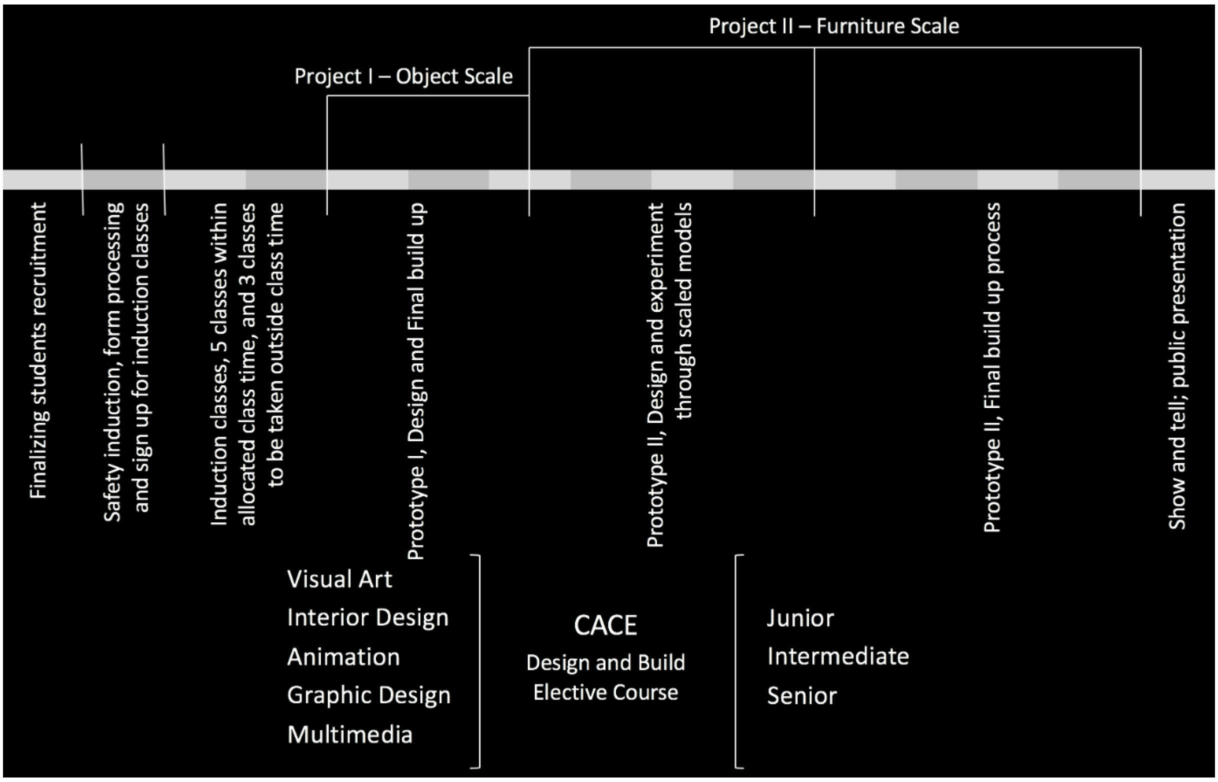

Figure 2. A diagram showcasing the course structure.

The course was structure to adhere to the university semester timeline compromised of 15 weeks;

- Week 1 - 2 was as dedicated to finalizing students’ recruitment and registration process.

- Week 3 - 4 was assigned to mandatory induction classes conducted within the allocated class time. Students selected on a first come basis 5 classes from the list of provided options. Then throughout the semester, they completed another 3 classes on their own time outside the class. The later classes specifically responded to desired skills or encountered problems.
- The first project which was an object scale took place between week 5 – 7.5 with the main aim to break the barrier between students and fabrication machinery allowing them to start exploring and experimenting with newly introduced methodology.
- The second object tool a format of furniture scale. It ran between week 7.5 – 14 in two phases. Phase one initial design, tectonic and methodology exploration through scaled models followed by project final build-up process.
- Week 15 was dedicated to project documentation and public exhibition.

Within both projects, students were asked to deliver a working functional prototype rather than a solution representation. Further, in addition to the traditional limitations present in the traditional classroom, students had two to take into account two additional parameters:

1. They were assigned a budget for the entire semester. Students were not allowed to go beyond the budget or supplement it with additional recourses. This created an interesting condition whereby students had to plan the cost for the final buildup as well as consider the cost of their various experimentation. Gradually and overtime, majority of the students successful optimized strategies to minimize waste and maximize the possible material use and / or reuse.
2. Material tectonics and properties. Although students always work with material and are required to understand and comprehend material detailing making them primary elements of the design. The hand-on learning approach allowed the students to directly interact with the material properties. The projects evolved through a practical understanding of materiality and joining mechanism; an opposition to the traditional design studio material are typically assigned to project concepts. Because of participants novice experience, the focus was directed towards material implementation and prototype realization using established techniques. Even though students were encouraged to think outside the box, the commonly used material was Timber (MDF and Plywood), Metal sheets and Metal square section tubes, and Acrylic sheets. Within this limited palette, students had to address practical issues typically not encountered in traditional academic setting;
    a. The minimal variation in material thickness which affects the woodworking joints.
    b. Variation in discoloration due to the specification difference of the same material when sourced from different suppliers, and
    c. Material mechanics and its ability to withstand external tension and compression forces.

The devised experiential learning process compromised of the following main three steps;

1. Identify a problem or a condition related to either a personal or immediate community need. Respond through quick rapid sketches. Communicate a design proposal through scaled 1:10 model. Understand the geometry, design the material joinery, figure the buildup process through scaled 1:5 model.

Figure 3. Step 1 of the devised experiential learning process

2. 1:1 prototyping. Work with the actual material, testing conditions and mechanism, test the intended functionality or the created conditions, examine the overall structure and prototype stability and work towards building the final outcome; 1:1 prototype.

Figure 4. Step 2 of the devised experiential learning process

3. Position the prototype on the intended site or location appropriating it into the community. Demonstrate a possible solution to the identified condition and visually record its use and representation. Use a series of photographs and a short video as a medium to narrate the entire process from initiation to completion.

Figure 5. Step 3 of the devised experiential learning process. Project by Fatima AlAmeri, Graphic Design, Intermediate level.

Selected Project Examples

It became directed evident from the very early project stages how the maker structure altered and positively affected students' learning process. Informal classroom setting, personal alliance to the worked-on project and presented challenge through the communal collaborative atmosphere are the three main attributes that were evident and identified by the authors in the four cohorts. It was also noticed student's personal systematic growth that accompanied the learning process. This manifested itself through collegial involvement, participatory learning activities, critical dialogue, and innovative thinking.

Below are selected examples;

- College branding in a form a different postcard interpretation. Showcasing an aerial view of the campus, the USB takes of the existing Art and Desing building. The applied colours are inspired by the UAE flag. Used material 3mm MDF and 2mm Plexi glass.

Figure 6. Project by Fatima AlAmeri, Graphic Design, Intermediate level.

- Phone / bag holder, a dual functionality responding to the student's identified specific needs.

Figure 7. Project by Rawdha Alketbi, Visual Art, Senior level.

- Prototype created through gluing timber parts. A simple mechanism was derived from aggregating horizontal and vertical linear timber elements, combined with fragmented circular peices. Simple in appearance, the student utilized the shifting methodology to create an asymmetrical composition. The main challenge was to achieve stability while simultaneously retaining the linearity feeling.

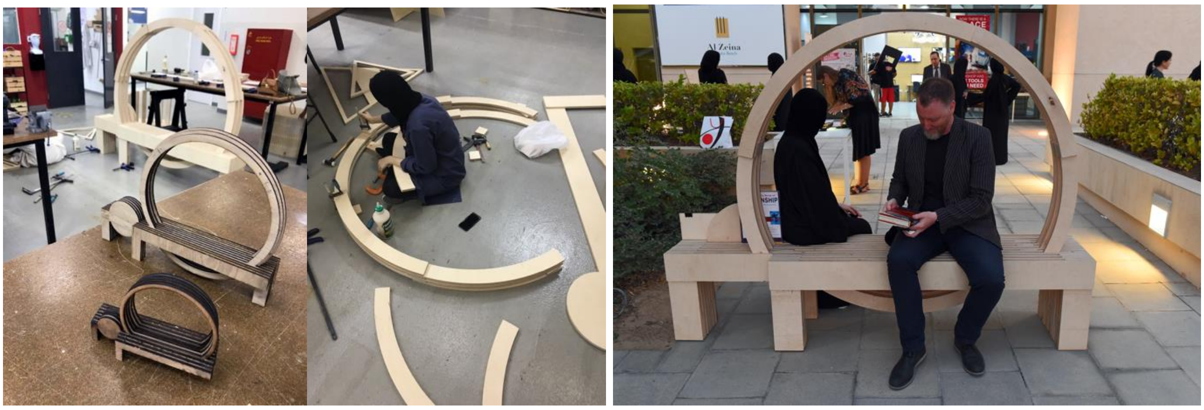

Figure 8. Urban π by Zainab Alblooki, Interior Design, Junior level.

- Prototype's unique aesthetic is a reflection of its assembly mythology; alternating between full and partial elements, which also played a significant role in reducing the overall weight. The initial concept was developed using digital modelling software which was then 3D printed to understand the formal complexities of the proposal. The design proposal was then laser cut as a 1:5 model to understand the fabrication process and most importunately, how to manufacture the 1:1 piece practically, efficiently and economically.

Figure 9. Hexagon by Rawdha AlKetbi, Visual Art, Senior level.

- The simple chair is designed through bending a single plywood sheet to accommodate the concave and convex curves of the basic skeleton. The students used making and testing, and through a process trial and error process to designed the pattern alteration to comply with the needed curvature degree.

Figure 10. Strip by Yafiet Araya, IT student, Intermediate level.

- Through an interlocking mechanism, the student created four elements that allowed for a variation of different setting. The slight variation of material thickness combined with the computerized mechanical milling process created two pieces that are difficult to interlock. This required from the student to go through a sanding process. The piece was finished with a bent timber sheet.

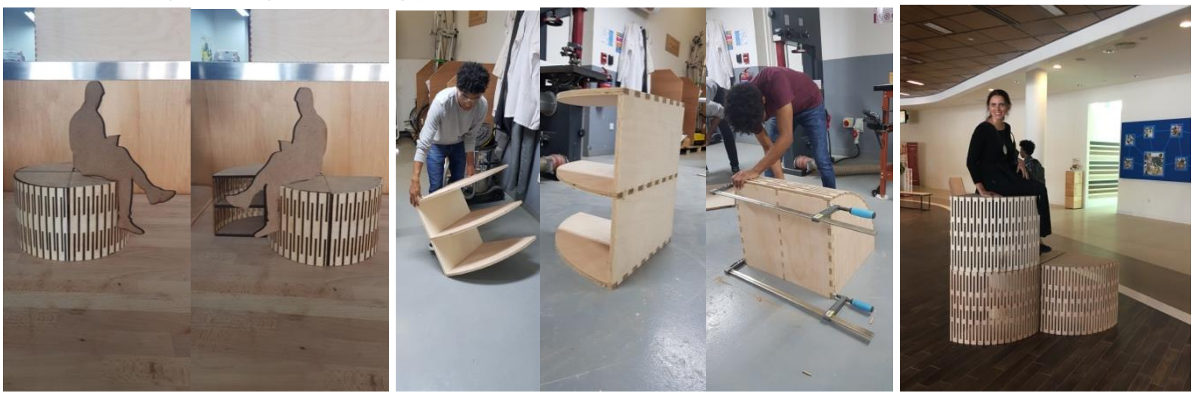

Figure 11. Quarters by Natnael Gezae, IT student, Intermediate level.

BRIEF REFLECTION AND CONCLUSION

It was directly evident how the making process diversified students representation techniques and design methods. The main observed trait was their accelerated learning process, their deeper engagement and involvement level and the self-acquirement of various needed and complementing skills. The course instigated opportunities for personal development and progression through collegial involvement, participatory learning activities, critical dialogue, and innovative thinking. Moving away from the theoretical classroom settings, students dealt with and took into careful consideration real life parameters; such as: budget, materiality, fabrication methodology and prototyping machinery. The cross-disciplinary nature of the work setting along with a multi-level classroom and the interaction with like-minded members from the society, created a rich non-linear based on-need learning environment. In addition, the process itself created an interesting synergy where instructors attended introduction sessions alongside their students, thus confronting the conventional classroom hierarchy. 80% of the involved students completed the course at an accomplished level. The interdisciplinary based-on need vertical pedagogy approach created a condition where that merged the academic level and difference discipline.

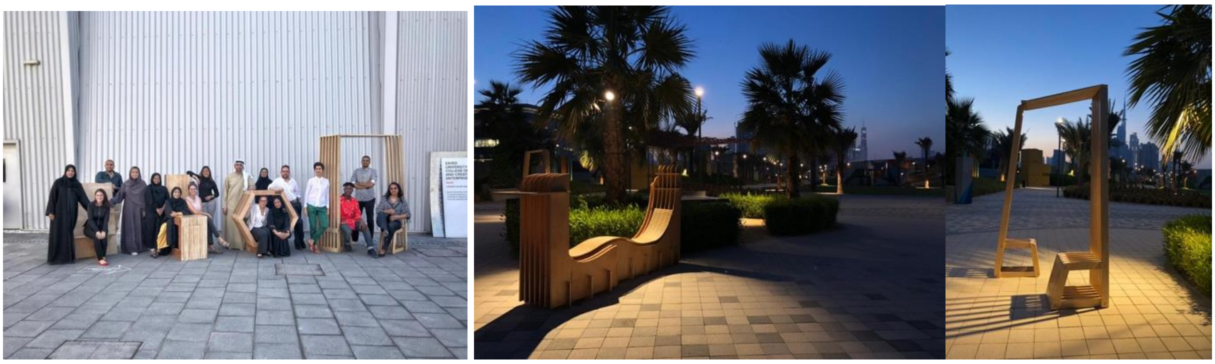

Figure 12. Prototypes exhibits at two main international setting; AlSerkal and Dubai Design Days Exhibit.

The course advocated for the ‘making’ process to supplement the traditional classroom followed pedagogy. Capitalizing on the overall course success, it highlighted the immense benefits gained the adaption of ‘making’ process as pedagogy approach. Despite the overall success, the course presented four adverse attributes:

1. Limited outreach; the gained knowledge was restricted to 15 students in each of the four semester which constitutes the minority of the overall students’ population.
2. Limited knowledge transfer; further embellishment and cross-courses skills’ appropriation were left to the individual students to conform.
3. Limited impact, the skills utilization was limited to the course. Many students perceived the approach when applied to other courses as unnecessary added work and deviation.

Further, despite the present interest from all parties to supplement the novice design and built class with an advance one, its realization is halted due to the small pool of trained individuals combined with the prescribed numbers of elective courses within the programs’ semester plans and the administrative allowance of minimum class enrollment.

Nevertheless, the following statements examples extracted from a students’ blind survey echo the overall success, and presents a testimony to the success of the experimental active learning approach;

- *“It was one of the most precious time that I had during my university journey. Seeing what I did made me proud of myself. Thank you for giving us this opportunity.”*
- *“This course has really helped me in my interior design journey, it opened my eyes to news things and made me more confident to design.”*
- *“This course gave me the confidence to do what is on my mind even though it is hard to accomplish.”*
- *“The course made me see the world differently, and it taught me how to overcome obstacles.”*

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TEACHING EXPERIMENTATION IN THE FIELD OF DESIGN: CROSSING DIGITAL TOOLS WITH ANALOGICAL ACTIVITIES

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METADESIGN AT THE SCHOOL OF DESIGN, POLITECNICO DI MILANO

This paper gives an account of an innovative teaching experience from the Bachelor's Degree in Interior Design, Metadesign Studio at the Politecnico di Milano, School of Design.It is a traditional studio that for years had a static structure, but during recent years, following the preparation of the Massive Open Online Course (MOOC) on the topic of Metadesign, it was decided to review the course setting and insert different elements of innovative teaching.
Metadesign at the School of Design is a fundamental pillar of all the various Bachelor-level design programmes. In the framework of a technical university like Politecnico di Milanothese are shaped according to some central principles:

- Design is not just based on creativity and intuition but also on knowledges that can be transmitted in forms other than the atelier model;
- These knowledges come from the design field itself as well as from science and technology and from social sciences;
- The core of the design theoretical knowledge is based today on reflections, principles, methods and tools originated by the practice itself.

The main focus of the Metadesign studio is on the pre-project research phase: understanding the elements of the context (territory, market, company, stakeholders…), the needs of all the actors involved in the process, and exploring trends and opportunities, to generate new scenarios for concept development.
The design process is inextricably linked to all the elements of constraints and context that characterize the reality in which the product/service will be developed, communicated, marketed and used.
These are the contents of Metadesign and that's the reason why the first on-line course (MOOC) edited by Design School of Politecnico di Milano is focused on these topics.[1]

METADESIGN CONCEPT

If we go back to the definition of Metadesign we can say that it is the design phase that leads to the formulation of the project concept through a research path that creates a synthesis between project objectives, technological and productive constraints, market context and consumption trends of the reference social communities.

Μετά, in Greek, means through, after, behind, between. Over time it has acquired further meanings, such as besides, or beyond, or above, or "more general" that predates or reflects at a more abstract level on particular applications.

In the design field, Andries Van Onck (a student at the School of Ulm and later a professor of many generations of designers), was the first to elaborate a definition of “Metadesign” in 1964, meaning “initial speech”, “more general” and “more abstract” and “the particular project pre-trial”: “it’s about the visual-formal language design” that can be adopted in a later moment to individual case needs.

Due to this methodological nature, Metadesign assumes an instrumental role along the entire design process: it determines the sequence of actions, "programmatic nature"; the action’s contents, "what to do"; and the specific discipline to be applied, "how to do it".

The validity of this concept is originally based on the assumption of design as a scientific process, able to address contemporary complexity. Instead of the simple progressing by intuition, operational design methods allow complex problems to be processed by deconstructing them into more easily processed sub issues.

The modern movement in architecture and design contemplated the typical rationalist concept of considering design as a science; this ambition to achieve a scientific driven planning process, reached its full maturation in the 1960s and ’70s.

In his 1962 *Introduction to Design*, Morris Asimow, Professor of the Faculty of Engineering at the University of California, developed a design philosophy that aimed to define the basic principles, the methodology and the criteria for evaluating the validity of the results. In this framework the term *Design Science* was first recorded. This was adopted by Buckminster-Fuller shortly after Gregory returned to it in 1966.

In the field of architecture, Christopher Alexander published notes on the synthesis of form in 1964 and addressed the problem together with other researchers of the constitution of a scientific environmental morphology.

In 1965 Bruce Archer wrote *Systematic Methods for Designers* in which, in addition to function and production, the market also appeared to be also closely linked to the concept of need.

In 1970, in *Design Methods: Seeds of Human Futures*, Christopher Jones described and synthesized from previous studies a set of thirty-five methodologies transferred from different disciplines; even in its various configurations the model of the design process that emerged from these and other studies of this period is sequential, and fundamentally divided into two distinct phases: the definition of the problem and the solution of the problem. The first phase has an analytical aspect in which all the elements of the problem are defined, and all the requirements are specified. The second synthetic phase is when the different requirements are put into the system in order to find a solution.

This apparently simple and objective model breaks with the crisis of modernity. These texts effectively testified to the climate of trust in science and in the method that characterized all project disciplines during this time.

Starting from around the seventies the methodological optimism has given way to reconsiderations and redefinitions of their field of application. This is based on the recognition of the non-scientific nature of the design process and of the impossibility of a design methodology capable of tackling design in an automatic way and, finally, of the acknowledgment of the sterility caused by the separation between methodological reflections and design practices.

Among the first to react to these excesses, was Christopher Alexander himself, considered to be one of the founders of design methodology. The crisis of the sequential vision of the design process as well as the recognition of the impossibility to divide the analytical and synthetic activities in a clear way, led to new, more complex, models.

In 1969 in *The Sciences of the Artificial,* Herbert Simon made a distinction between nature and artificial sciences, and, starting within this distinction, he expressed the need for a design science based on principles other logic, rationality and certainty, and inevitably methods typical of the Natural Sciences.

Nowadays we record a progressive shift towards more barycentric positions, within the dichotomy of design as art and design as science, in contrast to the idea of design as applied art or as science a third approach introduced by Donald Schon in 1983. This presents design as a reflective practice, which is the capacity of building theoretical and general knowledge starting from practice.

This particular attitude is actually current with the general need for research and educational institutions to continue with function based on their traditional deductive approach, first theory and then as a logic consequence practice, to be able to better face the complexity of the real world.

Thus, the importance of reasoning as to how to form this new figure of the reflexive professional emerged, as well as considering the ways with which to form, stimulate and combine practical activity and reflection on action as the basis for generating new knowledge in the field of design. A vision of design emerged that is capable of producing knowledge through its own ways, which do not necessarily follow the scientific ones. In this way design research assumes a phenomenological perspective that observes the reality of the project in order to derive general rules and principles that continuously evolve together with the adopted point of view and the reference context. It is a vision of design as a thoughtful practice that elaborates and codifies new knowledge, starting from a professional action; the codification of a tacit knowledge based on experience.

To conclude, Metadesign today has abandoned its aspiration for a unitary methodology to assume a fragmented and heterogeneous configuration. Making Metadesign today means working on dimensions that are often purely subjective and qualitative, looking for complex and articulated identity projects and working on differences and specificity rather than purely quantitative and standardized parameters. This contemporary idea of Metadesign is enriched with cultural and emotional values in addition to the quantitative and rational values of the system.

Nowadays, Metadesign maintains its key nature as a theoretical and methodological approach to design practice but also plays an important role in some application fields, characterized by the shift from the design of the single project to the design of a project family.

INNOVATIVE TEACHING: NOT ONLY MOOC

There are historical moments in which the role of education systems is not simply replicating the existing social system but creating the conditions in which new worlds can be invented. When we propose a rethinking of the aims of education, we cannot help but reflect very seriously again on its methods and its styles.

We must engage in the learning experiences of which we are the protagonists, observe them with more awareness, and redesign them to make us be inspired by the great wealth of pedagogy, but also of the opportunities of the digital world to create classroom realities that are increasingly active, collaborative, creative and, above all, more and more effective.[2]

Innovative teaching requires that, in addition to gaining knowledge of the subject, students are also provided with the tools to maximize their acquisition, expression and implementation in their professional life at the end of their studies.

Going beyond the content means to combine traditional teaching, all those methods that facilitate learning, and to use codes and tools that are part of the methods of communication and expression of the students.

What are the transversal competences that can help students optimize their learning and memorization methods? What are the skills that can differentiate a recent graduate in the world of work and give greater impetus to her career?

Where to start to innovate our teaching? But, first of all, what does it mean to do innovation in the classroom?

Starting from the first MOOC focused on Metadesign edited by the Design School of Politecnico di Milano, the teachers of one of the Metadesign studios decided to innovate the studio format, adding off-line activities linked to the MOOC content.

"Introducing Metadesign" is a three-week module with a methodological soul. The goal is to present all the design phases: reflecting on them, organizing activities, and explicating every cognitive step with the aim of finding, developing and internalizing one's work method.

The "Introducing Metadesign" stems from the need to transfer a methodology, a consolidated research practice able to support the design process. The design process is inextricably linked to all the elements of constraint and context that characterize the reality in which the product/service will be developed, communicated, marketed and used. The course structure foresees the reconstruction in phases and successive elaborations of all the elements of context that come into relation with the object of the design process (product, space, service, communication artifact…) influencing its characteristics and creating the "platform" of elements that make its development possible. The set of contextual elements is the scenario on which the construction of the design brief is based, that is the explanation of all the elements that contribute to define a new product. This is not the result of a deterministic vision of design as a direct consequence of the elements of context ─ production, resources, market, context of use ─ but the formalization of a practice that in the Italian context has historically fueled the ability to continuously and constantly innovate. Design research thus becomes the tool through which the awareness of the system of available resources is built by creating an organized knowledge platform, a Metadesign, which already contains all the elements defining the product.

The course is divided into three weeks, each one examining a specific topic in depth: an historical and context analysis; an overview of tools and the process of Metadesign approach; and a final exploration of practical applications of such approaches in different fields of design, from fashion to cultural heritage, from products to interiors. Each week is divided into short lectures, bibliography and additional materials, a weekly quiz and a being active section.[3]

CROSSING DIGITAL TOOLS WITH ANALOGICAL ACTIVITIES

The Studio aims to teach a path through which the students are guided to the acquisition of specific knowledge for the design process, as well as for learning and experimentation with tools and techniques for reading, interpretation and ideation of specific spaces of use.

This path is focused on the places linked to the design of hospitality in relation to a sequence of different "points of view" from which to look at the genesis and evolution of some types as well as the emergence of innovative typologies.

The students will be introduced to an understanding of the dynamics that invest the spaces for accommodation (from the historical evolution to the typological analysis; from the study on trends to

paradigmatic case studies) to then arrive at the construction of a "concept" of the project in a specific context of the city of Milan. In particular, it deals with the design of hybrid spaces, between the spaces of low-cost housing and spaces dedicated to study and work.
The workshop activity is supplemented by a series of contributions from external guests regarding the issues concerning Metadesign.
The studio had maintained a static and traditional structure for years, consisting of:
(a) lectures
(b) reviews of different groups of students who carried out the project of designing new formats of low-cost hybrid housing (eg hostels + student residences) in existing structures in the city of Milan
(c) study of the bibliography, evaluation through a written test.
Starting in the academic year 2018-2019, the course also includes an innovative teaching component, delivered through the "Introducing Metadesign" MOOC (d), specially set up for the Metadesign Studio and described above. The general indications for the students were to appreciate online content and independently explore the specific topics covered by the videos.
The teachers of one of the parallel sessions of the Metadesign Studio decide to review the course setting and insert different elements of innovative teaching, consisting of:
(e) classroom exercises on the content of the MOOC
(f) short lectures and assessment of the content of classroom lessons via clickers
(g) collective presentations of the project work
(h) comparison between the MOOC content and the design path carried out by each group.

In particular, the first week of the MOOC focused on the analogical activities and the theoretical aspects of Metadesign. The class was always split into groups and the teachers asked the students to discuss the video topics using other materials to support their thesis, e.g. books, texts, images, information. During the first activities the teachers gave the materials to the teams and asked the students to research and highlight the most interesting references to discuss with the other classmates. One of the most interesting aspects of these activities was the debate generated by the students themselves.
During the semester six activities were carried out in class relating to the MOOC, through which themes and aspects presented in the videos the students had viewed at home were studied in depth. The size of the groups varied with each activity, sometimes smaller and sometimes larger. The last exercise also linked the MOOC issues with the space project dedicated to a low-cost housing service carried out by students during the studio.
The digital tools support the teaching activities, but they are not enough without a structured set of activities focused on collaborative learning. The engaged-learning activities are unique in that they rely on collaboration amongst peers and lend themselves well to collaborative/group-learning opportunities. Studies have shown that students who meet in learning groups at least once a week show significant improvements in learning (Marzano, Pickering & Pollock, 2001).
The analogical and digital mix was certainly a strong feature to carry forward in the coming years. The relationship between MOOCs, classroom activities and project development should be strengthened with the common aim of enhancing the skills related to Metadesign, its history, its tools and its processes.

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SHARED MENTAL MODELS AND ZPD IN TEACHING AND LEARNING ARCHITECTURE

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INTRODUCTION

We know that in the architectural studio students learn how to think like architects, but we don't know what this knowledge is exactly, nor how we share it. From the educational point of view, pedagogy in architecture is still insufficiently unequivocal and we also know little in regard to the coach's role as a 'more knowledgeable other'[1]. The studio master himself admits "I can tell you that there is something you need to know, and with my help you may be able to learn it. But I cannot tell you what it is in a way you can now understand… You must trust me"[2].

This paper focuses on knowledge sharing in coach-student teams in the architectural studio at the Israel Institute of Technology (Technion), at two specific points in student architectural education – the 1st and 3rd year studios. According to Dorst[3] 1st year students are 'novices', engaged in finding the ‘rules of the game’, whereas 3rd year students are 'advanced beginners' who have already developed "recognition that design problems are highly individual and situated". Both studios are headed by 'expert' coaches who are mostly practicing architects, usually possessing little or no pedagogic training[4]. We know very little about how students evolve from one stage to the next and how knowledge (mental models) is shared between the expert and the students.

Thus, this paper establishes clarifies a certain aspect of shared mental models in the studio utilizing Vygotsky's ZPD theory[5] as a conceptual framework in order to contend with the knowledge gap. The ZPD and scaffoldings metaphor is extended in order to clarify the development in knowledge construction and sharing process, as well as the coach's evolving roll in the studio.

The Studio

According to Schön[6], architecture cannot be taught, however, it may be coached. Formal architectural knowledge and skills may be ingrained by means of apprenticeship and practice; although, architectural thinking - the ability to conceptualize and identify valuable architectural solutions - is produced by knowing-in-action, reflection-in-action and reflection on reflection-in-action[7], which are still obscure. Moreover, architectural problems are ill-defined, meaning that unlike 'regular' problem solving - which itself requires several intermediate steps[8] - an architectural 'problem' has multiple solutions and there is no guaranteed procedure of obtaining a solution.

In the past, architectural skills were acquired through apprenticeship under a ‘master’ who passed on her/his knowledge to apprentices as an inclusive whole. Since the 19th century, the studio or *atelier* (workshop) has been the format of choice for teaching architecture in the western world[9], although not in the exact form currently implemented. Presently, the studio is a universal institution at the heart of

professional design education in many fields, based on the assumption that interaction among students in a group setting facilitates a free flow of ideas[10]. Studios must be attended in sequence, as projects are incremental and the level of performance in the studio presupposes mastery of specific skills, competencies and domain knowledge deemed to have been accrued during the previous semesters[11].
The studio is usually run by one or two studio masters (coaches), with 10-12 students per coach, meeting twice or three times a week in a dedicated work space for approximately five hours, during which coaches discuss the students' work as well as associated theory, precedents, applied science topics, and so on[12]. In the course of their 8 or 10 semesters, depending on their specific track, students interact with a large number of coaches, however, more often than not, coaches cannot define exactly what it is they are trying to impart to the students, nor what the best academic approach to take in order to share their expertise[13]. Compounding the predicament, during studio meetings coaches are rarely able to spend more than 20 minutes talking to any individual or team and rarely engage in actual design with the students.

Knowledge Construction and Mental Models

The architectural design process is a kind of experimentation involving reflective 'conversation' with the design situation and products[14]. During this process, the problem solver is compelled to attempt 'keeping in mind' a wide variety of variables, including cues perceived by visual apprehension, appreciative judgments of quality and apprehension of spatial gestalts[15]. In addition, when comprehending information, particularly during reflection-in-action[16] a Tacit Coefficient[17] is applied to the information received, allowing new concepts to be reconciled with previously existing knowledge. Thus, the interaction between knowledge of experience and rationality enables individuals to build one's own perspectives on the world and actions within it[18]. These internal structures or ***mental models***[19] help describe, explain, recognize and remember relationships among components of the environment, as well as to construct expectations for what is likely to occur next[20].

The Zone of Proximal Development (ZPD)

The ZPD is the "distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult [coach] guidance or in collaboration with more capable peers"[21]. Within the ZPD, knowledge is shared by means of scaffoldings[22] which are prescribed by the project and its objectives (academic and architectural) on the one hand, and on the other, are tailored to each student. ***Scaffolding*** describes a support structure for gaining knowledge, know-how and proficiency in the study area, which is gradually removed or faded over time[23].
In the studio setting, scaffoldings are mutual rather than unidirectional[24] and when the coach helps the student expand the space within which solutions can be explored, the student's mental models evolve toward new ones that are shared with those of the coach, advancing and extending the ZPD. This collaboration enables a state of *intersubjectivity*[25] or ***sharedness*** where the team-members collaboratively co-construct knowledge and dynamically provide scaffolding for each other[26]. Sharedness is achieved by means of *transfer* which occurs when the team mates' mental models are similar, overlap, or where common features are identified between the two representations[27].

Process

Student and coach utterances collected in the course of the desk critique[28] (crit) and project reviews serve as the main data source. The studied teams include a total of 11 participants, three coaches + seven students in Year 1; and three coaches + eight students in Year 3 (n=21). The 1st and 3rd year studio desk crit protocols were video-taped during 2016, 2017 and 2018.

Crit protocols document the discussion between the two teammates, were the student explains her/his design process and considerations, enabling the coach to provide assistance and advance the project. The crit utterances reveal a glimpse of the speakers' mental models in regard to the matter at hand while in discussion with the coach (***inter***-*psychological* or dependent level[29]), which are then compared with the student's utterances during the project review (***intra***-*psychological* level[30]) (The review protocols document only the student's utterances in regard to the project). During the review students present the work in their own words - which naturally are influenced by what she/he gleaned from the coach's statements during the crit discussions. Sharedness is achieved by means of transfer which occurs when the team mates' mental models overlap, or where common features are identified between the two representations.[31] The term 'sharedness' in this context is deemed appropriate to describe a close resemblance, although it does in no manner indicate full similarity. Thus, verbalizations uttered by the coach during the crit which were then used by the student in the course of the review served as sharedness indicators. In addition, in the framework of member checks[32], both teammates chose utterances or expressions designated as important by either or both of them. Figure 1 illustrates the crit handling from collection until final analysis:

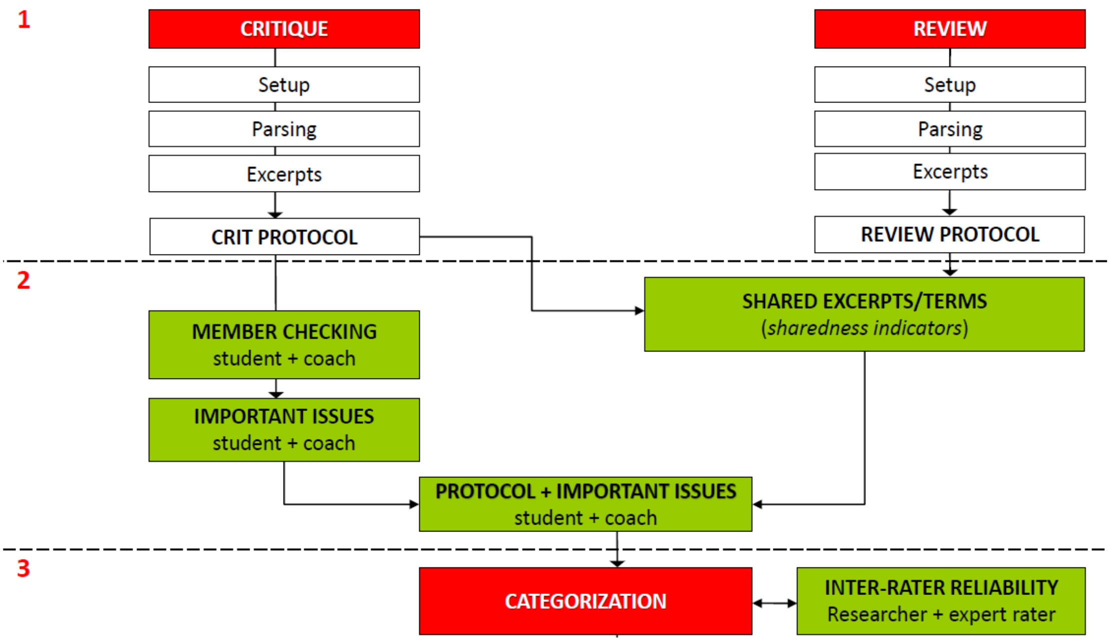

Figure 1 – Crit handing and analysis process

- Step 1 – collection of the crit/ review session verbalizations (recordings), transcription, parsing and excerpts. Excerpts (usually a term or expression) from the coaches' utterances were identified in each crit segment and then compared to the students' review which took place days or even weeks later. Granted, the nature of this research cannot indicate whether a certain term or excerpt were uttered for the first time by this specific coach, or how 'meaningful' (see Goldschmidt, 2005) these are, however, use of certain terms by both coach and student are deemed to indicate sharedness.

- Step 2 – work with the participants to produce a member-checked protocol including important issues and shared utterances / terms, providing a quick indicative note on its general topic (see Barzilay & Elhadad, 1999; Marcu, 1999).
- Step 3 – categorization of scaffoldings including vetting (inter-rater reliability) by the researcher and another expert.

FINDINGS

Emergent Scaffoldings

Literature does provide several taxonomies in regard to shared mental models mental in the sphere of design[33], although not specifically in architecture. Here, an inductive analysis of the protocols produced a scheme of four emergent categories[34]: 'objective', 'tactics', 'rationale' and 'framing', which in effect, constitute the scaffoldings used by the teammates to share knowledge.

'Objective' scaffoldings relating to the overarching project goal, Long-range objectives and ways of pursuing them that affect the system as a whole - or top-down thinking[35] - (*what?*).

'Tactics' scaffoldings concerned with shorter range goals, generally affecting only part of the overall project. Tactical planning (*'how?'*) tends to flow from the bottom up[36] and often refer to the *means* of achieving the tactical and strategic goals.

'Rationale' utterances promote critical conversations among designers and other project participants[37], supplementing and reinforcing the *different, redundant* and *synergetic* scaffoldings[38] needed to contend with wicked design problems.

'Framing' reflects an intuitive activity performed by the problem solver in order to contend with the task at hand in a holistic manner[39]. Framing essentially involves selection and salience. To frame is to select some aspects of a perceived reality and make them more salient. Salience means making information more noticeable, meaningful, or memorable to the audience[40].

Shared Mental Models - 1st Year Studio

Lack of examples, frames and mental models required to apply constructive forethought in the design process compels 1st year students to attempt to heuristically deduce a method of achieving their goal[41] based on familiar architectural solutions. Thus, as predicted in literature, rather than employing a comprehensive (metacognitive) strategy, the 1st year ZPD is inclined towards a tactical piecemeal approach. Interestingly, this inclination is not only due to the students' novice problem solving activities, but rather also the coaches' intuitive reaction to the students' rudimentary abilities.

Both coaches and students make use of all the categories in order to share mental models and knowledge, although in very different ways and measures. 'Rationale' is the most commonly used category amongst 1st year students, intuitively trying to translate the coaches' comments into clearer internal images and boost sharedness. Nevertheless, 'rationale' is not always sufficient to bridge the gap between the mental model proposed by the coach and the student's internal representation. Usually, in response to this approach by the students, 1st year coaches devote most utterances to 'tactics'. The term 'tactics' here corresponds to a great extent to Snowman's[42] 'military-like' description of tactical learning pertaining to short-term goals and activities, where the learner complies with instructions, while attempting to understand the ‘rules of the game’[43]. Consequently, the 'tactical' knowledge accrued by the novice learners is mostly applied 'directly' with little (or no) movement up

the ladder of abstraction[44] towards 'objective' or 'framing', which involve naming as well as a strategic aspect referring to the overall *'what'* of the project.
Clearly, framing/naming abilities, as well as designating a project objective require a metacognitive "deep approach"[45], including assessment, planning and coordinating which has yet to crystalize in 1st year students. Therefore, 'framing' and 'objective' scaffoldings are scarcely used by 1st year studio and almost never by the students.

Shared Mental Models - 3rd Year Studio

3rd year crits encompass all categories and levels of abstraction. 3rd year students possess schemata on basic architectural processes and concepts, allowing apparent reciprocity between the teammates and enabling students to be more proactive in the crits. Granted, 3rd year students are by no means 'experts', but they do demonstrate thinking patterns which are closer to the 'top-down' conceptually-driven process characteristic of experts. In this year, 'rationale' is the most used category, although this time by *both* teammates, closely followed by 'tactics'. 3rd year students' ability to move freely between 'tactics', 'objective' and 'framing'[46] shows higher metacognitive involvement[47]. This is part and parcel of the evolution from an ***inter****-psychological* (dependent) level in the 1st year to an ***intra****-psychological* level (3rd year) where the learner assumes increasing responsibility for learning[48]. *Intra-personal dialogue* may appear to imply an introverted process adversely affecting the ZPD and sharedness between learner and coach, however, in effect it rather increases sharedness as students transform their inner speech[49] into declarative knowledge. Skillfully, by mirroring and often using the students' own terms, coaches allow the students to lead the conversation and then 'arrange' their utterances into scaffoldings, leading to increased sharedness as noted by De Guerrero & Villamil[50]:

> "As the ZPD lesson progresses, the expert’s discourse strategies become less directive and less explicit in response to the learner’s gradual assumption of task control. Throughout the lesson, intersubjectivity emerges between teacher and learner… reflecting a shared perspective of the instructional situation."

Interestingly, both in the 1st and the 3rd year, 'rationale' still accounts for approximately 40% of all utterances, in an attempt to bolster sharedness and fill-in the gaps between the apparent shared mental models. Remarkably, 40% 'rationale' appears to constitute a 'necessary measure' required in order to clarify and support utterances made under the other categories, i.e. in order to advance mental model sharedness.

Coach-Dependent vs. Team-Dependent ZPD

Thus, it is possible to assert that the shared mental models evolve from year 1 to year 3 both in quantity and complexity, encompassing all four categories and all levels of abstraction. Naturally, shared mental models are more ubiquitous after more than two years of training, however, the fact that the coach's role in the ZPD changes so dramatically over this period is telling. The coach transforms from 1st year **leader and source of authority**[51] - proposing scaffoldings in order to establish the scope of the ZPD and maintain its momentum - into **mentors and facilitators**[52] providing scaffolding where needed and sought. In this manner, whereas in the 1st year the ZPD and sharedness are **coach-dependent**, developing **form within the project outwards**, by the 3rd year the ZPD and sharedness are **team-dependent**, developing both **inwards and outwards**[53], limited only (if at all) by the student's attentiveness, resolve and hard work. Remarkably, little by little over the semesters, the coach moves from the center of the ZPD to its outer rim, beckoning the students towards a variety of possible solutions outwards, as well as inwards[54]. That being said, regardless of the obvious increased shared mental models, 3rd year students have yet to reach a stage of internalization or automatization, where assistance is no longer needed[55], so they still require a ZPD structure, scaffoldings and increased mental model sharedness in order to progress.

Scaffolding Space

Architectural knowledge acquisition and sharing in the ZPD requires *near and far transfer*[56], achieved by rapid and seamless transition between *different, redundant* and *synergetic scaffoldings*[57]. Initially sharedness between teammates is limited, due to the gap between the scaffoldings *proposed* by the coach and those *internalized* by the students. With time, as suggested by Schön, learning-by-doing, reflection-in-action and dialogue enable mental models to be built-up around the internalized scaffoldings by means of *inter-contextualization*[58]. Inter-contextualization means that common features are identified between two representations[59], increasing mental model sharedness and narrowing the distance between master and learner.
However, as asserted, shared mental models *cannot* be completely congruent, due to the indwelling nature of the representations, tacit coefficient, etc. Thus, a *Scaffolding space* is defined between the proposed and internalized scaffoldings enabling variation between the teammates' mental models. In the case of scaffolding space, the inter-contextualization refers to the distance between the coach's mental models and the student's mental models.
Figure 2 illustrates the average categorized utterances by coaches vis-à-vis student utterances in each of the years. The coaches' utterances (appearing in brown) define an 'area' of *proposed* scaffoldings between 'rationale', 'tactics', 'objective' and 'framing'. The students' utterances (again by category), indicate the 'area' where they have accrued and applied knowledge. The overlapping areas in the diagrams allude to the nature of the shared mental models, showing that In Year 1, sharedness or shared scaffoldings occupy a relatively small part of the proposed scaffoldings, whereas by Year 3, the internalized and proposed scaffoldings overlap to a great extent = increased sharedness.

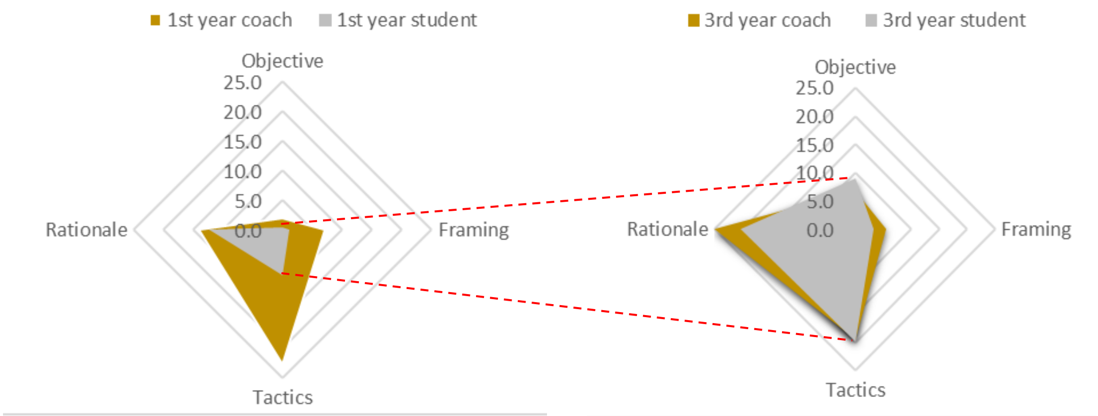

Figure 2 – Development of Scaffolding space from Year 1 to Year 3

When presented side-by-side the diagrams in Figure 2 show the development in scaffoldings and the scaffolding space over time from Year 1 to Year 3. As previously argued, in Year 1, the ZPD develops from within outwards, where the coach provides a wide range of *different* and *redundant* scaffoldings and courses of action, although to a great extent these scaffoldings remain 'unused' as it were. Furthermore, in Year 1 coaches' 'tactics' utterances (most used by 1st year coaches) are remarkably more extensive than the 'tactics' utterances by students, and 'framing' utterances appear completely beyond the 1st year students' ZPD. By Year 3, with the evolution in the coach's role from leader into a guide or mentor, scaffoldings are 'tailored' by the coach to suit the specific student and project, resulting in a relatively narrower scaffolding space or gap - as evident mainly under the 'tactics' and 'objective' scaffoldings (Year 3, Figure 2). It should be noted that in the 3rd year students use more 'objective' utterances than coaches, producing a scaffolding space which could be construed as a 'converse scaffolding space' so to speak, where the coach does not match the students' utterances. This notion is completely erroneous. The scaffolding space is intended to accommodate the teammates' shared mental models, whether provided by the coach as in the case of 1st year 'tactics' utterances, or *withheld*, as in the 3rd year 'objective' instance.

The scaffolding space takes into account the idiosyncrasy of each individual's mental models and provides the students latitude to crystalize their own on the basis of the shared knowledge. Interestingly, coaches regulate their use of *different, redundant* and *synergetic scaffoldings* as defined by Tabak, however, it is the specific student's scaffolding space which determines whether the exchange between the teammates constitutes *near or far transfer*.

CONCLUSION & PRPOSED FURTHER RESEARCH

The scaffolding space is a space of potentiality wherein students "juggle variables, reconcile conflicting values, and maneuver around constraints – a process in which… there are no unique right answers and no moves that have only their intended consequences"[60]. One would assume that the asymmetry between the mental models cultivated by the coach as opposed to student mental model would thwart sharedness and learning, but intriguingly, the participatory process means, among other things, that learning is mediated by the differences of perspective among the co-participants[61]. In effect, the difference or 'distance' between coach and student, and their respective skills, knowledge and problem-solving techniques allow development of a reciprocal learning sphere - a ZPD.

This work raises several implications which require consideration and further research. As demonstrated by the 3rd year teams, later on during their training, students begin adopting and adapting a team-of-one modus (after Goldschmidt, 1995), where the coach accompanies rather than leads the student. This aspect is intriguing for multiple reasons. Assuming that by graduation the students are sufficiently skilled to self-regulate their own design process, a question is raised regarding the 'team' aspect of this work. More information is required on 5th and 6th year students, their mental models, how they learn and problem solve as well as the coach's role in their ZPD in its most evolved form. A comparison between the early and final stages of training will enable the coach to position his/herself more effectively in the ZPD, possibly modifying the existing positions described herein. Last, but not least, after explicating (albeit slightly) the matter of shared mental models, supplementary knowledge is necessary on non-shared mental models, i.e., where there are no shared mental models or where mental models are incongruent. Understanding where sharedness breaks-down will be invaluable.

Hopefully, this research may serve to advance these, and potentially other aspects of learning and teaching architecture.

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23 Clinton & Rieber, 2010

24 De Guerrero & Villamil, 2000

25 Rommetveit, 1985

26 Puntambekar & Kolodner, 2005

27 Anderson et al., 1995; Reed, 1993; Sternberg & Frensch, 1993

28 Discussions of student work, known as a 'critique' (crit) may be in the form of a one-on-one dialogue at the student's desk (Goldschmidt, 2002; 2011) or consist of a group conversation or review involving the entire class (Oh et al., 2013). Crits in this work refer to one-on-one desk crits during the semester.
29 Gallimore & Tharp, 1990
30 ibid
31 Anderson et al., 1995; Reed, 1993; Sternberg & Frensch, 1993
32 Lincoln & Guba, 1985; Manning, 1997
33 E.g. Mohammed & Dumville, 2001; Mathieu et al., 2000; Kraiger and Wenzel, 1997; Badke-Schaub et al., 2007
34 Charmaz, 2005
35 see Ackoff, 1974; Curry, 2014; Kleinman, Luh, Pattipati & Serfaty, 1992
36 Ackoff, 1974
37 McCall, 2013
38 Tabak, 2004
39 Goldschmidt & Rodgers, 2013; see also Dorst & Cross, 2001; Cross, 2004, 2011; Lawson, 2004 & 2006; Lawson & Dorst, 2009; McDonnell, 2016
40 Entman, 1993
41 Dixon & Johnson, 2011
42 Snowman, 1986
43 Dorst, 2010
44 Schön, 1987
45 Biggs, 1988
46 Similar to *orientate - solve – evaluate*, see Goel & Pirolli, 1989; Newell & Simon, 1972
47 See for example Cross, 2004
48 Gallimore & Tharp, 1990
49 Vygotsky, 1987
50 De Guerrero & Villamil, 2000, p. 54
51 Goldschmidt, Hochman & Dafni, 2010
52 ibid
53 see Neisser, 1976
54 2nd stage of the ZPD evolution according to Gallimore & Tharp, 1990, see p. 21
55 Gallimore & Tharp, 1990
56 Barnett & Ceci, 2002
57 Tabak, 2004
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BILGE KARASU'S *FEAR WITH VARIATIONS* AND THE STUDIO FOR POTENTIAL ARCHITECTURE

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INTRODUCTION: *FEAR WITH VARIATONS*

Bilge Karasu (1930-1995), one of the leading authors in contemporary Turkish fiction, completed his unparalleled experimental piece titled *Fear with Variations* (*Çeşitlemeli Korku*) in 1974. Although he seems to be inspired by madrigal form of Renaissance music and mainly "composed" his text for five human voices, *Fear with Variations* can hardly be narrowed into any formal category. Moreover, Karasu wrote his prose *Fear with Variations* in a poem-like structure in four columns akin to avant-garde writing, which reminds of Stephan Mallarme's *Un Coup de des Jamais N'Abolira le Hazard* of 1897, the precursor of modern graphic poetry. Although *Fear with Variations* is Karasu's only "direct" experimental and musical work, some texts in his book *Kısmet Büfesi* [*The Buffet of Fortune*] seem to be, to a certain extent, musically constructed.[1]

According to Aldous Huxley, a madrigal is neither a *song* –because it does not repeat from one stanza to the other a melody– nor an *aria* –because this form is written for a soloist accompanied by other instruments–. In the madrigal, all of the five (or six, even more) sounds are equally important unlike the aria in which one or two melodic themes modulate and return to the beginning. In other words, says Huxley, there are no systematic returns and repetitions in a madrigal; it is rather choral tonal poetry written in counterpoint.[2]

What is unique in *Fear with Variations* is as follows: These separate blocks of words/durations are structured in such choreography that, the text resembles a madrigal, but formally it has nothing further in common with a madrigal.

Mehmet Nemutlu wrote in his essay "Simultaneity, Texture, Form: On Probable Musical Imagery in Karasu's Writing" ["Eşzamanlılık, Doku, Biçim: Karasu Yazısında Olası Müzik İmgeleri Üzerine"] that the text was tramnsferred to a type of note sheet to be performed with sound. Each sound/partition emphasizes, repeats, derives, augments, variates, embellishes, echoes, spatializes certain part of the text in a simultaneous flux to create a playing space / a space for play. According to Nemutlu, the polyphony of the text is achieved by three main techniques: Replication, extension and distribution.[3]

What made me put this experimental work on the architectural studio agenda in Spring 2018 semester was the dramatic findings of Ege Berensel, a video artist and a film theoretician, of the tapes of Karasu's recordings in dump, which also included his 7 page type-written copy of *Fear with Variations.*

Art critic Cem İleri, states in his book on Bilge Karasu that:

> "[It is in poetry that] the *word* puts itself as form, and what corresponds to the word in poetry is, in Karasu's prose, *meaning* that puts itself as form; hence, *writing* is not the form that captures *meaning*, but writing produces the *meaning* what it captures." [4]

Karasu considers himself as an architect, as a space organizer, as a designer who tries to create empty spaces for the reader to exist, move, and play.[5] What Karasu demands from the reader is that, the reader should adopt the authors multilayered perspective, abandon the one-sided habit of reading and perceiving; also stop listening to a single narrator and admit that this is the only way to begin to understand Karasu's texts.[6]

İleri claims that Karasu aims at writing the temporality of music by his *Fear with Variations*; and by this, at finding in the field of literature, the equivalents and similarities of the possibilities of the relationship that music establishes with the audience.[7]

According to İleri, Karasu's entire literature is based on three major concepts: Spatiality, meta-textuality and simultaneity. In addition, incompleteness is apparent in the body of his work; it is as if the author is aware of the fact that the only text we possess is the remaining version of all the other possible, unmade versions.[8] Thus, İleri assumes that, any of Karasu's texts work as a text-machine that produces other texts, on grounds that the work of art has long become a reading milieu, housing and agglomerating all possible texts, rather than being a single one. As a result, says İleri, rather than becoming a poem, *Fear with Variations* does the opposite; it wants to introduce the gestures of the music listener to the reader; not to morph into sound or being read like music.[9]


FEAR WITH VARIATIONS
A Text for Five Tones
BİLGE KARASU
To the friend who mistakes himself limited for a "connective"
A fur,
a feather
left be-
hind by
a bird
unat-
tended
made up
of air soft
-ly falling
down to
the ground
a fur,
a feath-
er,
a leaf
split a-
way from
a fall
branch,
swift
yellow-
ish
split
a leaf
no one
hears
when it
touches
down on
the ground
gentle
to ground
to dirt
to rock
a fur, a feather

an autumn leave
it was like; fell down and sprouted
in me
inside me
in my heart
in my flesh
f e a r
LIKE AND AVALANCHE YOU CAME DOWN ON ME
Ants
I was
like
ants of
dream,
hard ants
i was
like
enduring
ants i
was like,
enduring
lain
still
infinite
unlimit-
ed
on a smooth plain
CAME DOWN ON LIKE AN AV-
ALANCE, YOU EMBEDDED ME
not distract-
ed, not in
the eye,
not in
the foot
intended to-
wards no-
thing
on a
plain
smooth
lain
ground
with endurance
w a l k i n g

ants,
i was
like.
s a w y o u
d i e d y o u
YOU YOU YOU
: YOU : YOU :
saw -:- heard -:-- :
lived - - died - :
know-
ing
no-
thing
but to
walk
know-
ing
not,
going
where
know-
ing not,
even go-
ing or not
hard ants
i was like
walking with
endurance
on this
plain
roughless-
ness
YOUR UNACCOMPANIMENT WAS A
PALE QUIETITUDE, YOUR VOICE, YOUR
FACE, YOUR WALK WOULD TEAR OPEN
THEDOOR OF MY SPOTLESS DARKNESS
again,
knowing
not going
where
know-
ing not
even go-
ing or not

Figure 1. Bilge Karasu's "Fear with Variations". Translated by Serdar Metin.

THREE VERSIONS OF *FEAR WITH VARIATIONS*: THE TYPEWRITTEN VERSION, THE SOUND RECORDING AND NOTATIONS

Let me begin from the first version in *Figure 1* above. The text –titled "Text for Five Voices" – makes us think that it is a close relative to the graphic poem *A Throw of the Dice Will Never Abolish Chance* (*Un Coup de des Jamais N'Abolira le Hazard*) of the symbolist poet Stephan Mallarme (1842-1898) written in 1897. In the preface of the book, the author acknowledges İlhan Usmanbaş, Gürer Aykal, Alpay İzbırak and Kaya Güvenç who contributed to the voiceover text. What is remarkable here is: The text is written for five tones, but why is it in four columns? Between the first three (from the left, Soprano, Alto and Tenor), a more vigorous exchange takes place. The first three columns are in lower case and are often interrupted with dashes, and this encourages a vertical reading of each sound block. Written in uppercase, the fourth block is Bass, which appears at far right on the page. Unlike the first three blocks, it is scarcely broken and rests on more extensive passages. Unlike the quartet's (Soprano, Alto, tenor and Baritone's) rapid and transitional nature, the bass exhibits the continuity of a monologue, which can be assumed as the author's fundamental narrative heard from below. There are also sparsely arranged rows that connect three vertical blocks, which can be considered as horizontal binders. These appear several times on each page. Karasu seems to use these to start and to end portions of images. The text consists of a total of five poetic imagery and each constitutes a section: Feather/leaf; Ant; Insect; Olive / poplar / willow; Fear. A sixth one might be added, i.e. the repetition of the initial Feather/leaf.

The total number of sound blocks in seven plates and their distribution can be examined quantitatively. In the studio, *Pomi* (*the studio for potential architecture),* the duration of each sound block in the recording was measured. These durations are also apparent and foreseen in the Notation/Vocalization sheets drawn by Bilge Karasu. There the text blocks are occasionally single-tone, frequently multi-layered. These aspects have also been analyzed in *Pomi*. By assigning a color to each sound type (from Soprano to Bass partitions), it was possible to observe monophonic/polyphonic characters of the blocks.

The second version is the voice recording of 1974. Tijen Pa and Candan Teksoy are Soprano and Alto vocalists, respectively. The famous Turkish composer İlhan Usmanbaş is Tenor, whereas Başar Sabuncu is Baritone and Cüneyt Türel the bass. The first part takes 2 minutes and 10 seconds (2'10"). After a few seconds of silence, *Ant* begins, and at 3'47" *Insect* begins. In 4'17", in the middle of the recording, an intermezzo made of sounds such as "k-kh-hi-ha-ho" begins. After a short passage of the *Fear* theme at 5'03", the trilogy of *Olive / poplar / willow* begins at 5'14". In 6 minutes 33 seconds, the last part, *Fear,* begins and the last monologue of the bass lasts from 8'12" to 8'45".[10]

The "K-kh" sounds often remind themselves at the second part of the recording. These voices occasionally have the rhythm of a military march: The echo of a dominant, repressive connotation of fear.

The sound layers of the recording score the fall of a leaf or the curvature of a willow tree with ascending and descending syllabic sounds or with resonating syllables.

The recording is very innovative even for today, and keeps its uniqueness; Cem İleri and Mehmet Nemutlu's in-depth writings keep their specificity and importance.[11] Thus, it was very demanding for us to decipher the *Fear with Variations* in *Pomi* and to have access to veritable knowledge in order to fabricate its architectural significance. Karasu gives the notation schemes at the end of his book *Kısmet Büfesi*.[12] The notation consists of 21 pieces of horizontally drawn diagrams. Each diagram has five horizontal bands for Soprano, Alto, Tenor, Bariton and Bass.

In *Table 1*, I have given below the results of my initial analyses of the voice recording sheets: Each row shows the duration, polyphonic character, the superimposition technique of words, syllables and sounds, as well as the playful voicing techniques like echo, synchrony and sliding. Although it is not easy to have these playful parts translated into another language, I have given the lines where some of these noteworthy plays occur in the notation sheets of *Fear with Variations*.

Table 1. An Analysis of the Vocalization/Notation Tables drawn by Bilge Karasu for Fear With Variations*. Each raw corresponds to Karasu's sheets/tables and indicates not only length but also character. The last two columns exemplify phrases that are synchronized or echoed.*

sheet number	*duration (seconds")*	*polyphony*	*superimposition*	*echo*	*synchronic words*	*sliding*
1	19"	+	word to word	+	"a fur" "a feather"	"a fur" "a feather"
2	20"	+	word to word	+	"left behind" "a bird" "unattended"	"left behind" "a bird" unattended
3	35"	+	word–word–sound	+	"falling down to the ground"	"of air" "falling down to the ground"
4	25"	+	word–word–sound	+	"a leaf" "autumn" "yellowish" "split"	"a leaf" "branch"
5	25"	+	word to word	+	"a fur when it touches down on the ground no one"	"to ground"
6	25"	+	word–word–sound	–	"in me" "fear"	'ş' 'n'
7	20"	+	word–word–sound	+	"Sprouted in me" "lain" "you"	"Sprouted" "in plain"
8	20"	+	word–word–sound	+	"with endurance" "walking lived	"you"
9	12"-18"	+	word–word–sound	+	"knowing not"	"knowing not" "your face" "your face" "your walk"
10	22"	+	word–word–	+	"again	"where it is

			sound		knowing not" "where it is standing" "of fear"	standing" "all around"
11	15"	+	word to word	−		
12	20"	+	word to sound	−		
13-14	45"	−	−	−		
15-16	60"	+	c	–,+	"beyond" (15)	"beyond" (16)
17	25"	+	word to word	+	"how to"	"how to"
18	30"	+	word–word–sound	+	"you"	"lived" "died"
19	50"	+	word–word–sound	−		"a feather"
20	10"	−	−	−	"with the fear"	"gently"
21-22-23	30"	−	−	−		

Sheet (Row) 1: In the initial sound block or the beginning of the piece, rise and fall indicated by lines occur only in Soprano and Baritone; they establish a rhythm the repetition of the word "tüy" ("feather"). Baritone says "tüy" 23 times. The frequent monosyllabic repetition "tüy" also reminds of wing flaps or bird singing. Font sizes on the sheets differ to match the volume of the sounds. *Sheet 2*: Soprano, alto, tenor, baritone and bass: "left behind by a bird unattended" all at once. Bass does the clearest, legible articulation. S(oprano), A(lto), T(enor) and B1 (Baritone): S, A and T, are the elements that make the least letter/word repetitions whereas B1 (Baritone) continues his bass rhythm by repeating the word "bir" ("a") sixteen times. *Sheet 3*: S, A, T, B1 have dynamic graphics. The most active part in terms of rise and fall and quest. The word-to-word scroll effect is also enabled in this section. The last letters of the words are extended to establish the ups and downs. *Sheet 4*: "A fur / a feather / a leaf" exemplifies a morphing, multiform image. The same image is distributed to all five sound partitions. S and A rise and fall, are in action whereas t and B1 stay mostly linear. *Sheet 5*: Each partition talks one by one; which is typical for the second half of the work. T, A s and B1 figure out the same words jointly: "a fur". Instantly, as if they avoid repetition in purpose, they give three variants of a word, which Bass adds another fourth immediately: ("içime"/"içerime"/"gönlüme" – "etime"). The narrative character of this part of notation is that, the rise in the fourth sheet is received and responded with succeeding falls; thus, structural reflections and symmetries become apparent. *Sheet 6*: The first unveiling of *Fear* in all partitions with a dramatic emphasis. Also the first drop of rhythmic single-letter fear effects. *Sheet 7*: Geometric line of the tenor with a singular midline, demonstrating the horizon and flatness. Words become discontinuous after the appearance of *Fear*. *Sheet 8*: Discontinuous phrases resume what one leaves behind and they begin to be interwoven. At the end of the episode, all the voices simultaneously make a pause. Also in the middle of the episode, all voices hush and the Baritone's "you" series communes with Soprano, Alto and Tenor. The Baritone's most passionate booms are these "you"s. *Sheet 9*: The echoing of the Baritone by Soprano

and Alto, as in Sheets 7 and 8. At the end of the episode, Baritone and Bass strongly repeat the same words simultaneously ("your voice" / "your face" / "your walk"). This is also the emergence of passionate concrete memories of the prior "you"s. Soprano, Alto and Tenor extend the last letters of their lines. *Sheet 10*: A common formula for each partition is apparent for Tenor's ripple which makes it possible to divide any line into three: "T-Tminus-Tplus-T". This formula is like a melodic pattern. Soprano and Alto are mostly silent and completely disappear at the second half of the sheet. Tenor builds an intermittent fear statement. The word "Fear" is a common line for Tenor, Baritone and Bass. *Sheet 11*: The centre-piece. A frightening march resides in the "long long - short short short" rhythm of the sounds: Uniform, arid, "k" and "h" sounds siege and envelop the space where nobody is allowed to speak, only to follow the rhythm. *Sheet 12*: Soprano, Alto Tenor non-existent; only Baritone. *Sheet 13* and *14*: Non-polyphonic/monophonic partitions begin. This characterizes the second half of the entire work. Each partition utilizes a spatial array for itself and none of them collide. The strongest emphasis is on "sonra" ("beyond") and silence reigns. *Sheet 15*: This section is a mélange of Sheet 10 and 13-14. *Sheet 16*: Soprano, Alto and Tenor's separate, consecutive "beyond"s. "K" and "h" sounds intervene discrete words. *Sheet 17*: The domination of Baritone and Bass; silencing of Soprano, Alto and Tenor. Two separate, short and intricate sound braids of S, A and T dawn strongly in front of the quiet background. *Sheet 18, 19* and *20*: S, A, T, B1's rhythmic "u"s and "o"s, an interruption, then braided again with "you". Bass gains dominance. Words do not overlap. *Sheets 21-23*: The monologue of Bass.
Above I tried to give an outline of the *Fear with Variations* notation sheets because this analysis was the basis of the proceeding architectural designs.

Figure 2. Pomi Project, 2018, Gözde Göğem, İsmail Kayan. "Architectural Variations for Variations on Fear".

THE FIRST POMI DESIGN: NAVIGATING BETWEEN FRAMES AND LAYERS

The duration of the sound blocks in the first version of *Fear with Variations* are significant for the calculations in the architectural design process. Which sound block is tenor and which one is alto etc., is a more complicated issue, because text blocks are sometimes monophonic but are often polyphonic. Here I will address two (out of four) architectural projects designed in *Pomi*.

The average walking speed is 5 km/h for humans, an almost nine-minute voice recording complies with an average of 725 meters walking distance. If you listen to this recording through your headphones while walking, you would walk that distance. Subsequently, we reduced the speed to 3 km/h and the distance to 600 meters, a low-paced stroll.

Designers Gözde Göğem and İsmail Kayan, architecture students, divided the text into 19 text/duration blocks. The first partition comprises a short duration block of the words "a fur, a feather". In the design, this portion is architecturally shaped by a triple text-recording-notation comparison. This part is read by all. The design uses a frame for each partition and each frame is structured by free-standing steel profiles. The frame at the center of the section corresponds to Bass, while the last and largest one to Soprano. Polyphony matches with concentrated, stratified framings. The durations of the strata are consistent with their elongation. In the plan, they are laid in accordance with walking speed. The 19 text blocks in the architectural design are separated by spacious breathing intervals. This allows them to be deployed in space. The monologue of Bass is positioned one meter above ground. The seemingly unstructured "kh" sounds become an important architectural "empty signifier". So the rhythmic section of the repetitive sounds that divide the text into two equal parts, correspond to a colonnaded garden in the layout plan. The plan consists of two groups of frames at the ground level, and another two below the ground level, each located perpendicularly. After the initial two groups, a ramp reaches the garden, leveled below the ground.

Figure 3. Pomi Project, 2018, Tamerlan Jafarov and Süleyman Özlü, "A Variable Topography of Fear".

THE SECOND POMI DESIGN: A TOPOLOGICAL TOPOGRAPHY OF POSSIBILITIES

Designers are Tamerlan Jafarov and Süleyman Özlü. Their design, which presumes that the Soprano partition constitutes a solitary line from the onset to the closing, augments the convolutions by five times to make the vertical gesture comprehensible. This transaction is also appropriated for four tones. Distinct graphics for Soprano, Alto, Tenor and Baritone are made. Karasu's notation interweaves these sound layers. The fifth layer, Bass, does not join the interweaving of the quartet; hence, Bass is specified as a neutral constituent, as water. Soprano, Alto, Tenor and Baritone are scaled to 300 meters. These parallel lines are inlayed by five meters. Thus, with two vocals, a topographic corridor of 300 x 5 m. is established. Permutations of four elements result in a total of 24 possibilities constituting the overall topography of sound.

The terrain is simply a sequence of these permutations. Here, a unique mathematical situation emerges: Let us take "S-A-B-T" as a lined-up unit in the topography of possibilities. SA constitutes a plane. This plane is adjacent to the plane AB. And this, to plane BT. "SABT", is one out of 24 possible combinations, and in fact, is made of three merged planes: "SA-AB-BT". The "SA corridor", repeats 6 times in all terrain cross-sections in 24 possibilities. 73 ribbons are used in total by omitting all consecutive repetitive features.

In the universe of possibilities we live in, we can only walk along a straight line because a single possibility can occur at a given time. However, by placing a network of grid paths at an angle other than 90 degrees to this topography, we can go through a meta-universe where more than one possibility may well occur at a given time. This situation is spatially, a trans-temporal polyphony, a type of meta-polyphony that Karasu's text probably did not theorize.

A quantum-polyphony: The topography as a meta-diagram.

SO WHAT IS *POMI*?

The Studio for Potential Architecture is an architecture studio I launched in 2002, inspired by *Oulipo*, *Ouvroir de Litterature Potentielle*, the workshop for potential literature founded by Le Lionnais and Queneau in 1960. While I was arriving at this idea of a studio at an architecture school in the preliminary years of my assistantship, my aspiration was to experiment the procedures of the *oulipo* in architecture. In seventeen years, I had the opportunity to experiment on numerous topics, each time with a different group of architecture students every semester. Finally, in Spring 2019, inspired by Raymond Queneau's *Exercises in Style*, and by Matt Madden's *99 Ways to Tell a Story*, we made a book titled "199+: Architecture After Pomi". This book invents some two hundred procedures, tests these "synthetic oulipian" procedures all on a house project, and thus turns out to be an encyclopedic theorization of architectural constraints. The book is reproduced as a very limited edition of fifty copies, and all book binding work is hand-sewn: A homage to the word "ouvrior", meaning "sewing atelier" in French (the "ou" of the abbreviation "ou-li-po").

Can those *oulipo*-inspired experiments that Pomi pursued be considered as a "proof" that architectural design under constraints can lead to a productive track that no other method can promise?

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[5] Ibid, 40.

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[7] Ibid, 59.

[8] Ibid, 66.

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TOWARD AN INNOVATIVE LEARNING ENVIRONMENT TO SUPPORT EDUCATIONAL FACILITIES. SPACES AND SERVICES FOSTERING INTERACTIONS IN THE COMMUNITY OF THE CAMPUS

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INTRODUCTION

New learning models and technology

The new generations of students, born and raised with the web in the era of the world wide web, will soon start an educational path within one of the many universities' educational offers. The future users of university campuses, grown up with smartphones, social media and virtual realities, will expect the university experience to reflect the "connected in real time" nature of the web. As a result, the future of university education will require a more focusing on the figure of the learners, enhancing experiential, immersive and social activities between the users. To overcome these challenges, it is important to start a rethinking of the university environment, trying to make it performing and flexible, always ready to follow and stimulate students by offering constant access to learning materials and resources. It can also change the way in which teaching spaces are used in relation to new user behaviors:

Among these we can highlight:

- Work is fragmenting and becoming less and less tied to a specific physical place. People are moving outside the physical containers of their buildings into larger collaborative networks that incorporate spaces that can be located almost anywhere in the world.
- Space expresses culture and reinforces the values and identity of a subject rather than simply being a container in which work takes place.

These factors are affecting the entire structure of learning spaces, which is no longer conceived as a centralizing place of individuals but a facilitator of sharing and deepening of the disciplines: a place at the service of learning which becomes the fulcrum of interaction between students. Space and its occupation are interrogated through their dynamic intersection as social and spatial practices[2]. Rather than confining students to a passive experience, we need to consider how to more fully engage students in the learning activities.

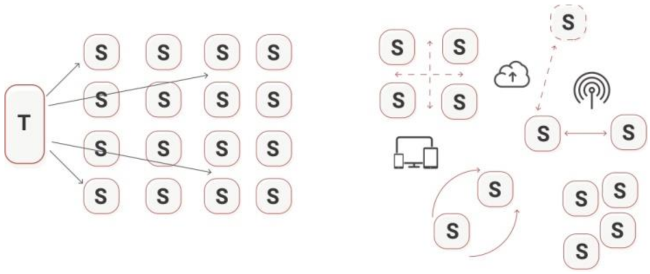

Figure 1. A comparison between the previous learning environment and the current needs

Learning spaces and learning corridors

University campuses are complex environments in which interstitial areas between learning and connection spaces are often poorly defined. It is necessary to redesign all those transit spaces, inside and outside the buildings, making full use of their intrinsic potential. The creation of corridors equipped both for individual work and for teamwork, can constitute a strategy aimed at creating a continuous network of information exchange: the creation of these spaces with different densities can either generate different activities or favor the creation of social relationships and work synergies.

"Learning happens everywhere, not only in classrooms and libraries, but in corridors, social structures and walkways, courtyards and squares between buildings. Even the academic space as an end in itself is disappearing. There is still room for traditional classrooms, but they too can be remodeled to meet other needs".[3]

With the diffusion of a teaching based mainly on the development of group projects, the need for larger, hybrid and flexible spaces that allow for active and collaborative learning becomes evident. Traditional classrooms and libraries are no longer able to properly support new teaching models due to the obvious design limitations imposed in a different historical context.

All those spaces designed for other types of activities - such as cafeterias, bars, green areas - and all the connective and transit fabric, seems more suitable to intercept more efficiently the changes imposed by the revolutionary technological learning tools. Nowadays, thanks both to new devices currently in use in educational offers and the consequent redesign of the canonical idea of space, much of the time spent in studying and learning takes place in those informal spaces outside the classroom where it is possible to trig new ways of collaboration.

It is interesting to see how the exponential increase in users of hybrid spaces is due to the new concept of activity-based working (ABW) achievable thanks to personal electronic devices such as computers and tablets. This function is evolving as a nomadic type of activity that does not require traditional spaces, designed solely for a specific activity, but hybrid environments that provide individual spaces and shared infrastructures to which all users can access quickly and easily. In the activity-based reality it is the single user who chooses, according to his needs and requirements, the best position to work from: the space is subordinated to the activity since the latter can potentially be applied everywhere.

Schools and university campuses are no longer seen as a series of "educational" buildings or containers, but as a holistic combination of spaces all with the potential to contribute to the educational impact. They must be outlined as "*a complete network of connected learning environments [...] where the learning process does not exist individually, but takes place within a range of different types of pedagogy, spaces and technologies*"[4].

An Italian informal learning experience: the Politecnico di Milano

A big challenge has emerged from present and plans of the Politecnico di Milano, defining a general program with these primary goals for the next three years, to address the new contemporary needs on the topic by developing different prototypes of innovative university classrooms.

An in-depth revision of its spaces to understand the needs of all the university users, with a particular focus on the design discipline of the School of Design.

The primary purpose it's not only to rethink the environment referring to the design disciplines in general, but it's also fundamental to think about a system to combine the different subjects, with a total integration between them.

For these objectives, a research team of the Politecnico di Milano has been appointed to define a series of requirements and needs for the general organization of the innovative teaching and learning spaces, involving the users directly to investigate new demands in the field. The team has been asked to dissert on spatial needs, potentialities, new habits and uses, and organize all in spatial requirements in "directions", especially focus on the design field, to be applied to one classroom's prototype and then finalized and revised for large-scale dissemination.

An evolution of the teaching space in which analogical and digital, physical and intangible aspects contribute to improve the relationships between the different actors involved in the teaching process. The context in which the application will be tested, the School of Design of the Politecnico di Milano, 5th in the worlds' university ranking, 1st university in Italy, 44.300 students' population, a place in which we are teaching spatial design and architecture, and so the space has to be Able to support the learning activity. The strategy of the Politecnico action plan presented in this paper aims at the creation of informal, porous, hybrid zones closely related to learning spaces, an integral part of the new educational classrooms, detailed in the next chapter.

It also presents the introduction of spaces defined as informal learning spaces, which become 360-degree connectors, spaces that favor the interaction of different campus users for a total dynamic and fluid use of these spaces. It is a first example prototyped by the "Agorà degli studenti", inaugurated in July 2019. The area appears as a large square, a work and meeting welcoming place with 200 study places, built in the wide corridor leading to the traditional classrooms of the university, enlarged by the demolition of a central room in which there were some administrative offices. The demolition of the central part led to the creation of a large space designed to accommodate different types of use. The more traditional workstations, with tables and chairs arranged in a linear way, are flanked by higher workstations along the large full-height windows. Along the walls there are lockers designed as a support surface for study models, which can be positioned vertically even in the upper part of the modules, creating exhibitions and providing students with information about their projects. The space is also thought of as a lunch break area, with microwave ovens and a filtered water dispenser.

The new space belongs to the VIVIPOLIMI project, aiming at improve the use and life of Politecnico spaces via actions of redevelopment, enhancement and implementation of the existing structures.

The plan is to create relaxation areas to facilitate socialising, study areas (with student spaces for individual, group and "flexible" study), work areas (through the creation of faculty spaces for teachers), and multi-purpose halls suited to events as well. Use will furthermore be made of a lighting-technical equipment to enhance the campus buildings.

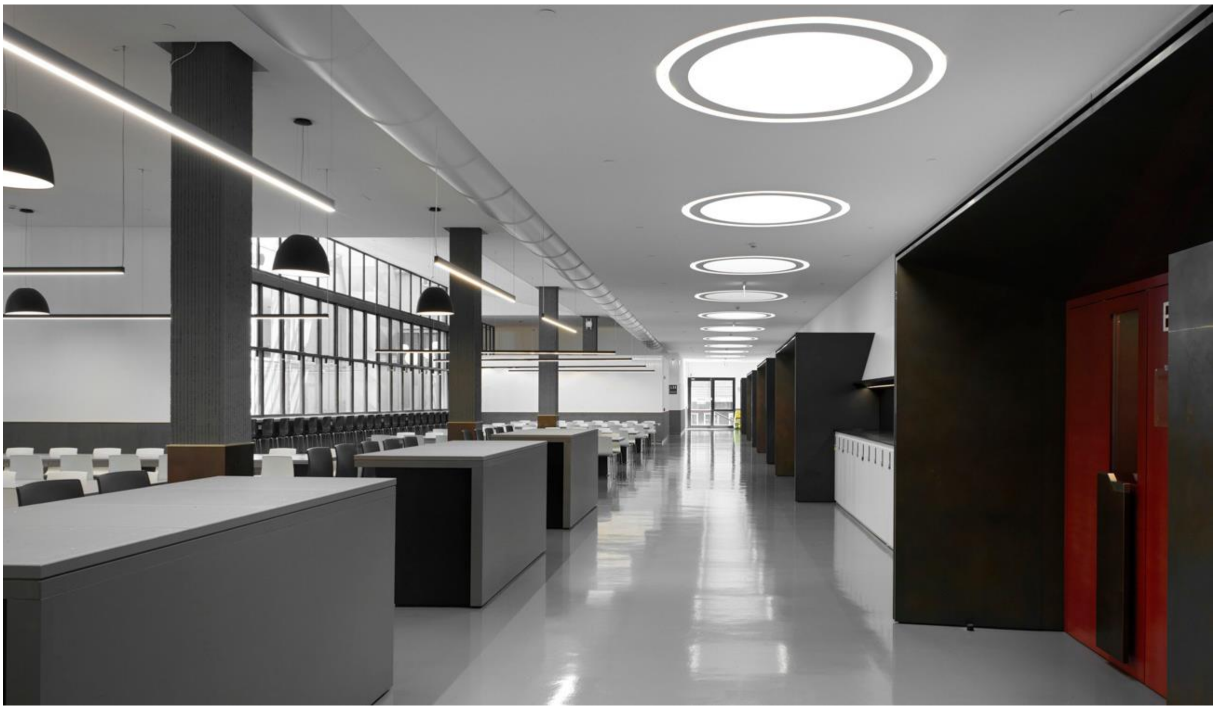

Figure 2. View from the entrance of the "Agorà degli student" (picture by Marco Introini)

Grammar Of Directions for connective spaces

A complex system of spaces, with a large number of different types of users, requires strategic planning to facilitate the usage of the space. It is useful to build and manage a whole and complex system of elements that is made of a technical shell and performative furniture to be flexible in terms of time, functions and users' needs to achieve the learning environment goals. Using a planning system following rules and criteria can also help planners, technical offices and area management to develop all the functions required.

A grammar of directions (GOD) has been defined both to create a common base for the spaces of the new disciplines and to verify the types of intervention to elevate the space to an innovative and flexible status. The use of this grammar, which arises from the basic needs related to the behaviors found in the learning spaces, is useful for planning an environment that can gradually be implemented over time. Understanding the needs in common and the individual requirements helps to establish a hierarchy of interventions to be planned immediately to prevent the space becoming unable to support the present and future ways of teaching and learning.

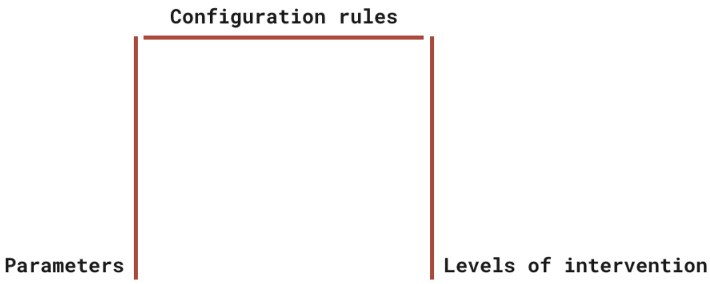

Fig. 3 Grammar of Directions' elements

Levels of Intervention

In order to allow the development of a basal matrix to be updated with possible optimization interventions for the peculiar activities, a scheme has been adopted to interweave the different spatial components with the possible degrees of intervention. To differentiate the types of intervention needed, 3 groups of elements and components, physical and virtual, with a significantly different impact were outlined:

- Building: the framework of the space consists of systems and surfaces to better support any activity to be performed within the space.
- Furniture: the furnishing components with high flexibility to allow a quick recomposition of the layout according to activities needs.
- Technology: everything that includes the virtual appearance and digital devices to amplify the experiences.

The three groups of elements contain all the supporting components necessary to allow an effective teaching and learning path. However, as verified in the previous paragraph, since the space has to support different types of activities in addition to the common ones, it is necessary to make changes through an implementation and installation of resources. Following all the new types of innovative learning it is vital to implement the learning environment with a portion dedicated to informal activities. The space requires a flexible arrangement able to mold according to the users' needs in different situations and must be design with a high capacity of configuration.

Configuration

Designing an innovative learning environment, it is necessary to introduce a configuration based on different thematic areas. Additionally to the didactic area, the portion assumed to teaching and learning activities equipped with specific furniture, is necessary to design a portion of space for the storage of all those elements and devices (such as smart boards, furniture, student's belongings and others) that are exceed or unused during a specific activity. Based on the argument previously presented, we introduced an informal area as an essential part complementary to the didactic one. In this case this area has the specific function to facilitate collaboration and working activities to support teaching which can be carried out at different times, in an unstructured and autonomous way compared to the teacher's action in the classroom. These three main functional areas are suggested a ratio of 70/15/15. The informal area, being a porous component, helps to facilitate the transition between the different activities connected to the classroom and the connective spaces within the campus. This different type of informal area can be used by all the users who need to interact or work in a space not strictly related to formal didactic activities in the same time.

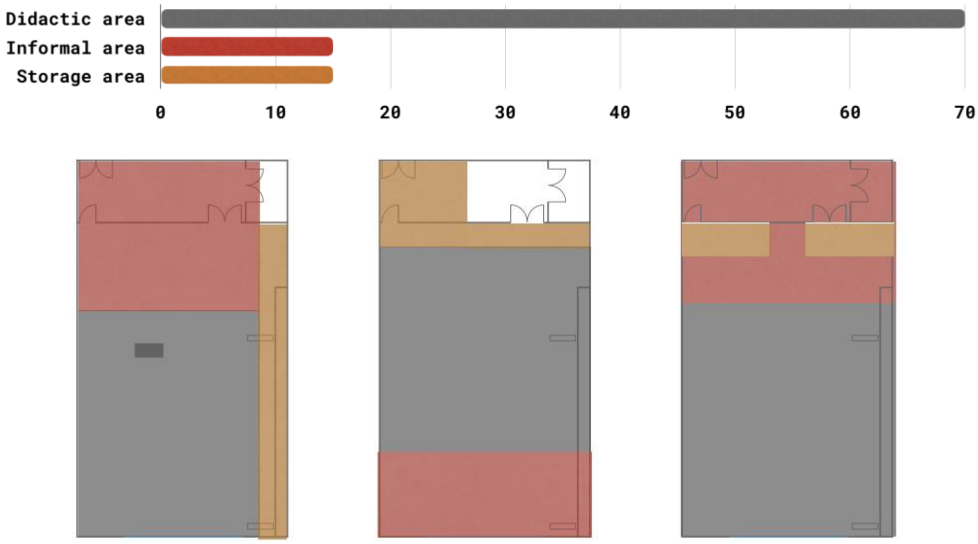

Fig. 4 Configuration element and sample of application

Student-teacher relationship in informal spaces: democratization of roles

The choice of this type of intervention aims to create and emphasize the kind of interactions that can occur between student and teacher in hybrid and connective spaces. The informal conformation of space, and its quality as a connection area between the sphere of learning and leisure, favors the exchange between users with a significantly different role, democratizing the relationship between student and teacher. The space can indeed be used to implement all those revision or explanation activities existing in the teacher-student relationship but which still struggle to materialize in a defined space.

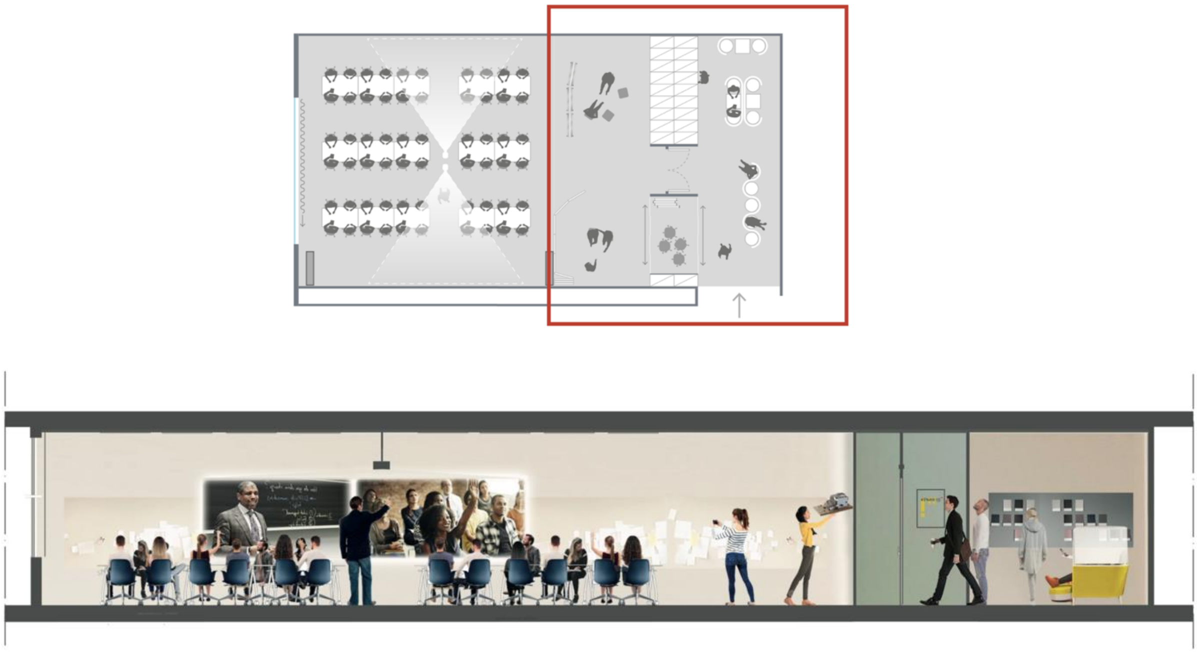

Fig. 5 Scenario of different activities in the same location

The concept of a classroom as a space specifically designed for conveying knowledge is an idea that has developed more recently than the institution of universities. Initially most of the teaching was held in the private homes of the teachers, temporarily used as a place of teaching, for a small number of students[6]. For more important lessons, instead, the universities were forced to rent more spacious public or religious buildings, therefore subjecting themselves to the availability of the same[6]. Only from the 16th century onwards, thanks to the modernization and expansion of the universities, it was possible to design and define a series of spaces to be dedicated solely to teaching.

Student-student relationship in informal spaces: interdisciplinary content

The informal space, in addition to providing an effective space for discussion between professor and student, is usually used as a space for both studying and decompression by the students themselves. The connection areas of the university campuses are increasingly emerging as spaces equipped for the continuous exchange between students, who find themselves in groups to operate both study and informal activities. The interactions between groups of users can therefore enrich individuals by encouraging the exchange of theoretical information and methodological skills. These informal spaces are not only focused on connective spaces but also include a wide range of non-conventional environments (such as cafeterias or student residences) where knowledge is exchanged through the study and cooperation of students based on cooperative learning[7] as show in the Figure 6.

The informal and connection spaces, if equipped with a series of furnishings and technologies, can be transformed into real interdisciplinary areas where students can operate a wide range of activities. The informal space must in fact provide adequate furnishings for the various activities to be performed: chairs, armchairs, pods, electrical sockets, tables, whiteboards and others, must be flexible and functional, also allowing a rapid configuration of the space in a short time.

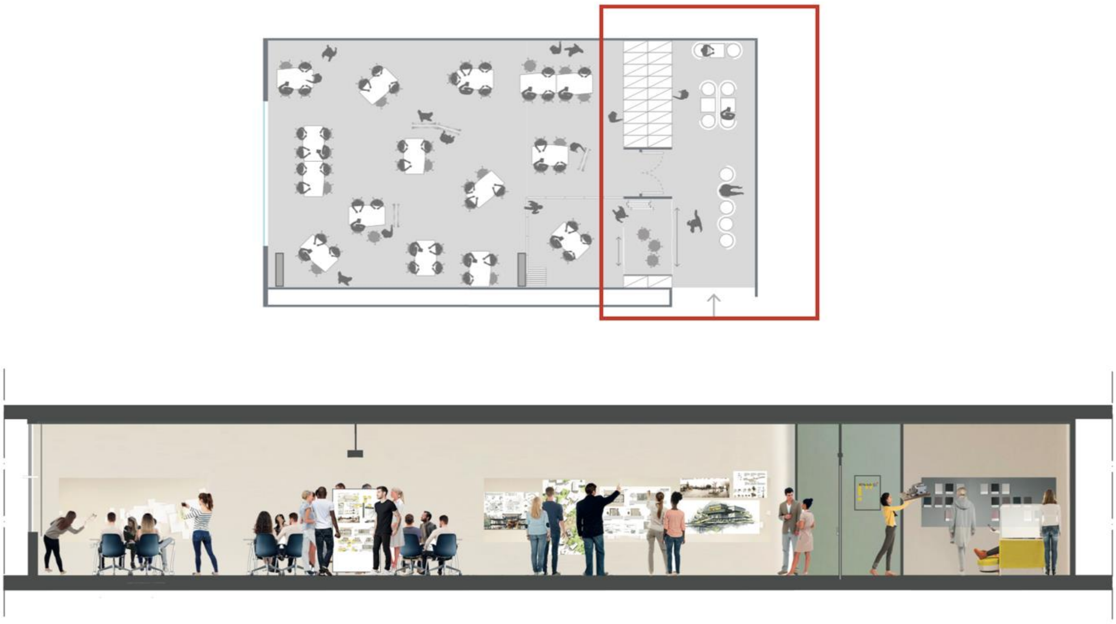

Fig. 6 Contemporary presence of the didactic and informal area

It is interesting to see how the exponential increase in users of hybrid spaces is due to the new concept of activity-based working (ABW) achievable thanks to personal electronic devices such as computers and tablets. This function is evolving as a nomadic type of activity that does not require traditional spaces, designed solely for a specific activity, but hybrid environments that provide individual spaces and shared infrastructures to which all users can access quickly and easily. In the activity-based reality it is the single user who chooses, according to his needs and requirements, the best position to work from: the space is subordinated to the activity since the latter can potentially be applied everywhere.

Fig. 7 Scenario of different activities in the same location

CONCLUSIONS

The learning environment is going toward new directions due to pedagogical approaches of the "active learning" strand, trying to stimulate new human behaviors and relationships that break down the definitions of roles and barriers in the campus within a total connection of the entire social system.
The very concept of education is expanded as an act that can happen anywhere and at any time[1] and new learning dynamics lead to the definition of spaces intended for formal learning, such as classrooms or laboratories, for a planned didactic conveyed through the traditional lesson of a teacher. Informal spaces, on the other hand, include a wide range of places where the exchange of knowledge takes place through the study and cooperation of students or researchers.
These areas are located in "the space between" or in those places characterized by a great design flexibility that allows the discovery of new environments devoted to group study and that act as a filter between the different functions in the campus.
The expected results aim at a rethinking of the spatial model that can support the learning environment within this continuous mechanism of interaction between people and space, to foster new forms of interaction, collaboration and multidisciplinary for the future growth of the Campus.

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UNDERSTANDING URBAN COMPLEXITY THROUGH RESEARCH-DRIVEN DESIGN: THE CASE OF MONTREAL

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INTRODUCTION

An important aspect of a modern-day design education is learning to understand the complexity of a problem and developing analytical thinking and problem-solving skills to address the evolving needs of society, question traditional practices and search for solutions that make the world more habitable, sustainable, equitable and more resilient.[1, 2, 3, 4]

As the spectrum of design practices has broadened, so have design approaches, animated by debates about ethical practices. Designers need to claim their role as creative problem-solvers and assert their position on socio-cultural and environmental issues.[5, 6, 7]

Thus, the design attention has shifted, looking beyond the object and its aesthetic qualities; focusing on the users and their experiences, the process of designing and the actors involved. More recently, design concerns for ethical aspects have led to socially relevant, sustainable, eco-friendly design considerations.[8] Evidently, ideological shift can affect the way of life, favouring for example progress and sustainable lifestyle, despite the hindrances of an economy-driven decision-making process,[9] explaining in part the growing design interest for understanding a problem field and the needs of all stakeholders involved.

Design research

Research-driven approaches help design not only understand the underlying complexity of a problem, they also nurture the creative process.[10] Hence, design scholars and design professionals increasingly rely on research in order to develop relevant and justifiable design solutions. Therefore, several design schools have made research-driven design approaches an integral part of their programs.

At the University of Montreal, Canada, design research is being introduced from the 3rd year of the design education to allow 4th-year undergraduates to tackle complex "real-world" issues during their diploma year. Firstly, human-centred design is a fundamental part of their curriculum that teaches a problem-driven design approach. Students learn to engage in design research and study the contextual environment in order to recognize the interrelationship between different issues. Thus, they adopt systemic thinking while examining products and product systems, actors and user interactions. This allows them to identify problems or needs and understand how they affect users and society. They learn to derive objectives and design criteria from analysing theoretical and empirical data rather than having them imposed arbitrarily.[11] Their research supports the subsequent creative process, giving rise to more relevant and innovative alternatives. The following sections describe how research-findings nurtured the creative process of an urban design problem.

THE CASE OF MONTREAL CITY

Rapid urbanization of cities such as Montreal contributes to the world's environmental crisis.[12] Global warming and rapid urbanization triggered major interrelated issues: inaccessibility to water, despite Montreal being an island;[13] urban heat island effects (UHI), flooding and stormwater runoff, caused by the impermeabilization of soil, which hinders natural processes.[14, 15] These issues affect urban life and lead to a premature deterioration of infrastructures. To counter this developments – while adapting to climate change – modern cities are searching for more sustainable solutions.[16]
Furthermore, Montreal used to be known as a city of water, situated on the Saint-Laurent river. It has recently asserted both the ecological and cultural value of its water through politics and civil movements, pursuing its protection as a collective heritage.[17, 18] Yet, this status is barely noticeable.

Limited access to water

Despite being surrounded by water, it does neither look nor feel like an island. Public access to watersides diminish due to privatization and construction, despite Montreal's efforts to develop nautical activities.[19] Inland, hundreds of natural sources have been buried over the years. With the arrival of water utilities in households, streams and ponds have become inconvenient, considered as an obstacle to the expansion of infrastructures.[20]

Urban Heat Island

With the changing climate, the consequences of urbanization have become unbearable, especially during the summer season when temperatures can reach extreme levels. Indeed, many downtown areas are plagued with Urban Heat Island effects (UHI) caused by the predominance of the impermeable concrete landscape and the scarcity of natural elements[21]. The vulnerable population (e.g. toddlers, elders, disabled) is particularly touched by the effects of UHI,[22] which have been recognized as a threat to public health.[23] City officials are now considering various strategies to mitigate UHI effects, including the reintroduction of vegetation, water, and permeable pavements.[24, 25]

Rainwater runoff

Another consequence of urbanization is the phenomenon of local flooding and stormwater runoff that existing drainage and sewer systems hardly manage. In fact, the unusual amount of precipitation in recent years has led to more incidents of flooding that contribute to the premature obsolescence of concrete infrastructure, the contamination of drinking water, as well as to the errosion of the Saint-Laurent riverbanks, causing significant ecological damages. Alternative ways to manage stormwater are needed.[26]

Water and sociability

According to research, natural elements have a positive impact on the quality of urban life and encourage social interactions.[27, 28] Consequently, urban developers should also include nature in form of vegetation and access to water, to provide conditions that encourage friendly encounters and improve the habitability of urban space.[29] According to research, it is an effective way to ensure people's well-being, sociability, place attachment and civic respect.[30, 31]

Quality of urban life

Gehl draws attention to the **"human scale"** and the need to adapt the public place to fit people's needs is critical for a functional and enjoyable public space.[32, 33] His perspective on urban development echoes the one of industrial design, which has made human-centred design its primary mission. Indeed, Gehl's criteria for assessing the quality of an urban space reveal his focus on habitability and sustainable lifestyle: conditions of **security** (e.g. providing protection of pedestrians from traffic), conditions of **comfort** (e.g. providing opportunity to walk and sit) and, finally, qualities for **enjoyment** (e.g. providing positive sensory experiences). Interestingly, the City of Montreal adopted Gehl's criteria and expanded upon by including among others **greening**, and **reintroduction of water**, both of particular interest to this study. The latter notably aims at diversifying the ways people experience water features in public spaces.

RESEARCH-DRIVEN DESIGN APPROACH

With sustainability in mind, GRAD's research creation program studies the urban space from an industrial design perspective, looking at the evolution of infrastructures, technologies and design practices. The goal is to envision solutions that make the urban space more resilient and user-friendly.

Green walls and green roofs are already options that are being considered to mitigate heat.[34, 35] Others develop vegetation-pervious materials and more performant drainage systems (SUDS) in order to prevent floods.[36, 37]

GRAD's research examined water features and their functions throughout history, revealing their changing roles: utilitarian, ornamental and emotional.[38, 39] It was particularly focusing on water as a means to mitigate UHI effects and its role as a social catalyst.[40]

The compiled research data inspired several design projects that were launched under the theme *Water and the City*, which were conducted over a period of two years (2017-2019) involving one researcher, two graduate and 4-5 undergraduate students. All took part in studying scientific literature, analysing case studies, observations (locally and internationally), analysis of existing solutions and practices, as well as studying the evolution of the urban water features and their changing functions.

The data provided included a study of the history of water features and empirical data from a comparative case-study observing two successful water features located in Montreal and London. This research was aimed at understanding the evolution of water features (artefacts and their uses) through time and societal changes and their impact on urban life. The observations took in consideration multiple scales: the object at the user scale, the relationship with the surrounding architecture and the integration in the urban landscape and neighbourhood. At the user scale, uses were observed, as well as spontaneous behaviours, human interactions and socio-demographic profile of the attending crowd.[41]
These findings allowed the designers to prioritize the issues and define the scope, objectives and criteria for their 8-month long design project. At critical stages throughout the process, design students were confronted with critique and discussions with experts. During weekly work sessions they were receiving critical feedback from professors, graduate students, teammates and experts, helping them to progress significantly.[42]
The research provided them with a better understanding of the issues related to the contextual environment and helped students justify their design concepts. Two kinds of resources were offered on a regular basis:

- Professional expertise from external specialists: partnership with a water features industry (namely *Vortex*) and multidisciplinary team with expertise in the field of sustainable urban drainage systems (SUDS) in the city of Montreal (namely *The Alliance for blue-green lanes*)
- Scientific expertise (theoretical, methodological, technical, ethical, etc.) from professors, researchers and graduate students.

It was interesting to observe the offset of disciplinary jargon and expectations by the multidisciplinary team (SUDS). Although not planned, this experience encouraged the students to reflect on their role as industrial designers and to develop strategies that help enlighten other disciplines (professionals) on the nature of their work, the design process, and the scope of their involvement.

DESIGN-RESEARCH FINDINGS

Studying water features from a human-centred design perspective implies studying the artefacts, the user interactions, the contextual environment, the material culture and lifestyles.
The historical study showed that the way water features were built reflects people's relationship to their body and values of society. From Antiquity to modern days, water features have been perceived as significant, able to foster a sense of community. They were appreciated as cultural and spiritual institutions. During certain periods, they were tied to fear and interdiction, especially when associated with transmitted disease and promiscuity.
Throughout history, these artefacts played different roles. Some were magnificent works of art and symbols of power, while others were modest commodities for daily consumption. With the hygienist movement, water became a tool to clean the city and eventually arrived in households, making public water features lose their initial purpose.

However, technological progress and new practices of urban design that favour the human scale led to new kind of water features, more accessible and integrated into the urban landscape. For instance, water jets are directly incorporated into the pavement surface, set in open space, allowing for a bodily experience, instead of being inaccessible due to a basin as a barrier.
The comparative case study analysed two fountains of this new type. Latest trends show however other uses of water as an acoustic backdrop to mitigate city noise, to animate the urban place, or for recreational purposes. Some of them have shown to be more successful than others.[43] The analysis of the data shows the following observations:

- Water features evolved throughout history motivated by functional, political, religious, psychological and technological considerations;
- Their role and functions have also changed over time: utilitarian, symbolic, religious, ornamental, recreational, experiential, etc.;
- Accessibility in an open space, inclusivity and flexibility of uses facilitated the "togetherness" among various socio-demographic profiles of the users (e.g. young and old);
- The setting allowed passive socialization, the ability to enjoy atmosphere generated by others without directly confronting them;[44]
- Water features were experienced as a multi-sensory experience, not restrained to visual aspect only;
- Non-obtrusive artefacts allow for a harmonious architectural integration and offer phenomenological aesthetic and hedonic experiences according to a philosophical perspective.[45, 46, 47, 48, 49]

RESEARCH-DRIVEN DESIGN

Project 1

The first project (Fig. 1), named « Ô », referring to the French word *eau* (water), is designed to reduce UHI effects by diffusing mist through a tubular system. This seasonal system can be placed in strategic areas of a city. To avoid the saturation and overload of the walkable space, the system is meant to be suspended and attached to existing infrastructures (building walls, light posts, trees, etc.) using cables and tenders. Its form language is inspired by the molecular structure of water.
A separate layer provides lighting and helps create a dramatic effect which attracts crowds during warm summer nights. It can be suspended vertically, horizontally or inclined, making it very versatile. It offers an aesthetic and experiential quality that could animate streets, squares, parks or building facades. This design is stylistically unpretentious and will integrate easily into any urban environment (Fig. 2).

*Fig. 1. Suspended mist and light diffusion system, « Ô »
by F. R. Vinet, directed by T. Leblanc, 2019*

*Fig. 2. Suspended mist and light diffusion system, « Ô », view from above
by F. R. Vinet, directed by T. Leblanc, 2019*

Project 2

The second project (Fig. 3), named « réseau », French for network, seeks to enhance the experience of rainwater and better manage its use. It tackles issues such as experience of rainwater, stormwater management, and UHI effects. This project proposes a modular pavement solution to redirect and reuse stormwater, unburdening the city sewer system.

It is made from eco-friendly concrete using circular economy-derived materials such as micronized glass and rubber fibres that also add interesting physical properties to the new concrete: more resistant to freeze-thaw cycle, more resistant to impact/erosion, lower environmental footprint, self-healing, more resistant to graffiti, better albedo effect, etc. It is dormant during the winter season. Under the pavement, a steal conduit acts as a sound chamber, which produces and amplifies the sound of the trickling or running water during rainy days.

The textured surface helps slow-down runoff guiding the rainwater towards the duct. The design is inspired by the ripples that seawater creates during low tides.

Multiple features can be added to develop all kinds of configurations with various materials and finishes. The system can be deployed incrementally, include vegetation and even splash pads with temperature and/or motion sensor-activated jets (Fig. 4). They are only functional during hot summer days, when the surface temperatures reach a critical point. This design offers pedestrians a unique sensory experience during rainy days.

The prefabricated system of concrete modules and accessories can be easily installed or replaced and still provides access to the underground utilities, avoiding demolition and replacement of concrete and the use of heavy machinery. It thus offers a sustainable alternative by employing eco-friendly materials and by limiting waste production during maintenance of the buried utilities.

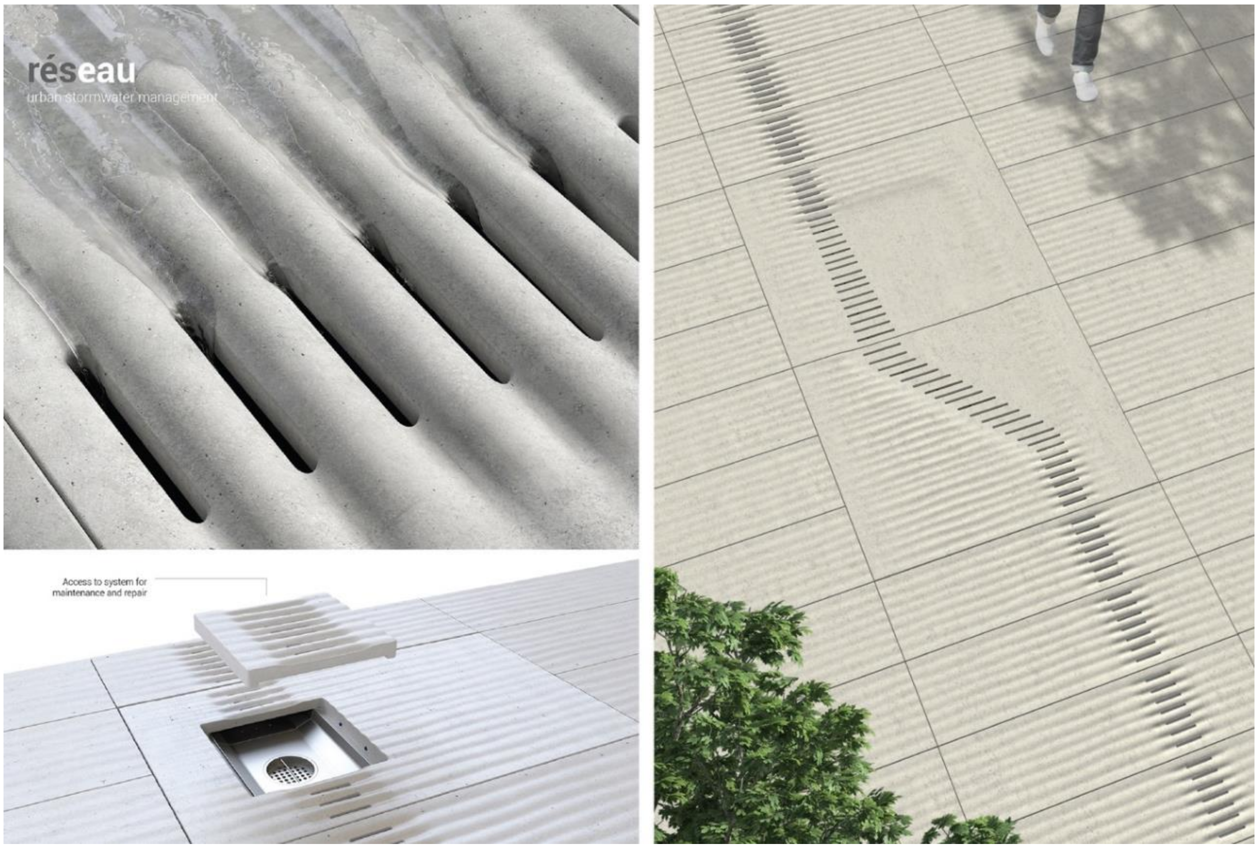

Fig. 3. Urban storm management system, « réseau »,
by J. Bergeron and M. Le Sant, directed by T. Leblanc, 2019

Fig. 4. Urban storm management system, « réseau », detail splash pad with integrated jets by J. Bergeron and M. Le Sant, directed by T. Leblanc, 2019

Both design proposals received enthusiastic response from the industry and design experts. Their quality and relevance have been acknowledged by the multiple awards they received, including the international Red Dot Award 2019. The project, *réseau* even distinguished itself as the "Best of the Best" in its category and is nominated for the Red Dot Luminary Award 2019.

CONCLUSION

Results show that design proposals driven by design research have a greater likelihood to be relevant and original, especially if research is significant and well interpreted. When designers understand the issues at hand, they are likely to develop concepts that are significant and appropriate for the context of use. However, the importance of design research is often ignored. Students need to be reminded that their concepts will be more convincing if they are based on a deeper understanding of the problem and needs.

In this case, research findings suggested that successful modern water features should respect the human scale and should be designed with the user in mind. The design should be seen as an integral part of the

contextual environment and be in harmony with the surrounding architecture. The two featured proposals took in account the variety of users of the public space (and their various abilities), thus developing a rather multigenerational design that is accessible and unobtrusive.
In both projects, the careful choices of materials, colours and nature-inspired shapes make the overall display emphasize the aesthetic and sensorial quality of water (e.g. appearance, sensations, sound). The design concept also considers all various stakeholders, the logistics and maintenance. Multiple configurations and customization options are possible, thus facilitating their implementation in various neighbourhoods and the replacement of parts.
The overall design takes indeed into account all three dimensions discussed previously: the object itself, the actors and the user experience/ interaction, as well as the new way of living the urban space, acting as a social catalyst and developing the city.
So, how did research inform the creative process?

- Considering historical and cultural knowledge, empirical data and technological advancements (e.g. eco-friendly material).
- Awareness of challenges, stakeholders and heritage of urban context, socio-cultural, political and ethical concerns (users and biodiversity).
- Considering societal needs such as reducing UHI effects and developing sustainable design, socially relevant design and inclusive design solutions, which help reintroduce water and vegetation into the urban landscape.

Judging from the obtained outcome and its enthusiastic reception, we can conclude that the design research was critical in guiding the design process, helped justify and assessed the design concepts, thus strengthening the design discourse.
Furthermore, learning from other disciplines helps shape design's transdisciplinary approach – by extracting scientific knowledge from other disciplines to inform their own – a much-needed skill for collaboration. Finally, the scientific culture prepares designers to embrace their role of creative problem-solver capable to understand the interests of multiple stakeholders involved in a project.

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DESIGNING WITH UNCERTAINTY

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INTRODUCTION

In a recent radio interview in which she spoke against the certainty expressed by political figures, Montréal playwright and author Fanny Britt argued eloquently for uncertainty as a critical and necessary aspect of social life. "The problem with certainties, she said, is that they kill our curiosity and make us mediocre. What we find in uncertainty, on the other hand, is shared humanity."[1] With this, she suggests that avowing and sharing uncertainties binds us to others socially. Uncertainties are common and, although some may be resolved, the general condition of uncertainty is permanent. Certainty, on the other hand, is an unstable, relative and ephemeral condition that requires intense work and a great deal of fiction.

This article draws a parallel between Britt's suggestion for the role of uncertainty with respect to social life and its role in design education. It suggests that uncertainty has the potential to tie student's critical thinking with knowledge production in university and in practice by exposing the ways in which design methods and processes are devised, institutionalized and incrementally developed through time.

The article will focus on a design studio I have taught for which uncertainty was taken as a conceptual foundation. The main ideas it brings up are the significance of making methods explicit in the late stages of design studies, the intertwining of project and subject, and the knowledge and experience this produces. The theoretical framework developed is based on an exchange between the concept of uncertainty within design studio pedagogy and concepts drawn from the work of Russian thinker Mikhail Bakhtin.

DESIGN AND UNCERTAINTY

As a general rule, modes of practice for professionals are aimed at resolving uncertainty rather than encouraging it. This is for obvious reasons if we understand architecture and design to be problem-solving, contingent disciplines. In this sense, the reduction of uncertainty aims at the improvement of the quality of design decisions.[2] Unsurprisingly, most positions that recognise the use of uncertainty in design processes look at it from the viewpoint of professional practice, sometimes as a necessary condition for reflexive practice to emerge,[3] for innovation,[4] invention[5] and creativity.[6] From a generalist point of view, and following Renata Tyszczuk, we could say that uncertainty might well be the single certainty of design.[7]

The inclusion of uncertainty into studio pedagogy, therefore, serves specific purposes. It would prepare students, among other things, for the contingencies of practice, the unforeseen, and better problem solving. That is, by encountering situations of uncertainty in the project, students get better at dealing with the counterproductive aspects of gaps in knowledge, experience or expertise. This tie between uncertainty and design pedagogy is now well established. Lee Shulman and others have identified it as a key component of the signature pedagogy for design professional programs,[8] as well as a way into critical and radical pedagogies.[9]

In the work presented here, uncertainty is not something tied to a gap in knowledge or skills, a difficult new problem that fits within previous understanding of what a design problem is (a different brief) or to particular conditions of collaboration.[10] Rather, it is tied to method, process and the organization of the project itself, by, for example, experiment and play,[11] methodological ties with surrealism,[12] the integration of chance[13] or accident.[14] Uncertainty, in these cases, aims at foregrounding the dialogue between the designer and the emerging project.

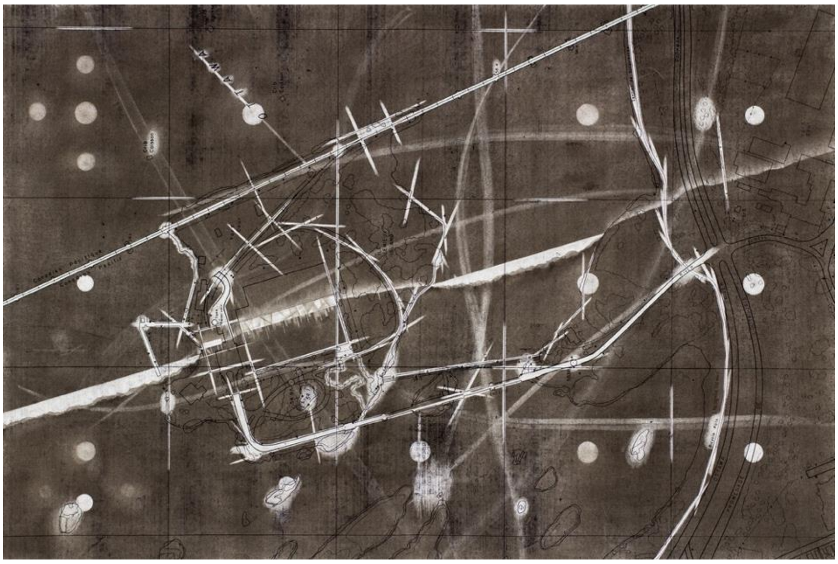

Figure 1. Cavan Liao, Voyageur, first exploratory drawing

AN EXPERIMENT WITH DIALOGUE AND CARNIVAL

This is the dialogue that can be read in this drawing (Figure 1), for which the student masked the given site map before starting a process of erasure as revelation and discovery. A game analogous to the process of design is being played, between knowing and not-knowing, occluding and revealing. The drawing is an example of work from a studio I taught at the Azrieli School of Architecture and Urbanism, Carleton University, Ottawa, in 2014 and 2015. This was a fourth-year preprofessional undergraduate studio in architecture and the last one of the degree. The pedagogical and institutional context is important since by that point, students have acquired the skills necessary for graduate professional studies in architecture or non-professional design practice. They have also developed problem-solving skills for specific briefs given to them and the confidence to know more-or-less how to "get through studio."

The principal pedagogical objective was to encourage a critical reformulation of methods learned in previous years, shifting the focus of each project from result to process. The brief required students to develop an approach that would explicitly *carnivalize* their ways of working and acquired skills so that they would be faced with risk and uncertainty about the outcome. This made for some discomfort, as the issue of methods had not been explicitly brought up as something "designed" but as implicit to previous exercises.

The choice of words, to *carnivalize* process, is not trivial. The studio's objectives were developed and presented through concepts drawn from the work of Russian thinker Mikhail Bakhtin, principally dialogue and carnival. Aesthetic, ethical and ontological principles, these tie together alterity, plurality and incompleteness and made up a conceptual framework for each exercise, which can be broken down into three main lines.[15]
First, *carnival ambivalence*, or, the temporary dissolution of oppositions and contradictions.[16] Carnival can be a social concept, an aesthetic concept or a method. It could refer, for example, to the insertion of differential elements into a system, of one text into another, or to the ambivalent state brought up by a "conjunction of opposites and [a] plurality of voices".[17] Second, *transposition and translation*, or, the ambivalent, contingent nature of things that are the results of texts moving from one language to another.[18] William Whyte, drawing on Bakhtin, describes how the architectural project's meaning arises dialogically from the relations between its various states, stages and modes of representation.[19] Third, *polyphonic whole*, or, the way in which all things are composed and defined from a multitude of equivocal voices.[20] Nothing can be considered in isolation to the relations it has to others, nor its meaning be finalized.[21] Nam Hoang's project from 2014 (Figure 2) captured these three main lines. He worked with chance as the principal operation to derive narratives involving multiple characters and voices. These were translated into a series of events, transformations and additions to the given site, that eventually took the form of a series of nine models assembled from found objects, each a fragment of a larger heterogeneous narrative.

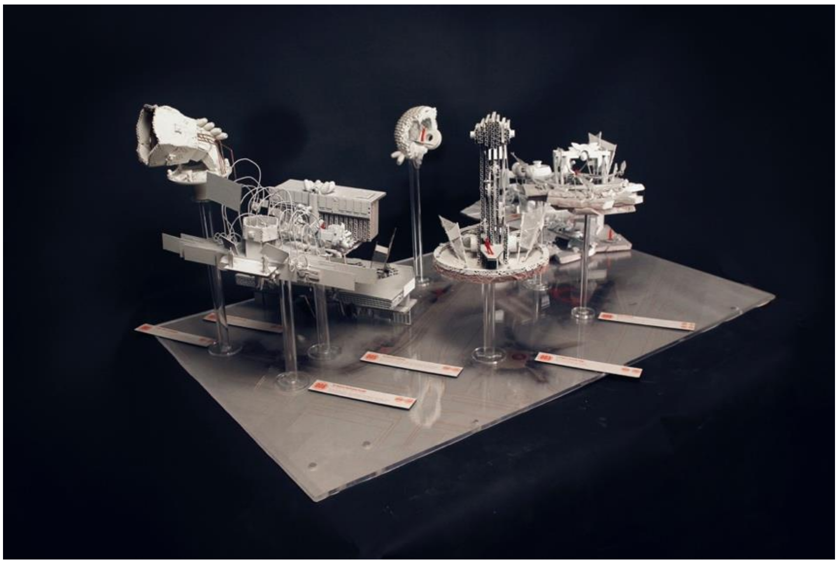

Figure 2. Nam Hoang, Chorus, assembled model

The structure of the studio followed a sequence from performance-research and installation work, narrative writing and exploratory drawing exercises that stood in for the program of a final individual project. The four-month term was punctuated by two public exhibitions at local and university art galleries. Objectives included avoiding a strict formalism by displacing the product of design to its process, and spatial forms of the architectural object to spatial forms afforded by the methods. This changed the definition of the architectural object as the usual end result of design studios, further underlining the ambiguity of design pedagogy,[22] as well as disconnecting the design act from its predetermined result (or knowing how to get to a desired result). Having students actively engage with methods and treat them as part of their design project had the added result of introducing and generating discussions on the institutional and social aspects of production. In the same way that Robin Evans wrote of drawings as locales of "subterfuges and evasions" with regard to drawing conventions,[23] the various genres and transpositions explored by students worked to reassert the value of process, imperfection and discovery within the usual linear development of the studio brief. Two examples from the studio include Vanary Lyboun's *décollage* drawings and Aileen Ling's time-based project. The first used collage and décollage as rough and imprecise operations to parallel a narrative on presence and absence (Figure 3). The second denied herself a safe starting point and approached her architectural proposition from its temporal dimension, using video and stop-motion as modes of sketching (Figure 4). As a final form of critical revaluation, students were asked to determine their own final output in order to think critically about the determinism involved in a typical drawing set or studio hand-in. In the section that follows, I go over the work of three students from the studio in order to illustrate how the framework described above was put to practice.

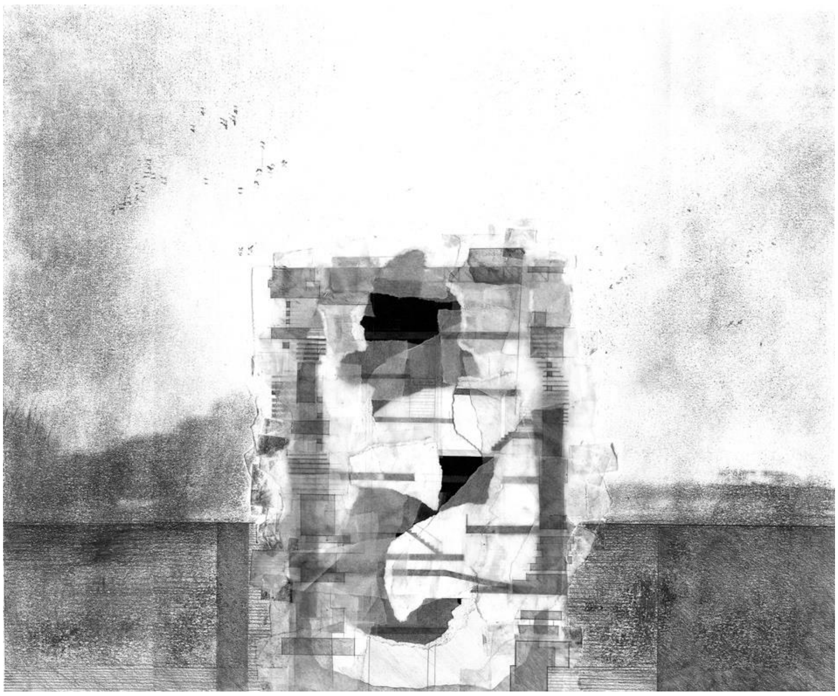

Figure 3. Vanary Lyboun, Coffin Island Archive for Lost History, section drawing

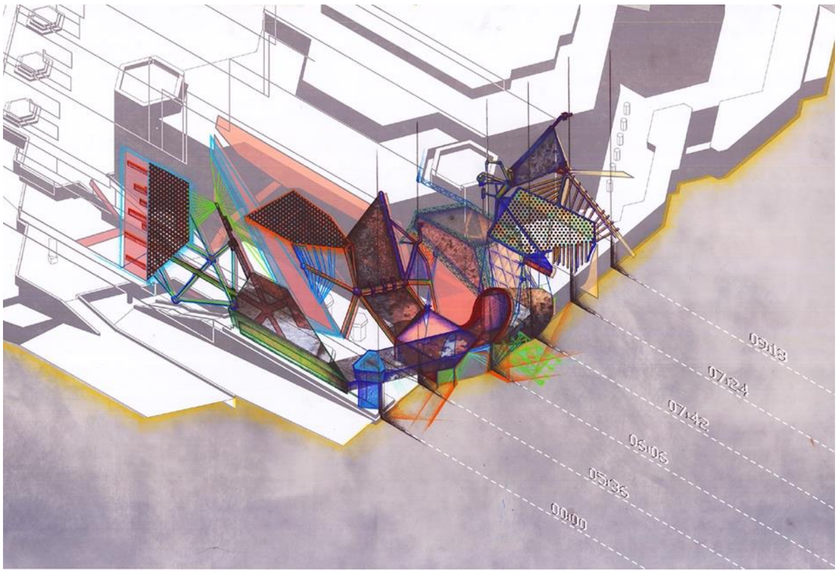

Figure 4. Aileen Ling, Passages, oblique projection

MADE-UP TOOLS, "OPEN" PROJECT AND INCOMPLETENESS

Arron Griffioen wrote a project narrative based on Alice through the looking glass. The narrative accompanied a first exploratory drawing that took the form of a viewing box that deformed the perception of Canada's National Arts Centre in Ottawa using existing drawings and archival material. Subsequent explorations into the project involved optical devices to construct perspectives of new spaces (Figure 5), that eventually led to the design of bespoke hand-drafting tools that guided the transformation of the existing structure through reflection, refraction and translation (Figure 6). In this project we recognize the object being designed, although its purpose is unknowable. The principal actions of the student, already skilled at technical drawing, were focused on denying himself the comfort of known tools, testing the spatial possibilities of invented drawing instruments whose outcomes could not be foreseen.

Figure 5. Arron Griffioen, In Through the Looking Glass, perspective apparatus (top) and resulting image (bottom)

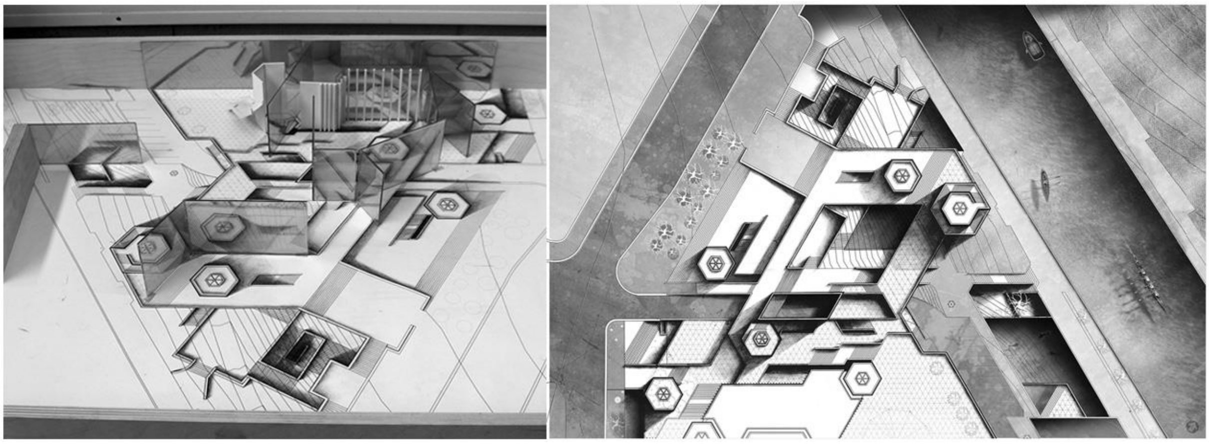

Figure 6. Arron Griffioen, In Through the Looking Glass, site plan in progress with bespoke drawing instruments (left) and final site plan (right)

Anoushae Eirabie worked from a sci-fi fairy tale taking place on small islands in the Ottawa River. The narrative involved mechanical analogies that tied together a thriving underworld with the "junk-space" above ground. Her initial bas-relief drawing reconstructed the site along those lines. She then devised a series of objects and drawings made from found objects and newly fabricated pieces as conceptual reconstructions that included process and transformation. This eventually led to the dismantling of a broken piano. Starting with a careful and intensive inventory of its disassembled pieces (Figure 7), she eventually devised precise models and drawings that explored the spatial qualities afforded by the new assemblies, some of which were reterritorialized on the initial site of the island (Figure 8). In this project the tools are known. Rather, it is the set of artefacts produced, a series of intuitive, iterative and loosely connected actions that amounts to an open architectural expression. The project is not easily read as architecture, avoiding building form, and constantly fuses the mechanical with the social.

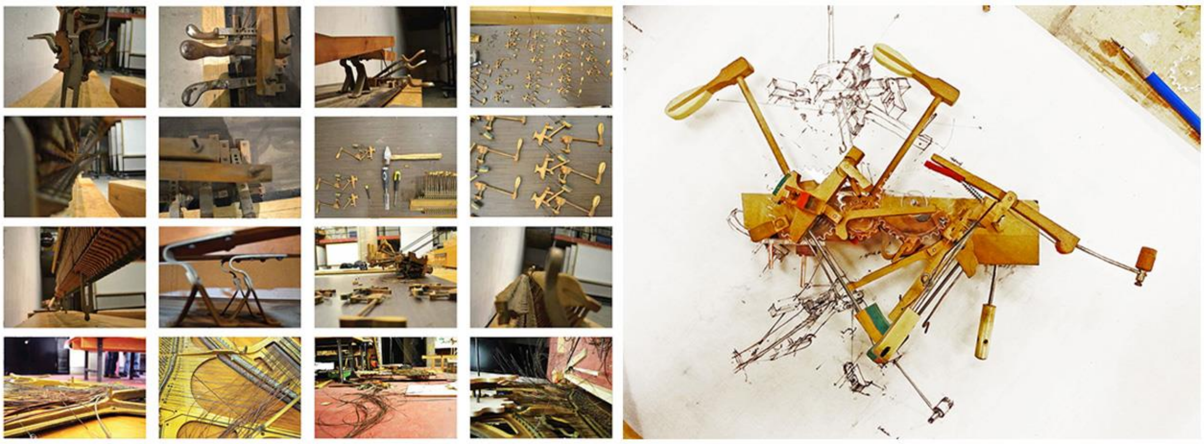

Figure 7. Anoushae Eirabie, Junkspace Contraption, dismantling of piano (left) and study model (right)

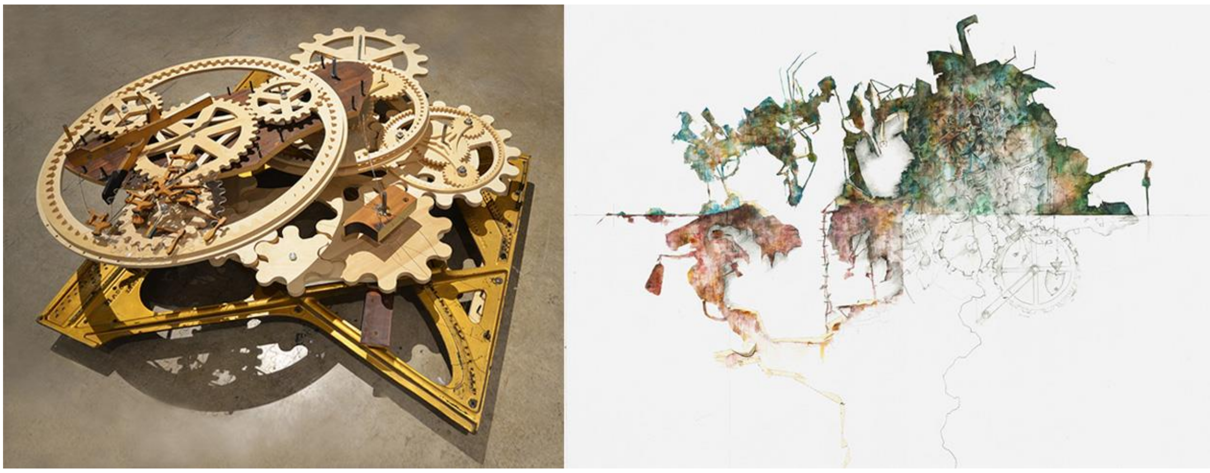

Figure 8. Anoushae Eirabie, Junkspace Contraption, final model (left) and section/elevation drawing (right)

Thompson Nguyen started from a tense narrative mixing personal self-realisation, coercive psychiatric procedures and institutional rules. His initial drawing explored hidden narratives of the National Arts Centre that continuously mixed the personal with the social and the political. He took the incompleteness of dialogue at heart, working and reworking the same drawings over and over, ripping and adding, leaving rough notes for others to read. He continued this strategy in his entire project, a National Bath House to carnivalize the National Arts Centre, working on a limited set of drawings that were eventually transformed with similarly rough three-dimensional explorations (Figure 9). The architectural outcome of this project, in comparison to the two just described, was much more uncertain because the student was simultaneously free given his messy approach to drawing and not free from having to constantly advance the project on the traces left over by previous actions. The messiness of the drawing paralleled the messiness of the subject's reflection, the traces left over bearing witness to the incompleteness of the project as well as to the hesitation of the designer.

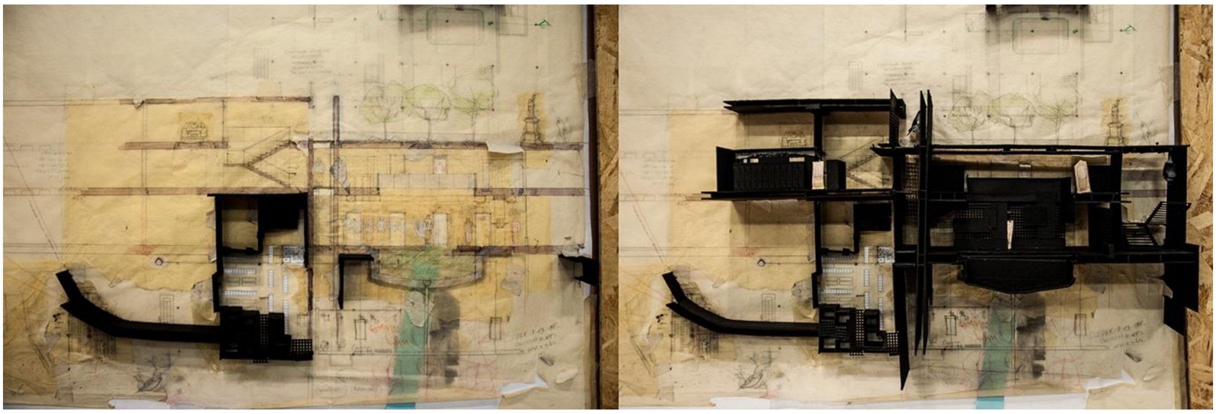

Figure 9. Thompson Nguyen, National Bath House, incremental bas-relief drawing/model

HABITS AND PUBLIC PERFORMANCES

I now want to reframe the work of the studio following the distinction made between the *habits* and the *public performances* of professional signature pedagogies.[24]

Habit, ambivalence and projective uncertainty

Within the encouragement to carnivalize methods, it was the previously learned habits of representation and production that were most destabilized. The typical drawing set asked of students in submitting their projects for evaluation carries with it an institutional and technical determinism. It implies that their project exists as a virtual object of which they have to submit representations. To undermine this determinism in the studio, it was stressed that drawings and models did not have to be univocal representations of the same reified object.

Each genre of the project (whether sketching, drawing, model making or fabrication) has particular rules, parameters and tools. Moving the project forward, the designer transposes the project from one genre to another. These transpositions express ambivalence but also uncertainty: neither state can be said to signify the project fully although the relation between them approaches this definition. The meaning of the work is derived from the dialogue between the designer and the work as this one develops through transpositions, uncertain movements, readjustments and unresolved ambivalent positions. Students were therefore encouraged to rework the same objects over and over again, and/or to continue rethinking the project until the end of term, adding new elements, in order to avoid the switch to a final production for which design would be over. The end products were usually messy, incomplete and polyphonic in a dialogical sense.

Asking students to answer for their final output was a way of asking them to make sense of what they were doing, had done in past studios and would do in the future.[25] But to find a complex resolution in incompleteness was not something students were prepared for. Ambivalence generates risk. The students know a partial resolution is needed, somehow, but are simultaneously encouraged to question this same resolution as a design problem to be set. In dialogical terms, this ambiguity plays with the contradictions that inevitably arise from any attempt at ordering, and thus positively affirms what Tim Beasley-Murray calls the beneficial failure of dialogue.[26] It is not an exaggeration to say that reassurance was constantly needed. This was especially true for students who hesitated to relinquish control over their production, having, in the past, equated control and assurance with success in design studio, as it was for students who had not felt comfortable with the pedagogical and technical demands of previous studios, but still found it difficult to methodically break away from learned approaches. Because they became answerable for a project's "beneficial failures", the students' public performances became much more intense and personal than anything they had experienced previously. Kristel Derkowski's final presentation exemplified this (Figure 10). Her project had transposed from a stream-of-consciousness narrative on cycles of creation and destruction to increasingly elaborate tensile models, and eventually to drawing. In resonance with her own description of her project as a "snake that eats its own tail", her personal writing was foregrounded by the invited critics to make sense of her eclectic and heterogeneous production.

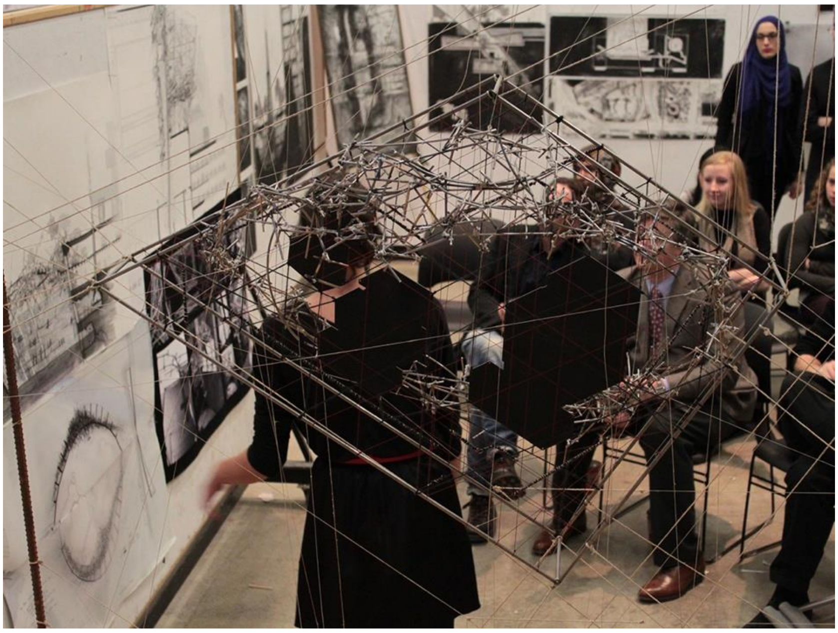

Figure 10. Kristel Derkowski, Cycle, final presentation with steel and string model in the foreground.

Public performance, alterity and subjective uncertainty

Because it involves public performances by students in presentations, critiques, exhibitions, discussions with peers and professors, in making sense together and in opening the work to others, the studio experience is closely tied to identity formation. Indeed, transformative subjective relationships in the design studio are a defining aspect of what Lee Shulman has called "pedagogies of uncertainty"[27]. By explicitly questioning technical, intellectual and moral dimensions of practice, studio engages the person acting as future designer dialogically, questioning their own position with respect to practice, collaboration and self-identity.[28] An observation made by many students was that they saw significant overlaps between themselves and their projects. Projective uncertainty seemed to generate as much a crisis of the process/product relation as it did of the subjects involved. Here is an example, written by a student in their final portfolio hand-in:

"The word 'process' became some sort of buzz word that I never really understood until completing this studio. Professors would encourage to focus on your process, but it was never clear what that really meant. It was truly something I needed to define for myself. […] I've learned that self-doubt is part of my process, so I can't ever really be sure if this is 100% correct. But process was understood to me as an ongoing discovery of oneself."

It is significant, in this case, that Bakhtin's early aesthetic texts characterise creative activity by a double-movement of the author.[29] The author starts from their own position in space and time, then momentarily shifts their position to identify with the work before finally returning to their own unique position. It is along this *exotopic* or out-of-place movement that the act is performed, simultaneously affirming the author's responsibility as well as the alterity, or otherness, of creative activity. The same student quoted above continues by questioning the idea of performance and identity:

"How much do I actually want to share with you? Is studio a performance?
To my professor? Or to my peers? Or to myself? What I'm really producing is –
Well I don't really know."

Because the studio and its performances were approached from the basis of uncertainty, but also, significantly, from a desire to destabilize previous knowledge about ways of designing and communicating, it appeared to speed up and intensify the moment of not recognizing oneself in the work as well as not recognizing oneself as designer. This contingent and dialogical activity between project and subject, is also what Bakhtin describes as *architectonics*, the process of constructing complex assemblages in which objects and subjects cannot be separated.

Appropriation of design methods and process as threshold concept

In the end, working with uncertainty as I have described it here did two things with regards to design's signature pedagogy. It brought design methods from the deep structure of studio pedagogy, and designer responsibility and identity from its implicit structure right up to the surface.[30] By doing so, it activated the project-subject relation in ways that regular briefs had not done. Appropriation of design methods and process, I would suggest, is what Ray Land and Jan Meyer define as a *threshold concept* for design pedagogy, along with concepts such as scale or the toleration of uncertainty.[31] Ways of designing that had been taken for granted by students and/or were implicit to the curriculum up to this point were destabilized and made apparent. Pulling the rug from under their feet, so to speak, brought out an irreversible awareness of how they had done things, how they were to do things, and how uncertain it all is.

ON THE SOCIAL VALUE OF UNCERTAINTY IN DESIGN EDUCATION

In her reading of Bakhtin, Julia Kristeva sees carnival as a method of engaging simultaneously with harmony and rupture as a mode of social transformation.[32] That is, the ambivalence inherent to carnival, where things can be more than one thing at a time and binary oppositions cease to make sense, is a critical and necessary dynamic between the acting subject and social structures.

Framed by carnival and ambivalence, the pedagogical framework of the studio attempted to tie the design process of students with preoccupations located in the social realm: practice, public performance, knowledge and responsibility, on the one hand, as well as experience in dealing with alterity, ambivalence and uncertainty on the other. The uncertainty developed here is not tied to lack, but tied to a productive aspect of creative, responsible and honest activity in design.

It is important, here, to recall the institutional context of the studio in which students had already been through three and a half years of directed design exercises. In this sense, the new understandings and discoveries encountered by students in the process are ways of productively linking design education to the architectonics of knowledge production as both an individual and a social collective project. Awareness that the design project, its process and its methods make up an architectonics of uncertainty, serves as a threshold in design pedagogy that points the way forward to public performance as a future practitioner as well as a critical member of society.

Finally, the inclusion of uncertainty and the focus on process and methods as the main narrative of studio also reveals to students that pedagogies are not matters of course, but fabrications. Rather than seeing them as given, they can appear as works-in-progress and reveal the social role of active learning, dialogue and what Jacques Rancière meant when he described education as something that should not be given, but taken.[33]

CREDITS

All students whose work appears in this article have given their consent for the work to be reproduced. The photographs were taken by the students themselves. Figure 10 is from a collection of photographs taken during the final presentations that were given to the author at the end of term. The photographer is unkown.

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DESIGNING WITH INDIGENOUS KNOWLEDGE: A JOURNEY TO DEVELOP POLICY AND PROTOCOLS FOR RESPECTFUL CROSS-CULTURAL REPRESENTATION IN DESIGN EDUCATION AND PRACTICE.

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INTRODUCTION

The Australian and International Design Charters were created to provide the tools to develop new ways of thinking under the premise that 'if we change the way we think, then the things we look at need to change'[1].

This paper is a reflective exploration into events leading up to the launch of the International Indigenous Design Charter at the World Design Summit in Montreal, Canada, 2017. This series of strategically aligned, professional practice inspired activities spanned an eleven-year period (2006-2017). A pivotal point within this series of events involved a doctoral research thesis undertaken by the author of this paper, Swinburne University (2012 –2015). The dissertation titled; Designing with Indigenous Knowledge: Policy and protocols for respectful and authentic cross-cultural representation in communication design practice (Kennedy 2015)[2] followed on from a body of interrelated explorations into ethical representation of Indigenous culture in professional design practice. These thematic, relationality-based inquiries investigated methods to develop respectful cross-cultural connectivity between First Nation cultures and contemporary national identities. The motivating proposition behind the direction of this research is represented in this seminal statement made by Robert L. Peters in the mid 1990s; Design creates culture. Culture shapes values. Values determine the future (Peters 2019)[3].

This ongoing practice based research continues to explore cultural innovation methods to improve, promote and maintain the respectful representation of Indigenous culture in professional design practice. This sequence of case studies dating back to 2006 includes a number of activities and events that have acted to ameliorate the comprehension of complex cultural narratives in design practice. At the time these case studies identified a clear knowledge gap which proved to be integral in framing the thesis of Kennedy's doctoral research. From the outset, this study asserted the need to establish best-practice protocols to assist design practitioners working with Australian Indigenous culture. Also identified in the dissertation was the potential to expand the protocol based, professional practice conversation globally. It is envisaged that formal methods to improve 'impact and effective practices' could be used to inform the content of professional practice documents developed by Australian professional design associations. There is also potential for further post-doctoral research activity involving policy development for other counties with similar Indigenous knowledge and communication design practice dynamics (Kennedy 2015. p. vii)[4].

This doctoral study also highlighted opinions that professional Indigenous practice guidelines should extend beyond just communication design to include architecture as a mode of communication that operates in much the same way as other forms of art, media and design. When interviewed as part of this research, Aboriginal Architect, Dillon Kombumerri (Yugemeir), suggested that cultural representation is a multidisciplinary design issue. We should be discussing design as a fluid process. It would be better to talk generally about design rather than focusing on a specific discipline (Kombumerri (Yugemeir), personal communication, March 1, 2013. p.229).[5] Kombumerri, Principle Architect - Office of the Government Architect NSW also spoke of the need for design practice guidelines for Indigenous knowledge. His comments speak to the primary question behind this research: The representation of Aboriginal Australian culture in design practice needs to be improved and design practitioners need guidance. There is a real need for protocols and guidance to inform designers about Indigenous culture. There appears to be a desire to do the right thing but the knowing is not there. Desire yes, knowing no. Guidelines for appropriate engagement would be of a great help for designers (Kombumerri (Yugemeir), personal communication, March 1, 2013. p. 230, 231)[6].

On completion of this doctoral research four investigators, two Indigenous and two non-Indigenous members teamed up to embark on additional exploration based on the findings expressed in the dissertation. A research cluster called, Visible Steps was formed. It included, Dr Meghan Kelly, Mr Jefa Greenaway (Wailwan, Gamillaraay), Dr Brian Martin (Muruwari, Bundjalung, Gamillaraay), and Dr Russell Kennedy. Visible Steps was formalised with a Memorandum of Understanding between Indigenous Architecture and Design Victoria (IADV), Design Institute of Australia (DIA) and Deakin University's School of Communication and Creative Arts (SCCA) and its Institute for Koorie Education (IKE).

The collective aim of Visible Steps was to further investigate the notion of best practice, Indigenous cultural protocols to assist design stakeholders including governments, educators, practitioners and their clients. Operating within a framework of *relationism* the research team worked systemically with a coalition of Indigenous and design stakeholders between 2015 and 2017 to produce both the Australian and International Indigenous Design Charters. It was identified early that such protocol documents needed to open, updatable documents. This approach was crucial to the success of the investigation. As Martin pointed out, principles need to be negotiated and are not necessarily binding because lived experience and actuality of relationality is ever moving (Martin et al., 2016)[7]. The international phase of this project was officially endorsed by the ico-D the International Council of Design (formally Icograda) and partially funded by the Australian Government, Department of Foreign Affairs and Trade (DFAT).

PRE-DOCTORAL - INDIGENOUS CULTURE AND NATIONAL IDENTITY

It was not envisaged that a series of cross-cultural design workshops and exhibitions starting in 2006, would lead to the establishment of internationally recognised guidelines for representing Indigenous culture in professional design practice, launched in 2017. As Steve Jobs stated at his 2005 Stanford University Commencement Address, you can't connect the dots looking forward; you can only connect them looking backwards. So, you have to trust that the dots will somehow connect in your future.[8] Mapping the development of the Indigenous Design Charter project revealed a series of convergent/divergent but aligned activities involving international and local events. Although not described as such at the time these multidisciplinary, cross-cultural activities exploring Indigenous culture and national identity relationality all followed a ‘user centred’ methodology of innovation facilitation. This broad consultation phase, would later be referred to by the researchers as an empathise phase of what was essentially a Design Thinking process. As the Hasso-Plattner Institute of Design (d.school) at Stanford University describes, Design Thinking is a design methodology that provides a solution-based approach to solving problems (2019). The five stages of Design Thinking, according to d.school, are as follows: Empathise, Define (the problem), Ideate, Prototype, and Test (2019).[9] Upon reflection the events listed below enabled the author to position the discussion and consolidate thoughts around the ethical application of Indigenous representation in design practice. These projects and events were either initiated but the author and/or endorsed by ico-D the International Council of Design):

- 2006 **MIXO6: Migrant Indigenous Exchange 2006**
  ico-D - INDIGO pilot project workshops (USA + Australia)

- 2006 **One Step Back, Two Steps Forward**
  ico-D - INDIGO pilot project exhibitions (USA + Australia)

- 2007 **INDIGO: International Indigenous Design Network**
  Official launch ico-D congress (Cuba)

- 2007 **NEW AFRICA**
  ico-D endorsed exhibition (Denmark)

- 2011 **MOTHER TONGUE**
  ico-D, INDIGO exhibitions (Italy, Taiwan)

- 2011 **ORIGINALITY 100**
  ico-D, INDIGO themed cconference (Taiwan)

- 2012 **REDISCOVERY**
  ico-D, INDIGO themed Design Week (Borneo)

The Migrant Indigenous Exchange 2006 (MIX06) explored the relationship between Indigenous and non-Indigenous culture within the context of national identity in the USA and Australia. It also investigated issues of cross-cultural co-creation and the methodologies required to do so effectively. MIXO6 was developed with the assistance of a research grant from the Institute for the Study of Global Movements at Monash University. The 2006 pilot project involved collaborative workshops and exhibitions with undergraduate students from both the University of Hartford in the USA and Monash University in Australia. Monash University was invited to participate in this exchange by Robert L. Peters, Koopman Distinguished Chair in the Visual Arts at the University of Hartford. The workshop outcomes were exhibited in galleries at the respective campuses in the USA and Australia under the title of One Step Back, Two Steps Forward. MIX06 was a successful pilot project for INDIGO,

International Indigenous Design Network also inspired further research in this area. Kennedy regards as a precursor to his Doctoral research (2015. p.v)[10].
INDIGO, International Indigenous Design Network was officially launched in 2007 at the ico-D General Assembly in Havana, Cuba. INDIGO was created by ico-D, the International Council of Design as a way to lead a global discussion about Indigenous representation in design practice. Its aim is to provide opportunities for local and Indigenous designers across the globe to exchange knowledge and experiences. It also offers a platform for evolving creative expressions that shape the formation of national and cultural identities. In 2016 ico-D, based in Montreal, Canada signed an MOU with Deakin University in Melbourne, Australia to take over the management of INDIGO[11]. In 2007 ico-d endorsed an exhibition in Copenhagen, Denmark titled NEW AFRICA. Curated by Danish Architect, Tina Midtgaard. NEW AFRICA showcased examples of traditional inspired expressions of contemporary African design. In 2011 ico-D worked with Monash University to produce MOTHER TONGUE, an international online exhibition exploring contemporary visual expressions of Indigenous language. MOTHER TONGUE, curated by leading Australian designer, David Lancashire also toured to Forli, Italy, and Taipei, Taiwan. The Taipei exhibition at the National Taiwan University of the Arts' Art Museum was part of ORIGINALITY 100. This INDIGO themed international conference was endorsed by ico-D and aligned with its 2011 General Assembly in Taipei. In 2012, ico-D held REDISCOVERY, an INDIGO themed Design Week in Borneo which was hosted by Swinburne University, Sarawak Campus in Kuching. The theme 'Rediscovery' celebrated Indigenous design with an aim to provide a platform for sharing, collaboration and inspiration among local and international designers in an atmosphere steeped in Sarawak's Indigenous cultures and traditions. The experiences, observations and conversations generated from the events outlined above were the inspiration for further exploration in the form of doctoral study.

DOCTORAL – DESIGNING WITH INDIGENOUS KNOWLEDGE

The doctoral dissertation referred to in this paper identified that despite the existence of protocols for the creation, distribution and ownership of Australian Aboriginal and Torres Strait Islander visual and media arts, there remained a lack of information, guidance and professional leadership regarding the appropriate creation and commercial use of Indigenous graphical representations. The doctoral research also responded directly to calls from the Australian Government and professional representative design associations to address issues related to cultural appropriation (Kennedy 2015, p.vii)[12]. During the PhD candidature the Australian Government called on the creative industries to consider more closely the relationship between Indigenous cultures and national identity. The design profession, represented by peak bodies, the Design Institute of Australia (DIA) and the Australian Graphic Design Association (AGDA), have identified a need to develop methods to assist communication designers to understand and appropriately represent Indigenous ontology in their work.
There are many terms used to refer to Native, Aboriginal or First Nation People. As with the previous explorations, this research used of the term 'Indigenous' because it was aligns with the language used by the United Nations as prepared by Jose R. Martinez Cobo. Indigenous communities, peoples and nations are those which, having a historical continuity with pre-invasion and pre-colonial societies that developed on their territories, consider themselves distinct from other sectors of the societies now prevailing on those territories, or parts of them. They form at present non-dominant sectors of society and are determined to preserve, develop and transmit to future generations their ancestral territories,

and their ethnic identity, as the basis of their continued existence as peoples, in accordance with their own cultural patterns, social institutions and legal system (UN 1981)[13].

The primary research question asked in this doctoral study was: Are protocols required to assist practising communication designers (Indigenous and non-Indigenous) in the respectful representation of Australian Indigenous visual culture in communication design practice; And if so, what should they be? The suggestion of protocols and practice guidelines raises additional questions such as whose voice do they speak with; who speaks on behalf of whom and what protocols would need to be put in place for use by designers (non-Indigenous and Indigenous) (Kennedy 2015.p.vii)?[14] Ultimately the question of "whose voice is it," who speaks on behalf of whom, and whether one can 'steal the culture of another" are not legal questions to be addressed in terms of asserting rights, but ethical one to be addressed in terms of moral and political commitments (Coombe, 1993, p.93)[15].

The research findings concluded the Australian design profession required workable methods and processes to help practising designers' access and engage appropriately and ethically with Indigenous knowledge on projects that involve the graphical depiction of Indigenous culture, national authenticity and the specific representation of 'place'. The findings also considered Indigenous designers who may require guidance when working on projects from unfamiliar regions of Australia and/or involving communities other than their own (out of country). Communication Designer, Marcus Lee a Karajarri man stated; I think guidelines to help both Indigenous and non-Indigenous designers navigate this area, is the only appropriate way to go…I've been involved in situations where I have presented what I thought to be appropriate contemporary Indigenous solution but even having an Aboriginal heritage I could still get it wrong. So, I think it's still important to go through that process with the Indigenous elders involved. I have to respect their opinions and at the same time subjective nature of design.…Coming up with a right design solution requires you to work hard to find a balance rather than focusing entirely to what you think is right, you can't ignore the situation, you need to respect and understand it (Lee (Karajarri), personal communication, January 23, 2013. p. 226)[16].

The doctoral findings further argue that the proactive facilitation of authentic, visible representation of Indigenous culture would also help advance the reconciliation process by promoting respectful cross-cultural exchange. Jonathon Wallace from Alter stated that a professional protocol charter or guide would help designers understand the issues, which would give them confidence to convince clients of the need for a culturally respectful methodology (2013); I wouldn't know where to begin, but it would help if there was some kind of roadmap. It would give designers some confidence when presenting to clients that they have employed an appropriate method of dealing with this issue. I think a lot of people, if given the opportunity, would be reasonably respectful but also that this issue is bigger than design. It's a broader issue within Australian culture. It's something that we tend to be a little bit ignorant of or apathetic about. That might be because of location, such as being Melbourne based. A Melbourne designer has a significantly different kind of engagement with Indigenous culture than a designer in top end of Queensland or the Northern Territory. I think if you look at the way countries like New Zealand represent themselves, there is a much greater sense of integration and a more contemporary Indigenous culture, which is intertwined with the mainstream. There is real pride that comes out of this, at least from a consumer's perspective; that's the sense I get. Australia wants to put itself on the map but is being hamstrung by the way it expresses itself. Combining contemporary location branding with traditional Indigenous knowledge is the real Australian to me, but it would be good to have a roadmap of how to achieve a result ethically and respectfully. A designer cannot expect to become an expert in this area without committing a great deal of time to it; but a guide would

be a very useful place to begin (Wallace, personal communication, March 7, 2013. p. 223)[17].
The doctoral research concluded there was a need for a framework of engagement, including ethical codes of conduct for use by communication design practitioners when undertaking projects requiring visual representation of Indigenous culture. It recommended that such a method to improve 'impact and effective practices' could be used by Australian professional design associations to develop a design-industry charter or associated professional practice guidelines.

POST DOCTORAL RESEARCH – INDIGENOUS DESIGN CHARTERS

In 2016 the project team produced the Australian Indigenous Design Charter (AIDC), a ten-step guide for the respectful application of Indigenous knowledge in communication design education and practice. The Design Institute of Australia (DIA) subsequently recognized the AIDC and publishing it 'Practice Notes' on their website[18]. In 2017 the International Indigenous Design Charter (IIDC) was launched in Montreal, Canada at the World Design Summit [19]. This globally focused document broadened the scope from communication design to embrace all design disciplines including Industrial design, architecture and the built environment. This multidisciplinary guide has been endorsed by the International Council of Design (ico-D) and currently appears on their website as a best practice document for all designers and educators. It is also proposed that regional charters such as the AIDC could be developed in other parts of the world to complement the ten-steps of the IIDC[20]:

1. Indigenous led
2. Self-determined
3. Community specific
4. Deep listening
5. Indigenous knowledge
6. Shared knowledge (collaboration, co-creation, procurement)
7. Shared benefits
8. Impact of design
9. Legal and moral
10. Charter implementation

Both Australian and International Indigenous Design Charters responds directly to Article Thirty-One of The United Nations Declaration on the Rights of Indigenous Peoples where by it states, Indigenous people have the right to maintain, control, protect and develop their cultural heritage, traditional knowledge and traditional cultural expressions, as well as the manifestations of their sciences, technologies and cultures (including, designs). They also have the right to maintain, control, protect and develop their intellectual property over such cultural heritage, traditional knowledge, and traditional cultural expressions (UN, 2007)[21].
The Australian Indigenous Design Charter – Communication Design was the first document of its kind to specifically address the need to develop new tools and approaches for designers to respectfully and ethically engage with Indigenous knowledge in their professional practice. The authors acknowledge that research into the Australia Charter has benefitted from changing public attitudes during the period of its development. The Australian Government apology to Indigenous people by Prime Minister, Kevin Rudd in 2008 and subsequent discussion about a constitutional recognition of Indigenous Australians has impacted positively on conversations relating to Indigenous identity. What started out as an awkward discussion in 2006 has matured steadily to a point where the need for respectful

representation of Indigenous culture is now recognized by design stakeholders in Australian but also worldwide.

The Australian Charter served as a starting point for the IIDC, which was further developed and refined through consultations involving a series of presentations and workshops around the globe. The process was endorsed by the International Council of Design and its Indigenous Design Network, INDIGO. A key component of this research was a series of workshops undertaken in several Nordic countries. The research tour was called 'Was. Is. Always – South to North: On Route to an International Design Charter' and was supported by Deakin University and the Australian Federal Government, Department of Foreign Affairs and Trade. Seven Indigenous students studying at Deakin University's Institute of Koorie Education (IKE) and three academics (one Indigenous) accompanied the students on the research expedition. The workshops took place in Sweden, Greenland and Denmark with Inuit and Sami community members and design practitioners. The knowledge acquired was used to inform the first iteration of the IIDC. Further consultations were conducted across the Americas in Chile, Canada and the United States, leading to the international launch in Montreal in 2017, followed by an Australian launch at the Koorie Heritage Trust during Melbourne Design Week in March 2018.

It is important to note that neither the Australian nor International Design Charters claim to provide the definitive answer to appropriate representation of Indigenous culture in design practice. Instead the aim is to encourage designers to ask questions and seek their own answers in a process creative expression (Kennedy, Kelly 2018. p.15)[22]. World-renowned Indigenous architect Douglas Cardinal reinforces this point when he states, 'I'm not an answering machine, I'm a questioning machine. If we have all the answers, how come we're in such as mess?'[23] Cardinal participated as a discussion panel member at the World Design Summit launch of the International Indigenous Design Charter (Montreal 2017).

The key objective of the Charters is to help designers understand that Indigenous representation must be led and supported by the appropriate communities, who are not only in control of their own culture but are also acknowledged to be in control. To do otherwise is merely to appropriate their rights, knowledge and status. Australia has a long and shameful history of appropriation and misrepresentation of Indigenous culture in media and the arts. Although the Australian and International Design Charters were originally conceived as best practice documents, the authors believe they should also be a key focus of design education (Kennedy, Kelly. p.15)[24]. They profess that Indigenous knowledge and cultural understandings must be included in design pedagogy so as to lay a foundation of competency required for responsible and respectful professional practice. In Australia, Deakin University, Monash University and the University of Melbourne have all embedded both the Australian and International Indigenous Design Charters in their design education curriculum. Greenaway believes the Charters represent an important step towards understanding, respecting and representing Indigenous views I think the reason why this has been so well embraced internationally among first nations peoples is because it's never been articulated so clearly and codified in a very accessible and legible way so it resonates immediately. When you hear it and read through the steps, and you see the first step is Indigenous-led, that connects people straightaway. It's understood that this has come from a place which understands and infuses with an appreciation of cultural value (Greenaway 2018. P.16)[25].

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Education, Design and Practice – Understanding skills in a Complex World

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TWO SIDES OF THE DESIGN: ARCHITECTURAL MEANING BETWEEN CONCEPT AND EXPERIENCE

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INTRODUCTION

It is common to see in the studio teaching that the visual presentation of the design is important that is related so much to the final grade of the student's work. Every student project ends with the exhibition, where intellectual ideas are presented in the form of drawings, diagrams, models, films and other artistic mediums. However, this might convey a sense to students that architectural design is about finding concepts and that it ends as these design concepts are presented in exhibitions, and the architect can be a single author and architectural meaning is fixed once the concept is made. This may omit a fact that events take place in actual spaces are diverse, unchangeable and unpredictable.

There is at times a gap between design intentions and actual uses of an architecture. The actual effects to the user cannot be controlled by the architect. It seems the way in which meaning is generated by the architect is different from that by the user. This paper would firstly clarify these two ways to have meaning, explore the reasons of the architect's interest in intellectual conception and visual presentation, and then examine the recent attempts of architecture in considering the user's agency and the diversity of experience into the architect's intention. These attempts can be brought into studio teaching which could convey an idea to students that architectural meaning is dynamic and never end with the end of design.

TWO WAYS OF MEANING IN ARCHITECTURE

There is one way of architectural meaning that can be considered developing from the architect's mind, from the architect's design philosophies, the circumstances of the site, the culture, and the complexities of the brief. Architects are, at times, in favour of constructing distinctive design philosophies as to creating personalised identities. Design philosophies are usually reflected in design projects, and some like producing publications further explain their thoughts. For example, Peter Zumthor's Atmospheres indicates something of what concerns and fascinates him during a design.[1] Bernard Tschumi's Architecture Concepts: Red Is Not a Colour comprehensively clarifies how his deconstructive ideas are embodied in design.[2] Other methods of dissemination, such as lectures and exhibitions, are also common in gaining awareness in the field.

The architectural meaning that generated from the architect's mind is referred to as "conceptual meaning" in this paper. "Conceptual meaning" is always in immaterial forms, such as drawings, diagrams, videos and text, and some can be materialised into physical architectural forms if it has chance to be built. Once people get to use the space, these users come to have their own understandings of the architecture, and this is another way in which the meaning could arrive. This way of meaning is referred to as "pragmatic meaning".

The term "pragmatic meaning" comes out of the idea of pragmatism that attempts to look away from supposed principles, and towards consequence and fact.[3] "Pragmatic meaning" cannot always be anticipated, it has diverse consequence according to immediate conditions of the user, which may be different from the intentional principles of the architect. One of John Dewey's most important insistence is that "philosophy should begin and end with experience taken in the richest, deepest sense". He claims the quality of an experience is the key to philosophical understanding. The quality is inherent in the fact that we can perceive, value and act.[4] Richard Shusterman's pragmatism sees that there is a world based on common sense, which directs us to act and identify things.[5] Pragmatic aesthetics tends to see architecture as an ever-changing fact, rather than a self-evident system of inherent meaning. Different from the "conceptual meaning" that is generative and fixed, the "pragmatic meaning" is emergent, changeable and diverse.

It is interesting to look at the two ways of meaning in light of Peirce's semiotic theory. If something is fit to be a substitute for an object that it resembles – for example, an image or an idea of the object – that thing is an iconic sign.[6] The "conceptual meaning" is an example of an iconic sign. The idea generated from the architect's mind is the interpretant (the meaning of the sign), and the presentation of a design – the texts, drawings, models, videos, and building forms – is the object where the sign resides, and which signifies the interpretant. To understand the architecture's "conceptual meaning", it is not necessary for one to use one's own creativity. Once the "pragmatic meaning" emerges as actual effects applied on the user, the architecture can be transferred from being an iconic sign to architect to being an indexical sign or a symbolic sign to the user. When the user's experience (perception and act) responds to a designed principle, this is when the architecture turns to be an indexical sign to the user.[7] The indexical sign does not depend on the user's creativity but a direct reaction to a given principle. However, an occurrence of a symbolic sign is a consequence of the user's creativity, depending on one's mental association of given conditions and personal intentions.[8] An architecture becomes a symbolic sign when people understand it based on their habits and common sense, and practice on one's own creativity, exerting a sort of self-control over present or future actions.[9]

THE ARCHITECT'S INTEREST IN "CONCEPTUAL MEANING"

The architect's interest in "conceptual meaning" refers to their appreciation of intellectual conception and visual presentation. There are numbers of evidences pointing to the architect's interest in "conceptual meaning". In design competitions, the judgment is mainly based on conceptual presentations; in magazines, numbers of photographic images are perfectly composed, without any people or event included. Peter Eisenman has claimed the "real architecture" only exists in drawings, regardless of whether it has been built and used.[10] Japanese architect Arata Isozaki also argues that the unbuilt projects are the same as those buildings that have been built and demolished.[11]

The architectural habitus inclined to artistic skills ties architecture closely with fine arts. The origin of this fine-arts-idea could derive from Italian Renaissance, when a universal consensus was established that architecture was comprised in the modern system of fine arts.[12] The ancient, medieval and early Renaissance thinkers did not distinguish the fine arts particularly from craftworks.[13] Since the Renaissance, painters, sculptors and architects tended to distinguish themselves from craftsmen, defining themselves as liberal artists whose art works were demonstrated through ideas and contemplation rather than manual work. The autonomy of architecture can be derived from this time, as apprentice-trained builders began to separate into two professions, designers and builders, designers

were offered more freedom to engage with visionary concepts and whose art works were demonstrated through ideas and contemplation. The intellectual idea is considered to be superior. This revived platonic idea brought architects new means to practise, drawing and writing, to affirm their new status.[14]
The change of the architect's status is also associated with the idea of artist-as-genius that started with the Renaissance and further developed in Romanticism and Modernism. This leads to the recognition of artists as mad contemplator whose works must be unusual and single-authored. "Star architects" is influenced by the idea of artist-as-genius. A famous architectural work is always considered the work of the "star architect", however, in practice there are diverse agencies involved in building production. The term "star architect" ensures architecture's sole authorship. The sole authorship enables the symbolic value of the star to be transferred to the whole team. It seems that "star architects" are more likely to be involved in public buildings with higher cultural significance. This kind of projects is closer to the production of fine arts – seemingly autonomous from practical demands while representing a kind of aesthetics, compared with housing and industrial buildings which respond directly to social and economic necessities.
Architecture is seen as contaminated and hence demeaned by its association with pragmatic thoughts, so that the user is often regarded as a threat to the authority of the architect.[15] Functionalism seems to be engaged with everyday needs of the user, but it offers a linear route from the architect to the user, which still manifests the architect's domination. Since then, there has emerged reflections on this linear route, more concerns on the user's agency and attempts to conceptualise the diversity of the user in the architect's intention. This tendency includes the thinking of the disjunction and the association of the two ways of meaning.

THE REFLECTIONS

The disjunction of the two ways of meaning

Tschumi discovered an alternative way of architecture that takes the multiplicity of experiential pleasure, programmes and events as architectural priorities. Tschumi opposes spatial determinism of the architect and an obedience of the user. The architect's creation and the user's practice are disjunctive: they can be reciprocal, contradict and indifferent to each other.
"Concept-form" further demonstrate the idea of disjunction. The concept-form is an abstract configuration that can be built in a particular place and welcomes its culture to be accepted and accommodated in the form.[16] Tschumi's project, Parc de la Villette, has witnessed the process in which abstract architectural configurations have gradually be accepted and engaged with local culture.
Tschumi's idea of disjunction of the architect's creation and the user's practice is analogous to Roland Barthes' disjunction of authors and readers. Architect's meaning production is from his/her supposing, the meaning emerges from the reality is isolated from the architect's mind, which means that the architect enters his/her own "death" in reality – and users take over the duty in meaning production. The users' practice begins with an encounter with the space, and what happened before the space was built is not necessarily related to users.

The association of the two ways of meaning

Though deconstruction questions the functionalist idea of the one-to-one unity of the two ways of meaning, it is too radical to define that the two sides have separated features. The architect and user can be associated without the architect being too deterministic.

The architecture of flexibility works on foreseen reactions of future users. Denying the presumption that the building should target for fixed and specific uses, more comprehensive understanding of users is affected the way the architect design, flexibility, therefore, allows numbers of uses to be predicted at the moment of design.[17] Adaptation is an essential characteristic of flexible architecture that could adjust to a variety of users, activities and changing climate.[18] It departs from the one-to-one causal relationship of form and use; the flexible architecture tends to offer a one-to-many or many-to-many relationship. The one-to-many relationship could be realised by means of spatial redundancy and open plan. A redundant space is large enough to accommodate different uses, such as a concourse in a building.[19] An open plan describes a building that can be arranged in different ways at different times.[20] Both the flexibility by spatial redundancy and open plan is dependent upon the user's perception, instead of a physical change, while the many-to-many relationship requires a change of physical forms of spaces by technical means.

Polyvalence, proposed by Herman Hertzberger, is another concept that tries to depart from one-to-one causal relationship of form and use. Hertzberger believes a polyvalent space resists coagulated meanings and can be "put to different uses without having to undergo changes itself", such as a concourse where diverse activities happening. A space that incites multiple individual interpretations happen is an archetypal form of polyvalence, which is what Hertzberger searches for.[21] An archetypal form and the multiple uses constitute a one-to-many relationship.

A polyvalent space tends to be suggestive instead of designative.[22] The users are highly invited in the way the space seeks meaning. The design of the Centraal Beheer building and Diagoon housing have similar approaches: the architecture consists of repeated space units as half-products and welcomes users to dedicate it according to individual demands.[23] However, polyvalence still hopes to see a route between the architect and user, as Hertzberger claimed, polyvalence tries to act as an "inviting form" that allows "an optimal solution" for every purpose.[24]

Towards an open end of uses

Flexibility and polyvalence both attempt to discover a relationship departing from a linear route from the architect to the user, yet the architecture still tends to dominate the meaning after the design, though the uses are supposed to be multiple.

There is another kind of relationship: "pragmatic meaning" intends to fulfil the "conceptual meaning": The architect looks towards open ends and merely offers an incomplete structure of a building, and the building will be developed and finalised in a dynamic way by users. Only when "pragmatic meaning" is plurally generated in a long-term time frame, will the concept be accomplished. In this way, users are not the threats but contributors in fulfilling the architect's concept. This idea can be explained with a Chinese project, West Village in Chengdu.

As to increase social vitality for the community and the city in a sustainable manner, the building intended to be an architectural complex: a big open yard, surrounded by the building. The architect claimed to create a collection of diverse and homogeneous architectural facades of everyday life but offered only a building structure. The architect anticipated that future users would finish the detailed construction and create future programmes, and his imagination would come true.

Figure 1. West Village, Chengdu

The interior space of the building has been separated into individual sections and each household has its own parts of facade on both side of the building, outward and inward. There is no spatial division in each box, but there are vertical partition frames reserved, leaving them for users to be further installed according to particular services. The user's individuality is largely emphasised, and the individual particularities are hoping to be comprised in the building framework, and therefore to achieve the architect's intentions.

A couple of years after the building completion, the users have been well fitted in the physical spaces. Looking at the building facades from nearby streets, it presents a sort of diverse and collective facade with a strong sense of living. The spaces have been used for catering services, children's education, creative art, health care services, and business offices. It is apparent to find, from the numbers of signboards hanging on the facade, that the south and east part of the building are more occupied. The users know the principle: the closer to the main roads, the more visual attractions it will have.

Figure 2. The south façade (outside)

Transient events happening on the slopping passages, which provides a more distinct and dynamic image of the building. A circular passage over the court is used heavily, particularly after work in the evening, when people come for jogging, walking, and cycling. Unfixed events are frequently emerging in the side yards as well – it has been used as children's playground, lunchrooms, and a cinema.

Figure 3. Event on the passage

Figure 4. Event in the side yard

Figure 5. Event in the side yard

The architect knows the plurality of "pragmatic meaning" and conceptualised it into his concept. Major parts of the space are un-programmed – serve as symbolic signs, which require the user's understanding to attach the event to the space, and this is the way in which "pragmatic meaning" emerges.

Spaces are lures, and events are something substantial. Spaces try to induce the user to explore more possibilities. Everybody who practises in the space helps to add "pragmatic meaning". Each new iteration of "pragmatic meaning" is inclined to be different from the previous one, through which "pragmatic meaning" become abundant. The production of "pragmatic meaning" never reach the end, and "conceptual meaning" always heads for its completion.

The open end of uses is similar to flexibility and polyvalence, in that "conceptual meaning" tends to be associated with "pragmatic meaning", without the former being too deterministic. It is unlike flexibility by technical means, in that the user's practice is creative rather than reactive, and that a change of space can be made in unexpected ways depending upon a change of the user's intention, instead of limited ways depending upon the physical changes of a building. It is similar to flexibility by redundant space, open plan and polyvalence, in that the user is creative and a change of space can be multiple depending upon the user's perception, whilst unlike them in that the architect intentionally welcomes the open end of "pragmatic meaning" and fully gives up the linear route from the architect to the user.

Reflections on design education

Having discussed the reflections on the user's agency and the relationship of the architect and user, then how these theoretical reflections can be applied in architectural design education needs to be considered. The tradition of the architect being the sole designer and the idea that architectural meaning is unchangeable once the design is finished ought to be replaced by the notion that design is a collaborative work by different parties all the way throughout the building's lifetime. The alternation of the design ideology is something essential to be imbued in design studios.

Particular teaching methods can be used in design studios that may be helpful in building up the alternative notion. For example, environment-behaviour investigation in actual architectural spaces can be incorporated in design teaching. Design studio often focuses on conception and spatial forms, while seems not to pay too much attention on how building functions in actual spaces. Usually, future users are not involved in design process, the people who are going to use the space are even unknown. Therefore, architectural students usually assume or imagine people's demands and perceptions. Environment-behaviour investigation in actual spaces can help students understand the tangible evidence of the user's perceptions and activities, and thus generating design ideas based on actual evidence. There are experiments on this teaching practice showing that a closer relation should be established between environment-behaviour and theories of architecture in design studio. [25]

"Living building" concept, an idea from civil engineering, can also be borrowed in architectural design teaching. "Living building" concept (LBC) is based on the fact that the function and circumstances of buildings are constantly changing. It aims to change the traditional demand-driven supply approach in construction into an approach of supply-driven demand involving all parties to develop a project. [26]

This demand-driven supply approach is a user-oriented management of the building over its life cycle, which is similar to public-involvement or community-involvement design approach in architecture, but LBC approach is more inclusive and can be applied throughout the building's life cycle. Bearing in mind with "living building" concept, architectural students will recognize how the changing and flexible "pragmatic meaning" shapes building forms over the building's life cycle.

CONCLUSIONS

“Conceptual meaning” and “pragmatic meaning” is neither disjunctive, like deconstruction suggests, nor one-to-one corresponding, like functionalism believes, they could be associated without “conceptual meaning” being too deterministic. The architecture of flexibility and polyvalence both attempt to absorb the multiplicity of “pragmatic meaning” into design intentions. The difference is that the user is reactive in relation to an architecture of flexibility, while creative in relation to an architecture of polyvalence. The open-ending of “pragmatic meaning” requires the empowered user and encourages the user to contribute to the architect’s intention. These tendencies in recent decades showing the architecture’s reflections on the intellectual conception and dynamic experience can be brought into studio teaching.

Though architectural concepts and visual presentations are important to legislate the identity of architecture as an autonomous discipline, the autonomy of architecture is hardly survived, as it has to attach to exterior agencies – the life, people, mind, and events – to make it fully meaningful.

Lists

1. West Village, Chengdu.
2. The south façade (outside).
3. Event on the passage.
4. Event in the side yard.
5. Event in the side yard.

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ADAPTING TO A CHANGING PROFESSIONAL CONTEXT

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INTRODUCTION

In a recent annual report of the South African Institute of Architects, Niel Kievet remarked that the role and influence of architects is shifting, necessitating a concomitant adjustment from practitioners and education programmes in keeping with the new socio-economic reality.[4] This was not the first or only alarm sounded about the future of the profession. Coinciding with the opening of the 2018 Venice Biennale, the architecture and design website *Dezeen* featured a challenging piece by Sean Griffiths titled, "Architects are not really required for the nitty gritty of actual building anymore."[5] Many might disagree. However, the curators of this exhibition agreed that the profession is under siege.[6]

Concerns regarding the continued relevance of the architectural profession have been around for some time. As far back as 2009, RIBA conducted an investigation titled "The future for architects?".[7] The study asked the senior partners and directors of architects' firms to describe how they foresee their firms developing over the following fifteen years, and "what skills and practices felt they would need to gain in order to compete over the coming years."[8] The report following the study concluded that:

> While the future for the practice of architecture as a discrete business is uncertain, the opportunities for architects have never been greater, notwithstanding the current recession. However, to grasp those opportunities architects will need to develop greater financial nous and commercial acumen, to welcome the integration of their work with others in the wider industry, and continue to work hard to promote the extraordinary benefits which society gains from the design process."[9]

Ten of the fifteen-years covered by the study have passed and we now find ourselves on the brink of the so-called Fourth Industrial Revolution. The World Economic Forum predicts that "… it is disrupting almost every industry in every country."[10] It is predicted that we will see the introduction of new technologies that will introduce innovative ways of serving needs, thereby significantly disrupting existing relationships. Disruption will be flowing from agile, innovative competitors who will push out well-established providers in no time by increasing the quality, speed or price at which services are delivered.[11]

Disruption and recognising and grasping opportunities, lie at the core of entrepreneurship.[12] This points to innovation and creativity; traits architects are blessed to have.[13] Thus architects should be well placed to function in this changing environment. Husain[14] reports that empirical research has found that in the current phase of the knowledge economy, countries with little physical, natural or human capital have grown their economies due to the value they place on these traits. This gives credence to the positive attitude contained in the response reported above.

However, it is only during the last 99 years that the link between architecture and business (not even entrepreneurship) has been recognized. Despite the rather slow warming to the importance of business management in an architect's firm, entrepreneurship, which is very different to business management, has remained below the radar. Entrepreneurship points towards business creation and self-employment but is quite different from either these descriptors. This is because according to El Dahshan, Tolba & Badrelin[15] entrepreneurship:

- Assumes innovation: New products, processes or markets.
- Creates added value: The market value of the output should be greater than the sum of inputs.
- Entails risk-taking and failure should be understood as part of the learning process.
- Does not happen by itself: The French *entreprendre* means to do or undertake, which implies intelligence, a viable idea, boldness, risk-taking and hard work.

The link between architecture, or architects' practices, and entrepreneurship has remained largely ignored until 2008 when Moreno[16] linked the two, stating that "architects - indeed all entrepreneurs - must make enough money to stay in business and prosper". During 2010, Robert Gutman published *Architecture: The Entrepreneurial Profession.*[17] In it, he argues that architects should develop greater assertiveness in "getting work and creating its own demand."[18] The following year, Nathan Richardson, produced a paper titled 'Architecture is Entrepreneurship and (Why) it Matters',[19] in which he states that "the changing nature of society and the issues it confronts should compel more architects to reconsider their expertise and the manner in which it is deployed". He says that "one key to exploring enhanced productivity for architects may reside in the profession's self-conception and its relationship to entrepreneurship". He followed this in 2014 with a chapter titled 'On Enterprising Architecture' in *Architecture in an Age of Uncertainty.*[20] Also during 2014, the Union of International Architects (UIA) concurred that socio-economic developments have led to the creation of the urban and built environment becoming more complex.[21] Hence, they adopted a policy to "encourage and promote the continuing extension of the boundaries of architectural practice" and "the corresponding extension of the knowledge and skills necessary to deal with any extension of boundaries."[22] Because entrepreneurship is about spotting new opportunities and turning these into commercial successes,[23] this push for a broadening of the architect's field of operation was by its nature, a call for a more entrepreneurial attitude amongst architects. Also, during 2014, the American Institute of Architects (AIA) amplified the call by increasing the prominence given to employing "an entrepreneurial approach" when starting a new firm.[24]
During 2015, Eric Reinholdt published *Architect and Entrepreneur: A Field Guide to Building, Branding and Marketing Your Start-up Design Business*[25] in reaction to the absence of entrepreneurial guidelines for architects. Entrepreneurship in architecture is now gaining traction with prominent architects, such as Odile Decq, stating that "we have to train the students to become architectural entrepreneurs."[26] Internationally, schools of architecture in universities and other training spaces have started to recognize that a need exists for entrepreneurship education. One example of this is the DesignX initiative started by the Massachusetts Institute of Technology's School of Architecture and Planning in May 2017.[27] The initiative functions as an academic accelerator workshop. Another is the Archipreneur Academy, which offers online video interviews with experts, coupled with case studies.[28] *Entrearchitect*, is an online support site offering business resources and live expert training. It also offers a support group of entrepreneur architects working together to grow successful businesses.[29]

Despite all of the aforementioned initiatives, and the fact that architects have been found to have the traits often associated with entrepreneurs,[30] research has found that the entrepreneurial orientation of a sample of well-established architects' firms is low.[31] Thus the challenge is to assist architects in making the changes required by the changing macro and micro-economic contexts in which they are practicing.

Two possibilities are to include entrepreneurship education in formal architectural education systems and to share with architects what other entrepreneurial architects have done. Such role-models could inspire young architects to think differently about architectural practice, while entrepreneurship education will provide them with the mind-sets and skills that this will demand from them.

RESEARCH METHODOLOGY

This study aimed to investigate international and South African architects who have ventured into associated fields, in order to identify some of these fields, establish what similarities exist with the profession of architecture, what obstacles they faced, and whether it has been beneficial to make the leap. The main motivation was to provide inspiration, guidance and encouragement to other architects and to encourage them to venture into new fields, as suggested by the UIA's 2014 policy. The focus was on gathering experiential data rather than measurements, implying a qualitative research methodology.

The plan was to use a semi-structured interview to examine the actions of the nine American and European architects featured in an article by *Archipreneur* and *Arch Daily* and to augment it by examining a sample of South African architects who have similarly broadened the scope of their architectural practices. Unfortunately, only two of the nine American and European practices responded. Regrettably, time differences and the schedules of these architects thwarted the original intention. Hence, the study of these architects and their scope-broadening actions had to be limited to a study of online and published material. This desktop study was broadened to incorporate the results of the previously mentioned RIBA study, 'The Future for Architects'.

Disappointingly, only seven South African architects responded to an invitation to take part. This resulted in a limited but useful sample given the topic of the study, particularly in light of the aim, which was not to compile a comprehensive list of areas that architects have ventured into. Whenever possible, interviews were conducted face-to-face. If not, the interviews were conducted by telephone. Transcription was done by an outside party and the content analysis was performed quantitatively (manual frequency count, possible because of the low response rate) as described by Creswell.[32]

RESULTS OF RESEARCH STUDY

The analysis revealed that the South African firms have ventured into (more than one activity per respondent):

- Building component design and manufacture.
- Design of prefabricated housing.
- Designing furniture.
- Designing interiors.
- Selling property.
- Furniture sales.
- Hosting a website offering house plans.
- Facilitating property developments.

- Managing properties.
- Coordinating building contracts.
- Managing property developments.
- Building information modelling.
- Designing landscapes.
- Space planning.
- Building construction.
- Resolving building disputes.

According to *Archipreneur*, international firms have ventured into:[33]

- Computer software development.
- Design of temporary housing.
- Design and manufacture of prefabricated modular housing.
- Designing building components.
- Property development.
- Digital modelling.
- Standardized house plans.
- Customized, prefabricated, low-cost, high-performance houses.

The RIBA study[34] found that smaller architect's practices have gone into:

- Light fitting design.
- Interior design.
- Facilitating community projects.
- Industrial and three-dimensional design.
- Design of exhibition and commercial installations.
- Branding.

The limited number of firms that responded to the invitation to participate was disappointing but this might be an indication that most architects are still operating in the conventional practice mode. This could indicate that the majority of firms have not yet made the required paradigm shift. This could be because they have not yet experienced the pressure to do so or because they lack the confidence to do so, due to a lack of knowledge and experience, or as a result of their education that presented them with too narrow an understanding of what being an architect entails.

IMPLICATIONS FOR ARCHITECTURAL PRACTICE

The study could indicate that some architects have indeed reacted to the changes in the professional context but that more still need to adapt. Architects are strong creatives. However, this innate quality needs to be applied in a different direction. How can this shift be encouraged? Coulson-Thomas[35] suggests that education and experience can inhibit the release of creative thinking and therefore, potential. Do too many schools of architecture present their students with too narrow a definition of what it means to be an architect? This could inhibit architects thinking about alternatives available to them. Valuing, questioning and challenging are encouraged but these practices should not be restricted to the design process.

In the work place, where as many as 18% of architects still practice autocratic management styles,[36] the development of a questioning attitude and entrepreneurial thinking will require a different approach to management and leadership. They will have to learn to encourage openness and candor.[37] Other changes suggested include, welcoming and building diversity, enabling collaboration and creativity, engaging and learning from the creative arts, adopting, implementing and commercializing ideas, and supporting innovation and entrepreneurship.

At the same time, unnecessary innovation and change should be treated with caution, incremental changes and improvements based on current strengths offer suitable starting positions. However, this may not be enough in the light of fast changing circumstances.[38]

Clark[39] holds that the differences between thriving and struggling architectural firms are that struggling firms:

- Are "playing to play", instead of playing to win.
- Have not determined 'why' they are in business.
- Are not being proactive in generating leads.
- Market themselves by what they do and not by the type of problems they solve.
- Believe it is only about design.
- Don't understand that architectural practice is a 'team sport'.
- Don't have a clear strategic business plan that includes clear vision and mission statements.
- Regard themselves as experts instead of facilitators.
- Don't plan for success.
- Don't review or measure their firm's performance.

Maria Ruiz Pardo[40] holds that architects should understand that in many cases the team is more important than the idea. Chris Precht[41] predicts that the business model in architectural practice will change and that the architectural bubble is bound to "burst wide open". He warns that the profession will have to change, saying that "at the moment I see our architecture too occupied with ourselves to change anything. We are still driven by intellectual, theoretic and academic statements, but there are more urgent problems than form and styles". However, the importance of good design should not be overlooked. Gonzalez[42] shares the World Economic Forum's prediction that in the foreseeable future (2020 and beyond), creativity and critical thinking will become among the most sought-after job skills. He continues by pointing out that leading companies know that meaningful innovation requires highly creative employees "who are willing to question, disrupt and redesign". Martin Barry, founder of reSite and Manifesto Market[43] believe that it is important that architects begin to conceive and perform their own projects.

IMPLICATIONS FOR ARCHITECTURAL EDUCATION

Despite the increasing recognition that architects need entrepreneurship skills, as far as could be established, no formal degree granting qualification was, until recently, available for those architects who are considering or are in the process of starting their own firms, or for those who have a need to acquire entrepreneurship knowledge and skills in order to expand their activities: The IE University has recently introduced a Master in Business for Architecture and Design programme. They describe the programme as "a unique learning experience where design professionals expand their core capacities with management, entrepreneurship and innovation expertise, preparing themselves to become the creative leaders of the future".[44] It would appear that the penny has dropped.

Choi and Klein[45] hold that entrepreneurship has formed part of architectural practice for many years. To them, continuing adjustments in the profession have now caused a state of affairs where architects require business and managerial understanding and entrepreneurial attributes, such as dexterity, a risk-taking predisposition and the skill to identify and explore opportunities. They believe that without these, the endurance and success of an architects' firm would be in question. This implies that architects' education should also include entrepreneurship education and training. Grozdanic[46] believes that the gap between what is taught in architectural education and the practice of architecture has never been greater, nor more problematic, than at present. She holds that architecture as a field has expanded to include various disciplines, technologies and products, and that this requires a new educational model, one that will teach students how to innovate and compete in an industry that is forced to be more outward facing. She continues, stating that there is a need for content that will enable students to become more pioneering when it comes to the business aspects of architecture. Maescher[47] is of the opinion that there are four areas that should be explored in more depth in architectural programs, and they are multidisciplinary projects, business orientation courses, soft skills courses and entrepreneurship courses. The question is how should these be included in architectural education?

A phased approach, with the phases combined into a framework, is the recommended format for entrepreneurship education. Furthermore, it is recommended that the aim of the first phase should be to change the perceptions, attitudes and mindsets regarding entrepreneurship.[48] Thereafter the focus should turn to developing learners' socio-emotional expertise. This implies developing aspects such as self-confidence, leadership, creativity, risk propensity, resilience, self-efficacy and fostering interpersonal relations. Growing the student into an entrepreneur should follow. Hence the third phase should focus on maturing the entrepreneurial orientation of students. Accordingly, this phase should focus on developing the competencies, knowledge and attitudes required to successfully start, nurture and grow the architectural firm.

However, architectural entrepreneurs will also need support as they embark on this road and therefore, a range of support services should be offered. This could include administrative support, mentoring, peer support and technical assistance. In this way elements of experiential learning aided by a trained mentor will be incorporated.

Because architectural programs are renowned for their denseness, the final three phases of the framework should be offered as post-professional offerings.

While the new programme introduced by the IE University is a positive development, the above shows that it should be combined into a framework structure. Furthermore, such frameworks should be established across the world in order for all architects to be able to round-off their education in line with the requirements of the modern economy.

CONCLUSION

Precht[49] concludes that "the challenges that are ahead for our generation are enormous, but so are the possibilities. In the end, it is up to us to determine the future we want to shape." He continues by stating that the change will either come from within the profession or be forced onto it from outside. Architectural practice cannot remain untouched by changes in the macro-economic environment and neither can architectural education. Entrepreneurship must be included at undergraduate and post graduate levels and not present a one-dimensional view of what architects do. Post-professional programmes in architectural entrepreneurship and leadership must be introduced and professional associations must introduce mentorship and support structures to their entrepreneurial members.

Finally, the limitations stemming from the limited response rate should result in future studies, conducted to establish if the introduction of more post-professional programmes has had the desired effect by encouraging an increased number of architects to adopt and practice a more entrepreneurial stance.

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TECHNICAL SKILLS FOR STUDENTS OF ARCHITECTURE

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INTRODUCTION

Architects employ science in order to understand the structural and environmental performance of their products, and apply technology in order to assemble them. And although the role of the architect has changed/evolved even within recent history, the relationship between engineering science, construction technology and the design of the built environment has been at the core of architectural practice throughout history. 2000 years ago, Marcus Vitruvius Pollio (80-15 BC) commenced The Ten Books on Architecture with a chapter on “The Education of The Architect”, where he states: “The architect should be equipped with knowledge of many branches of study and varied kinds of learning, for it is by this judgement that all work done by the other arts is put to the test”. Vitruvius proceeds to explain and differentiate between practice and theory with the need for an architect to have “a thorough knowledge of both”.[1]

This paper describes the pedagogic approach of the Technical Studies department at the University of Westminster to the architecture course for degree (B.A.) students. It demonstrates the product of this approach in the form of a small sample of student work over a period of roughly ten years.

TECHNICAL STUDIES

In the context of architectural technology, pedagogy implies the teaching of specific skills. In most schools of architecture the teaching of these skills is known as *Technical Studies*. In the year 2000, Pete Silver and Will McLean were charged – as joint-coordinators – with overseeing Technical Studies at the University of Westminster for the entire School of Architecture from first year Undergraduate through to final year Postgraduate. This gave them the opportunity to re-evaluate how Technical Studies was conceived and delivered for the whole school.

They found that whilst there was a wide range of technical information available, students throughout the course still lacked a basic understanding of many key principles. They realised that Technical Studies was not being taught within the context of architectural design and hence its application to, integration with and indeed its active participation in design thinking was often absent. Historically, the teaching of Technical Studies had been conducted largely by specialists – typically structural or mechanical services engineers – however the authors considered that understanding engineering science and construction technology from a purely scientific context assumed that the student could digest information in abstract (i.e. as distinct from design) whereas the study of architecture, along with the varied backgrounds of architectural students, was not necessarily conducive to such an approach.

They also found that there was no contemporary overview of architectural design within this context. Since the Industrial Revolution, there had been a continual and exponential increase in scientific and technological advances which would have an impact on how architecture could be engineered. What architecture was required to do over the course of the 20th Century was to make sense of the vast and ever-growing number of specialist fields that contributed to its discipline. And whilst this knowledge was available to specialists in publications dedicated to their fields, it was not being absorbed into publications for designers (and specifically for architects) in such a way that it might be readily digested: there was a lack of clarity and uniformity in the way that it was described and presented.

The authors considered that, as in other fields, the organisation and presentation of information were critical to an understanding of the subject, and that this understanding – that was in turn critical to how architects thought about design in relation to science and technology – was missing.

They therefore set about compiling a new knowledge database for architectural technology, while re-designing the teaching, learning and assessment of Technical Studies for the whole School of Architecture at the University of Westminster.

A NEW KNOWLEDGE DATABASE

Underpinning the teaching programme designed by the authors was the compilation and publication of a set of architectural technology textbooks (see Bibliography), and in particular *Introduction to Architectural Technology*, a publication whose aim was to introduce architecture students to the scope of the relationship between design and technology with the specific intention to enable them to integrate their design thinking with appropriate structural and environmental solutions. The book set out to explain the relationships between physical phenomena, materials, building elements and structural types, using simple classification systems and real-world examples. Photographic images were used to familiarise the user with common construction technologies, while historical examples were employed to chart significant moments in the history of architectural engineering. The Contents page was designed as a branching system so that the user could contextualize any topic within the book. Every spread had a topic heading that could be cross-referenced with the contents tree (Fig. 1).

General classifications

Although it was appreciated that for many early building types the structural and climatic enclosures were one and the same (e.g. earth or ice), architectural technologies were divided into the two major headings of Structure & Form and Climate & Shelter (see Figure 1). The section on Structure and Form was subdivided into three main topics: Structural Physics, Structural Elements and Structural Logic, providing a linear progression from the fundamental principles of structural form – materials science, materials technology and structural integrity – through descriptions of the common elements used in the construction of buildings (such as walls, columns, floors and roofs), to how these elements are combined to form different building types, from simple ‘post and beam’ structures through medieval vaults to aluminium monocoque shells and tensile nets.

The subdivisions in the Climate and Shelter section dealt with two main topics: Human Comfort and Building Performance. Before examining how buildings are constructed in relation to their local environment, it was considered important to establish the thresholds within which the human body is able to sustain life. The first part of this section therefore examined the principles of thermal comfort and its provider, the sun, while the second part considered ways in which the performance of buildings could be designed passively to maintain human comfort.

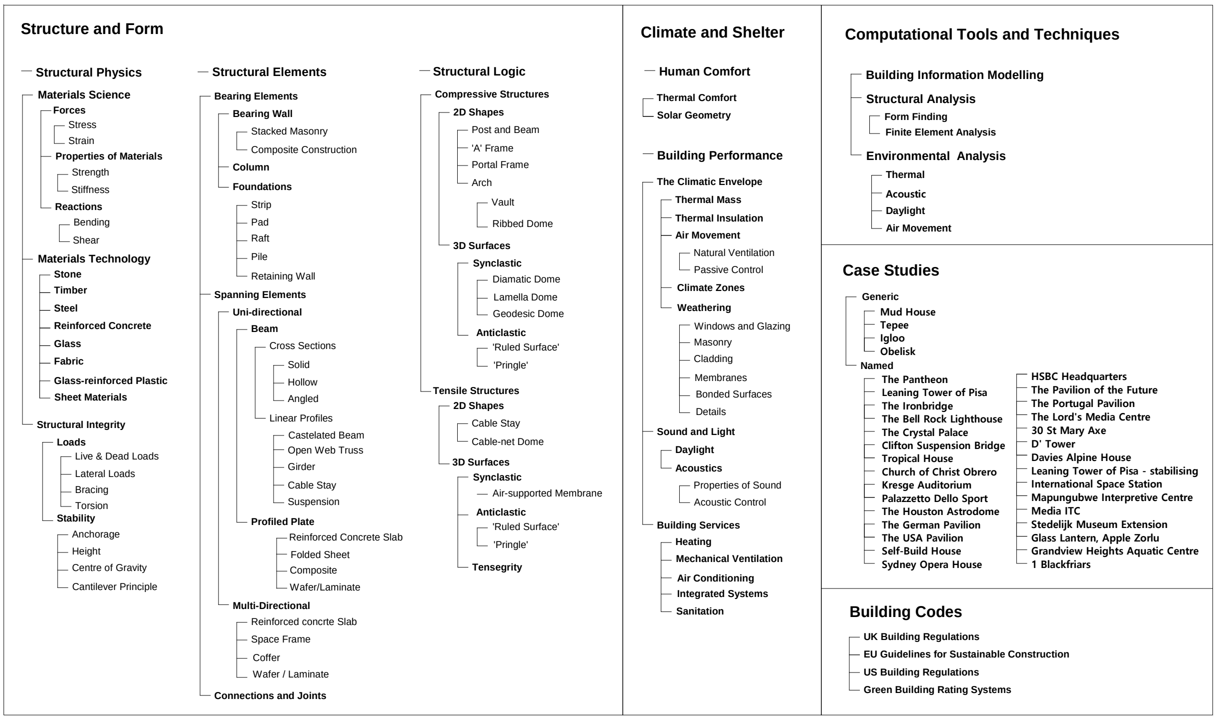

Figure 1. Contents page from Introduction to Architectural Technology (3rd ed,).

Structural taxonomies

The authors designed new taxonomy charts for the section on Structure and Form, demonstrating how to categorise a range of primary structural types, and covering both (mainly) compressive as well as (mainly) tensile structures (Figure 2).

It was considered that whilst engineers classified building types according to physical forces (Heino Engel in *Structure Systems* employed terms such as 'vector-active' and 'section-active'[3]) the key to understanding structural logic for architects was primarily visual – pictorial, hence through geometry and geometric procedures. This morphological taxonomy of structural logic was then designed using two systems: the first involved the application of geometric transformations to a set of primary structural shapes, i.e. to convert (two-dimensional) sections or areas into (three-dimensional) volumes through iterating by extrusion or rotation; the second described classifications for complex double-curved surfaces that could not be understood purely from one or more cross-sections. These were classified as fundamentally synclastic or anticlastic.

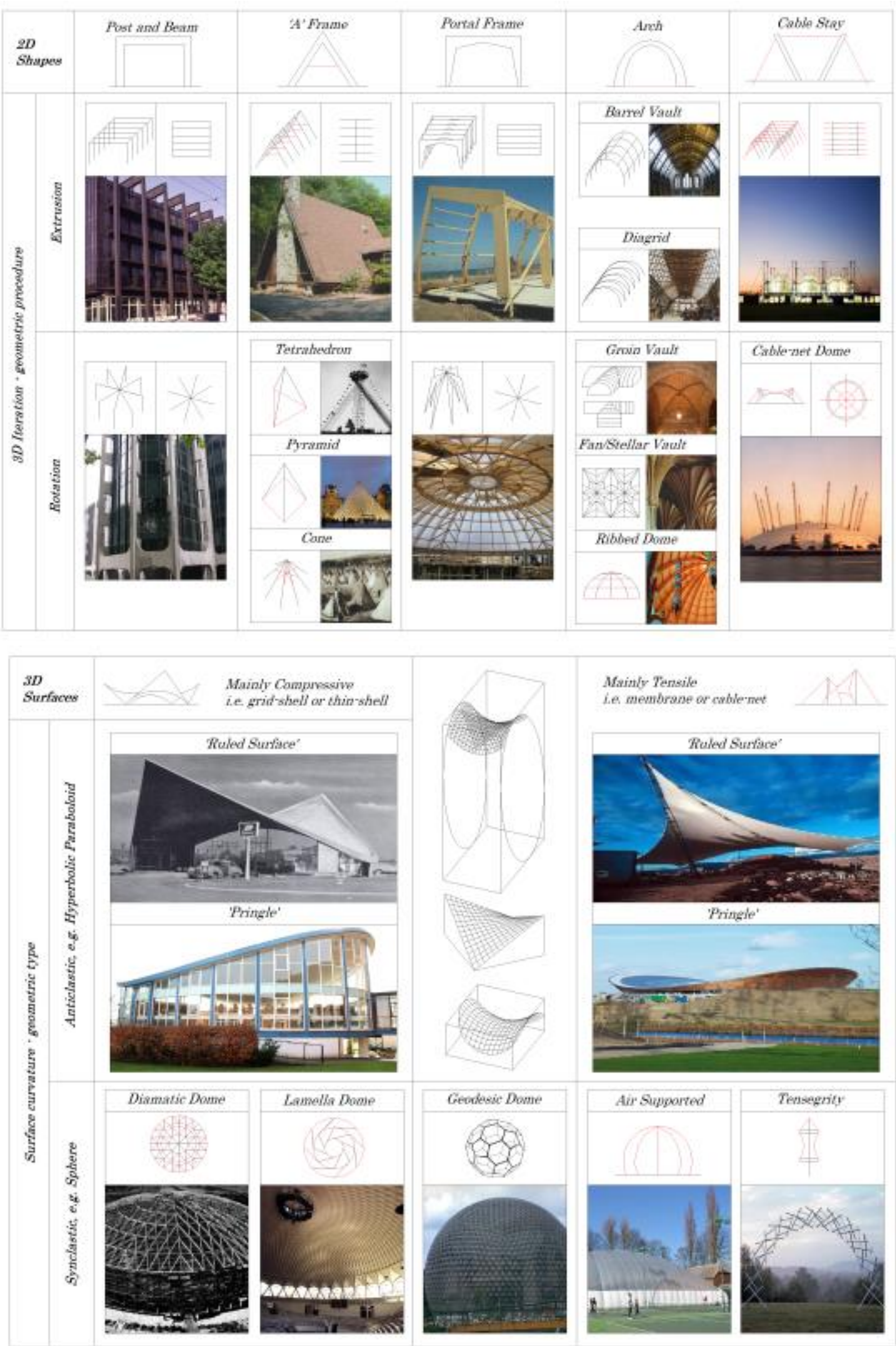

Figure 2. Structural taxonomies from Introduction to Architectural Technology (3rd ed,).

THE ACADEMIC PROGRAMME

The following pages are divided into sections that correspond chronologically with the undergraduate technical programme at the UoW School of Architecture during the relevant period, viz.:

- First year / term one: observational exercises
- First year / term two: 1:1 workshop studies
- Second year: small-scale structural design projects
- Third year: environmental design – façade projects

First year / term one: observational exercises

This first year technical courses were designed to introduce students to structural and environmental principles, with the aim of establishing materials technology, construction processes and building physics as integral to architectural design thinking. A dedicated lecture series was based around *Introduction to Architectural Technology* and covered the following topics:

- Structural physics – loads / reactions / structural integrity;
- Structural elements – bearing elements / spanning elements;
- Structural logic – compressive structures / tensile structures;
- Materials technology – timber / concrete / steel / glass / masonry / plastics;
- The passive climatic envelope / cladding and facades / architectural acoustics and daylighting.

Students were assessed through an assignment that required them to demonstrate their awareness of essential structural logic. They selected an existing large-span structure (such as a train station, sports hall, glass house or stadium) and make in-situ, annotated sketches in order to represent its overall structural composition, its principle structural elements, and how these functioned to resist loads (i.e. primarily in tension or compression). Students were encouraged to consider drawing structures as if they were producing a life drawing: It was presumed that structural form was best understood by studying and observing it with the same intensity and attention to detail as if sketching a bowl of fruit, a body, or a face. Students were also obliged to annotate their sketches as the lecture series progressed and they were able to identify the material composition, construction elements and general typology of the structures that they were observing.

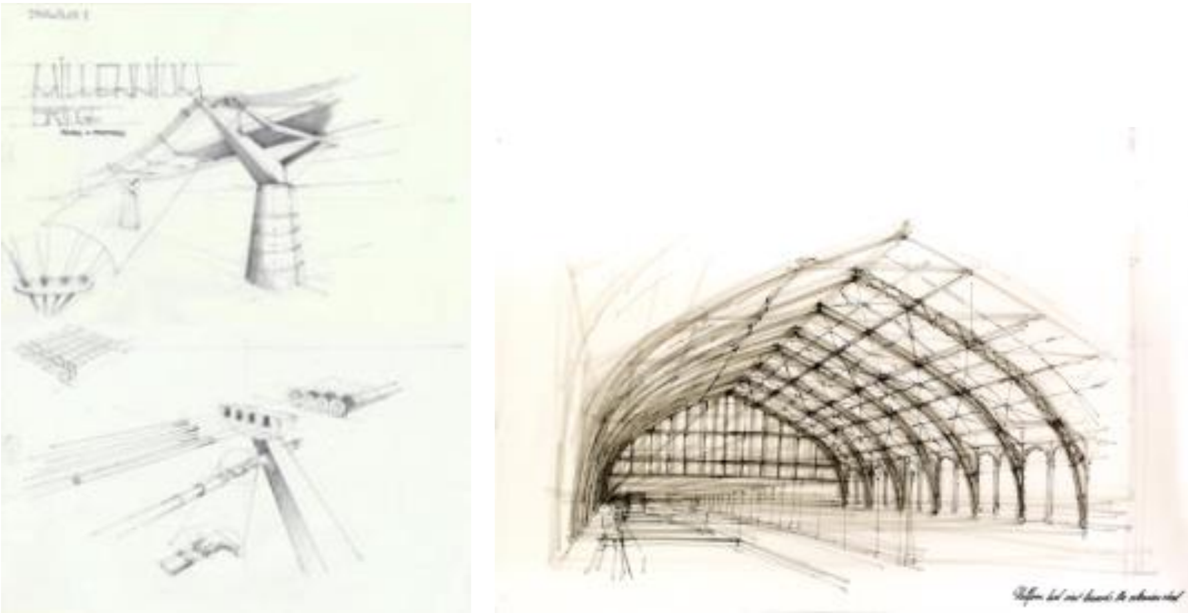

Figure 3. First year observational exercise.

First year / term two: 1:1 workshop studies

The second technical assignment for first year students was planned as a practical project. The aim was to develop an understanding of structural design through a hands-on exercise that would involve the students in exploring the properties and characteristics of materials and learning to use the workshop and fabrication technologies available to them.

Load-testing

To this end, students were challenged to solve straightforward structural problems. Each year at a 'show-and-tell' event every project was presented, load-tested and analysed. As well as meeting the criteria described in the briefs, each piece was evaluated according to its structural logic, its lightness and efficiency, the innovative use of materials, craftsmanship and detail. In none of the briefs was there an imperative for the objects to be demountable or deployable and yet students often chose this route (this could have been for purely pragmatic reasons, i.e. ease of transportation; nevertheless…). Similarly, a number of objects were designed such that they only achieved their optimum positioning once loaded. Projects included a glass floor, a cantilever and an open-web truss (Figures 4-6).

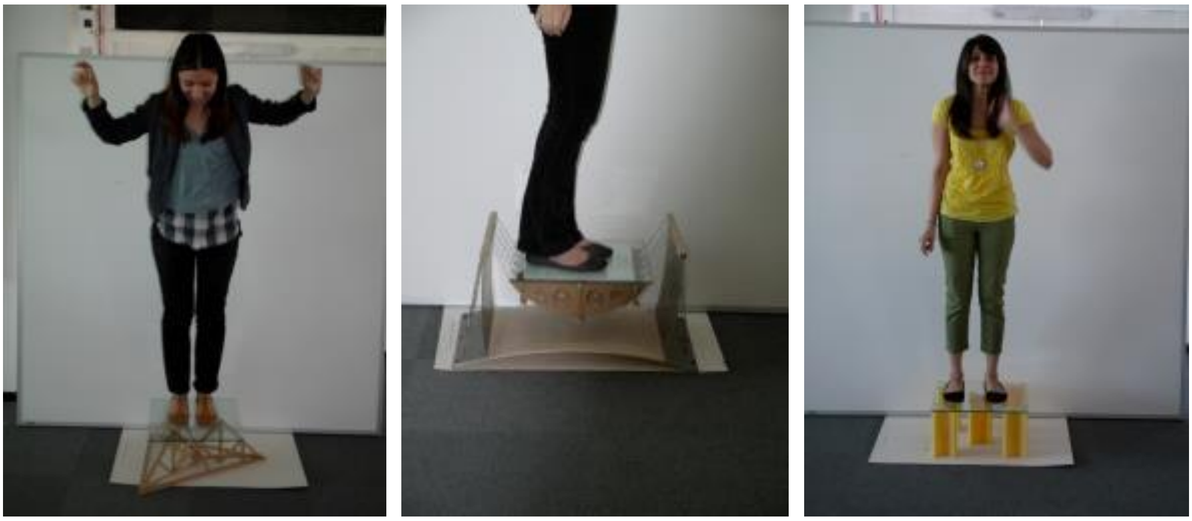

Figure 4. Glass floor project (2008) – Students were asked to design and build a platform that would support their own weight 200mm above the ground; the floor of the platform was float glass – 400mm x 400mm x 6mm.

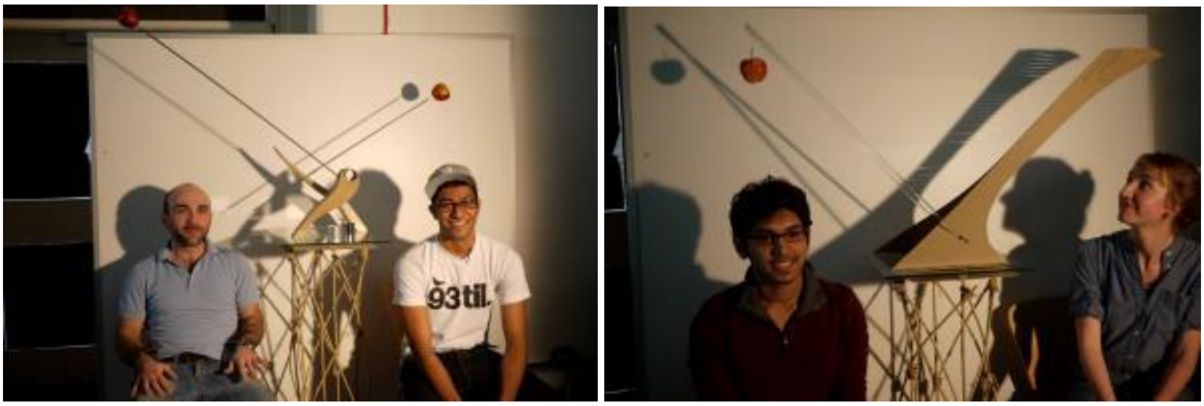

Figure 5. Cantilever (2011) – Students were asked to design and build a structure that could cantilever an apple at a height and distance of 400mm. The footprint should be no more than 400mm x 400mm.

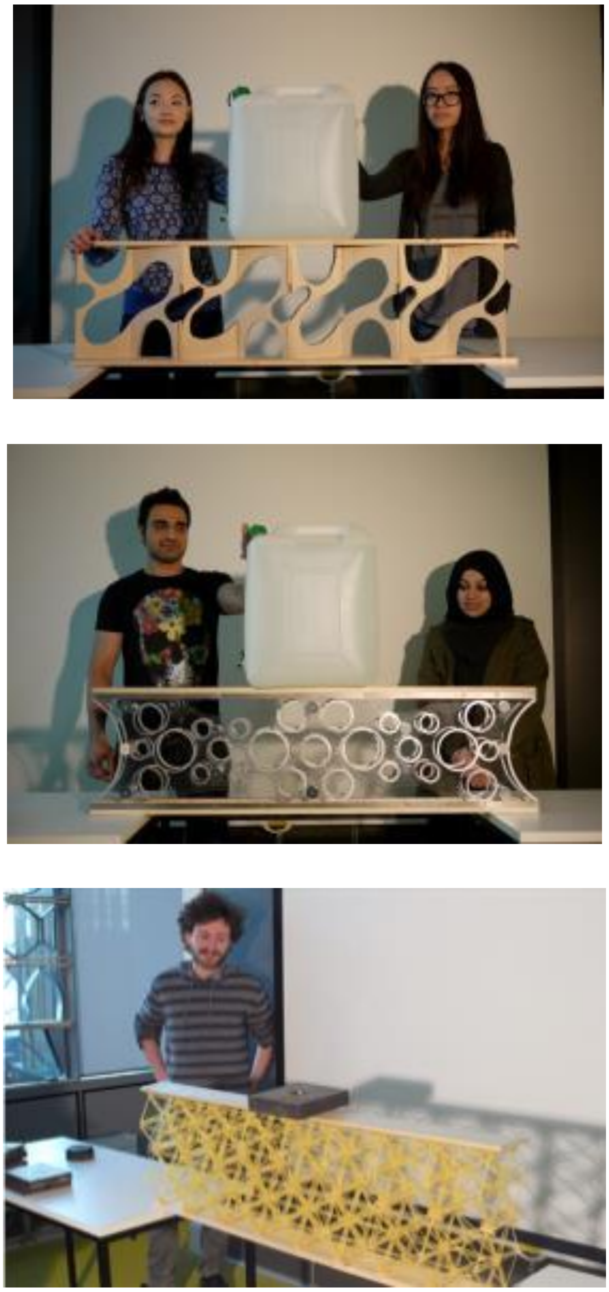

Figure 6. Open-web truss (2013) – Students were asked to design and build a truss that was 1400mm long and 330mm deep that could support a centrally positioned load of 20kg. (The size of the truss was based on the ground floor fenestration of the UoW Marylebone building.)

Second year: structural design

During the second year of their studies, students would embark upon a Technical Studies module whose primary aim was to improve their understanding of construction techniques and processes. The module title was 'Making Architecture' and students received lectures from architectural and engineering practitioners discussing a wide range of projects and how these came to fruition – from inception to realisation.

For their coursework assignments, the Technical Studies team set discreet projects that challenged the students to design a small scale structure. Though not site specific, the structures had to meet certain criteria (e.g. lightness and efficiency) and had to be detailed such that the students were able to produce assembly drawings with all of the key construction materials, principal elements and connection details specified. Projects included a ten metre pedestrian bridge (Figure 7), a bandstand – an outdoor auditorium with a footprint of approx. 25sq metres (Figure 8) and a lookout platform – the *Baywatch* project (Figure 9).

In addition to producing a comprehensive set of working drawings, students were also asked to build a scale model – normally at between 1:10 and 1:20. Students were individually tutored and received further advice at a 'show and tell' day, where many of the visiting lecturers and other consultants were in attendance.


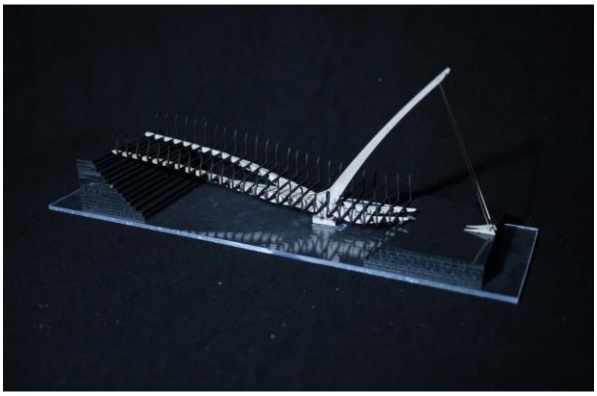

Figure 7. Ten metre pedestrian bridge.

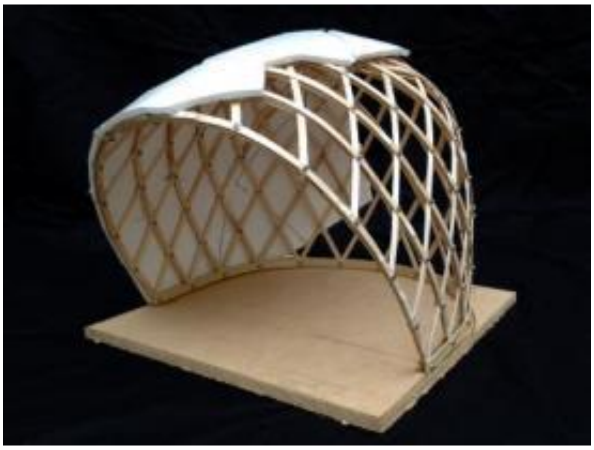


Figure 8. Bandstand.

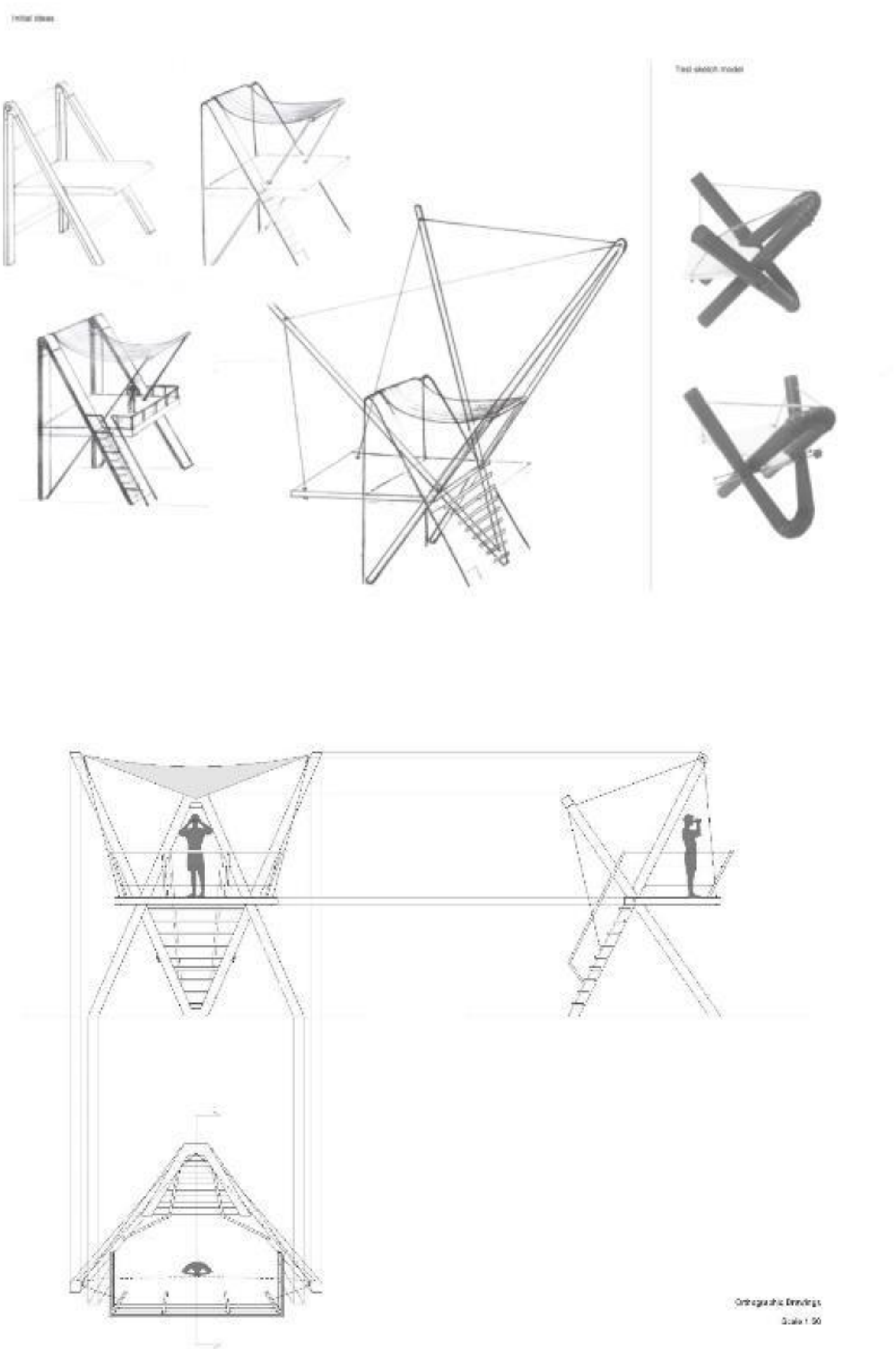

Figure 9. Baywatch project. Marco Catena

Third year: environmental design – façade projects

During the final year of their degree, students engaged with a Technical Studies module whose aim was to improve their understanding of buildings as climatic enclosures / ’envelopes’, as well as to introduce them to analog and digital (software-based) methods for modelling and analysing environmental phenomena. Students received lectures from visiting architectural practitioners and environmental engineers on projects that covered a wide range of both active and passive environmental design strategies.

For their coursework, the Technical Studies team set a discreet exercise that challenged the students to design a façade as a dynamic, environmental interface. The façade, though not site-specific, was likened to infilling a typical brick-vaulted railway arch, where a set of particular environmental conditions had to be considered:

- The façade was South-facing in the Northern hemisphere (or vica versa);
- There was a considerable diurnal temperature change – hot days, cold nights;
- Behind the façade would be a bar/café that required good natural light and ventilation.

The project therefore required students to consider that the façade might need to be dynamic, i.e. may need to adapt in response to the changing environmental conditions. Many students simply couldn’t resist designing a café; others invented their own programme and designed pavilions, greenhouses or entirely new, modular façade systems. Students were individually tutored and received further advice at a ‘show and tell’ day, where many of the visiting lecturers and other specialist consultants were in attendance.

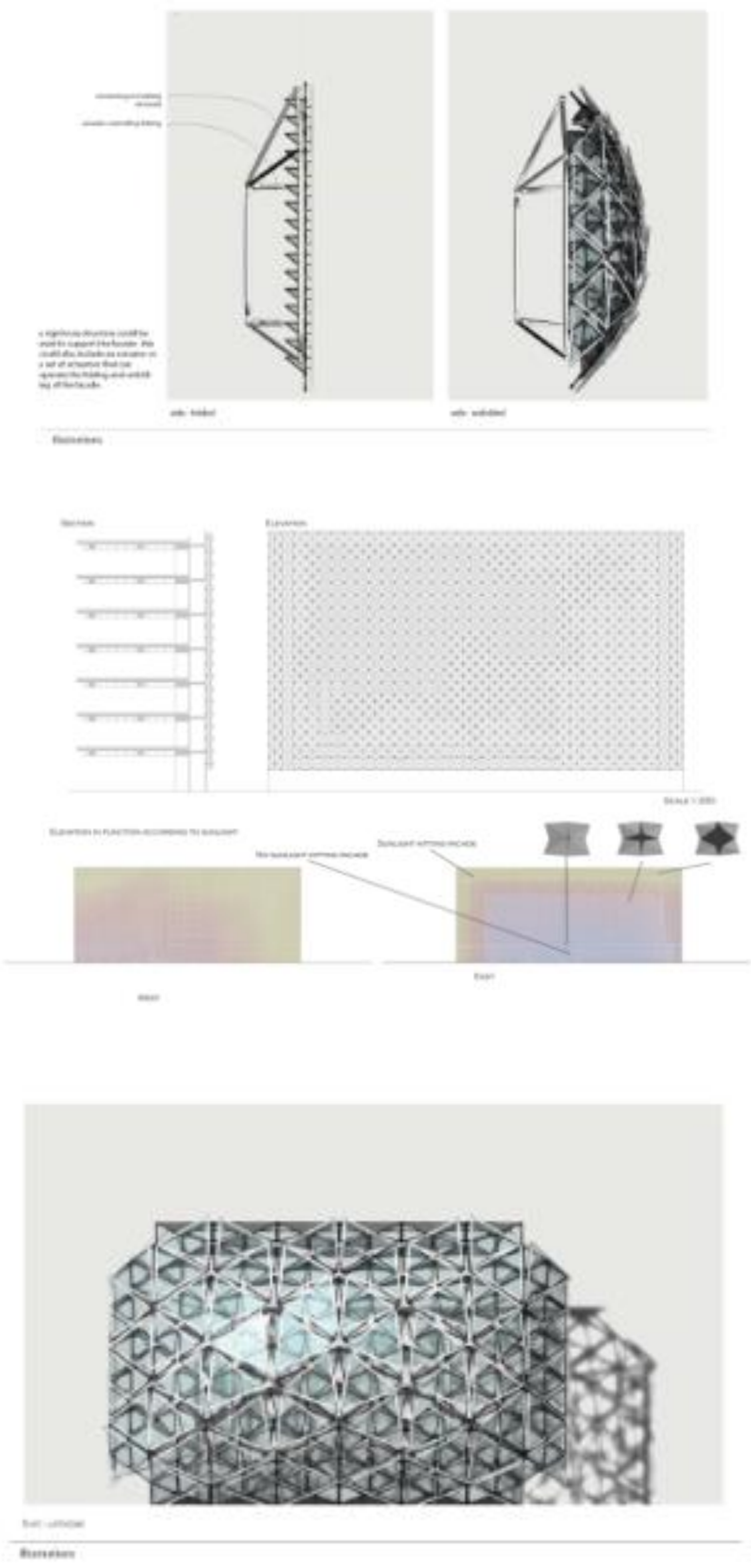

Figure 10. Façade project / Amer Aldour / Origami facade

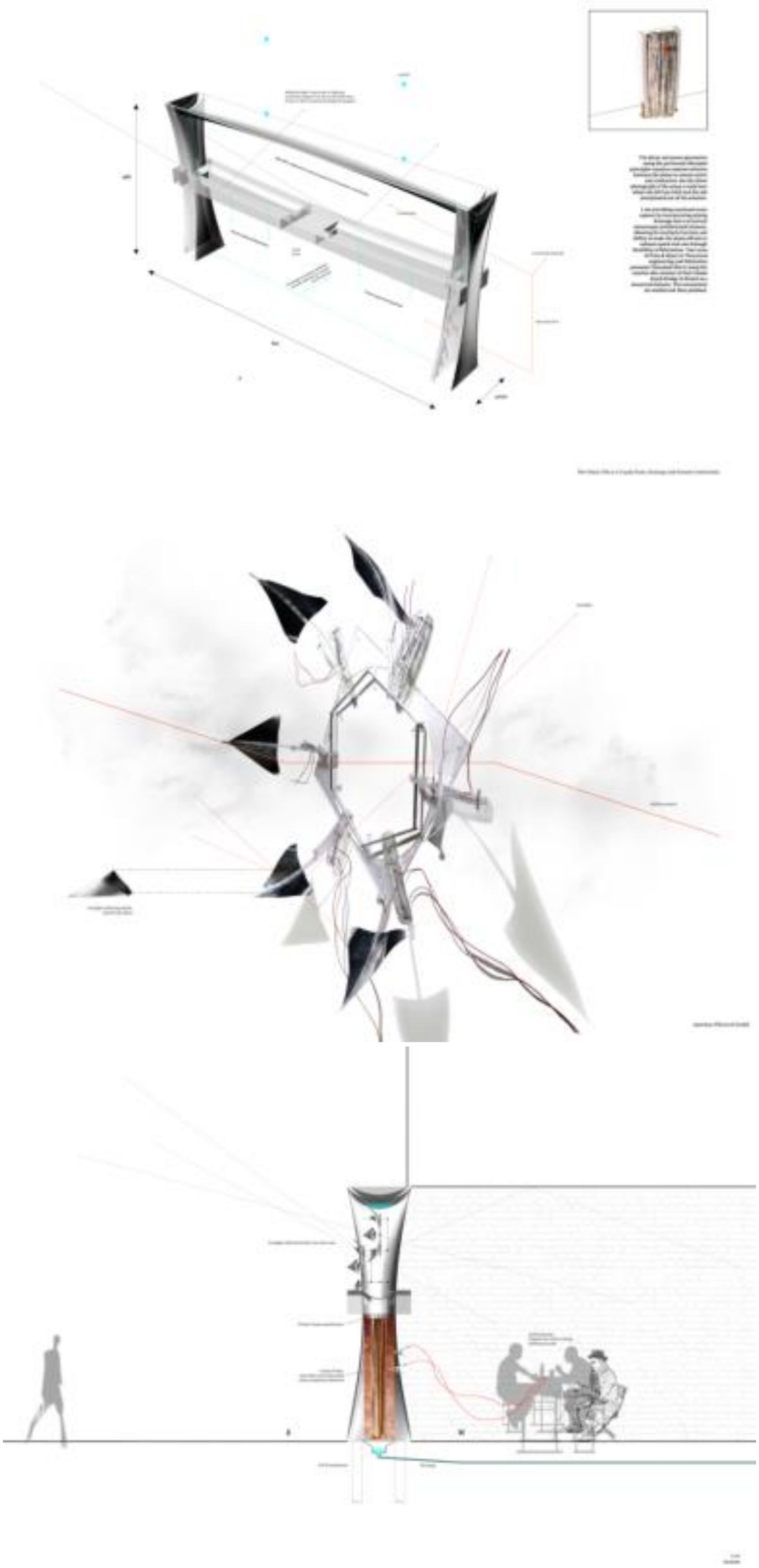

Figure 11. Façade project. Harish Persad / Memory metal skin

IN CONCLUSION

Evidence for the success of the pedagogic approach described in this paper may be found in the work of the students. When encouraged at the outset of their architectural education to produce ‘life drawings’ of structural form, students developed an appreciation for the built environment akin to that of the human form. This was evidenced by the quality and attention to detail in the sketches. Similarly, when asked to design a 1:1 construct to solve a straightforward structural problem – to resist loads and gravity – students, through prototyping and failure, developed an understanding of the properties of materials and how structures resist forces in tension and compression.

Using appropriate materials and understanding how to fabricate and assemble components was further developed in the second year Making Architecture projects. Here the underlying form of a small scale structure became the basis for its design, emphasizing the symbiotic relationship between design and technology in the built environment. It was often the first time that students had been asked to produce measured, scaled drawings: techniques that enhanced their confidence in the ‘buildability’ of their projects. This also helped to demystify the technical drawing, so that in their third year projects students were able to employ detailed ‘working’ drawings to illustrate complex and often dynamic façades.

The range of solutions that students proposed to the technical briefs outlined in this paper is evidence of one of Nature’s key lessons – that simple rules will often produce complex outcomes. Inevitably, an academic paper can only provide a ‘snapshot’ of this evidence, however the volume, range and quality of output has been witnessed over the years by a wide range of visiting lecturers and critics. Alex de Rijke, founding Director of dRMM, states: “The work of the students unselfconsciously demonstrates that it makes no difference how well off you are, of which sex, age or colour. These projects, a paradigm for the principles of architecture and engineering design, reveal the only thing that counts is brains and hands. In the fresh student faces, standing on or beside their first constructions, and in their tense expression of fear, pride or release one can see emerging a lifelong relation to ideas, teamwork, invention, experiment and fabrication, and the relative parameters of success and failure. Between the lines of the deceptively simple briefs are invaluable lessons waiting to test the unsuspecting.”

THE AUTHORS

Pete Silver and Dr. Will McLean are teachers and authors. They have co-authored four books on architectural technology that together have been published in nine languages and have sold over 10,000 copies worldwide. Silver is a Senior Lecturer and a Director of the Chartered Practice Architects (CPA) Ltd. McLean is a Principal Lecturer, a Doctor of Philosophy, and is widely published in his own right.

ACKNOWLEDGEMENTS

The technical projects described in this paper were set during the period 2005-2015 and could not have been realised without the support of Professor Katherine Heron, MBE, as Head of School. The authors’ gratitude and appreciation also goes to the Technical Studies teaching assistants - Lamis Bayer, Eleftherios Dousis, Yonca Erson, John-Paul Frazer, Reena Gogna, Fotis Grammatikopoulos and Gabbrielle Omar, and a special thanks to the Marylebone Campus workshop staff, Jed, Paul and Steve.

Over one thousand students have participated in the technical courses outlined in this paper, and the authors would also like to show their appreciation for the dedication of the students to their technical tasks over the years. The authors hope to be able to publish a full archive of their work in the future.

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[1] Marcus Vitrucvius Pollio, *De architectura*, Book 1, Chapter 1, definition of an architect.
[2] Friedrich Wilhelm August Froebel laid the foundation for modern education based on the recognition that children have unique needs and capabilities. He created the concept of the "kindergarten" and coined the word. He also developed the educational toys known as Froebel gifts.
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UNDERGRADUATE VALUE ENGINEERING COLLABORATION WITH INDUSTRY PARTNER

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INTRODUCTION

It was immediately evident in the introductory meeting with the executive leadership team of Freddy's Frozen Custard & Steakburgers (Freddy's) that the success of the franchise was not solely the result of pursuing continued growth and profitability for its own sake, but that instead, the growth and profitability was the result of the company leadership's insistence on and commitment to providing good value to their customers. "Value engineering" in today's design and construction market is a term that is rarely used in the proper context of its originally intended definition. Today, most entities in the design-procure-construct-operate process tend to view value engineering only from the perspective of cutting costs to the bare bones without due consideration of any proposed reductive measures with regard to value, sustainability, and return on investment. Freddy's is an exception to that trend. Their steadfast commitment to maintaining portion sizes and in upholding consistent quality in their food service both support their mission for providing the desired customer experience. This commitment to their customers translates into their value engineering goals and decisions. Any deviations relating to Freddy's design and construction processes will only occur as long as they maintain or enhance Freddy's customer experience while also providing the best value for long-term success of its facilities.

PROBLEM

A Proven Business Model

Freddy's franchise, based in Wichita, Kansas, has achieved a high degree of financial success since opening its first fast-food location in 2002 in its home city. The company began selling franchises for their restaurant concept in 2004 and is currently ranked 44th in the top 500 franchise business opportunities in the U.S., according to Entrepreneur Magazine's 2017 Top Company Cultures List[1]. After surviving the 2008 recession, the company experienced consistent growth with 287 locations established and operational as of 2018.

During these growth years, the Freddy's format has undergone incremental changes as the enterprise adapted to incorporate what worked and eliminate what did not. The expansion of their locations across diverse locales and the evolution of its business model has helped Freddy's to maximize the efficiency of its operations and optimize its customer environment to achieve a consistent appearance and customer experience across many different municipalities and locations that require compliance with a variety of different Authorities Having Jurisdiction and their applicable building codes.

Room for Improvement

Despite their track record of success, Freddy's was interested in continuing to look for new ways to further refine its proven approach. As part of this strategy, Freddy's considered the value of looking outward for fresh perspectives. One source of new ideas that was considered was to turn to the world of academia to gain those perspectives. Freddy's approached Kansas State University's Department of Architectural Engineering and Construction Science and Management (ARE/CNSM) to request assistance in evaluating Freddy's current business model and restaurant designs to see if new ideas might be uncovered through analysis by outside observers. To undertake this creative inquiry (CI) effort, a project CI group was established using an integrated team of CNSM faculty and emerging undergraduate CNSM students. This group took on the challenge of addressing Freddy's desire for an objective look at their existing programs.

CREATIVE INQUIRY (CI) PROCESS

The overall CI challenge provided by Scott Redler, COO and co-Founder of Freddy's, was to evaluate the current construction and design processes used in the building of new Freddy's' restaurants to identify any potential value engineering opportunities that could be incorporated into future projects.

Undergraduate Creative Inquiry Students

The main goal of this project from the perspective of the Department of ARE/CNSM was to get undergraduate students involved in a value engineering collaboration with Freddy's. This involvement required the engagement of motivated undergraduate students to participate in the CI effort. Three senior students and two underclassmen from the CNSM program were selected to work on the project, which provided a range of student perspectives. This team mix also provided beneficial collaborative educational opportunities for the underclassmen. The students were given three options for earning credit for their CI efforts. The first option was to use the opportunity, through independent study, to earn one of four professional elective course credits required by the CNSM degree program. The second option was to be paid as an hourly undergraduate student employee of the department for the time invested in the project. The third option was to credit the time invested toward the travel expenses to the Associated General Contractors of America (AGC) National Convention in New Orleans, LA with the ARE/CNS AGC Student Chapter. The costs of the second and third options were underwritten by endowed funding from one of the CI team faculty member's Tointon Construction Management Chair position.

Structure

Overall Timeline

This CI project was conducted over the course of eight months, from initial contact with the Freddy's leadership team through completion of the students' final report. The timeline diagram shown in Figure 1 indicates that a large majority of the time associated with this project was in the initial contact phase occurring between Freddy's and the ARE/CNSM CI team faculty at Kansas State University. The body of work conducted by the students was completed over the course of one academic semester.

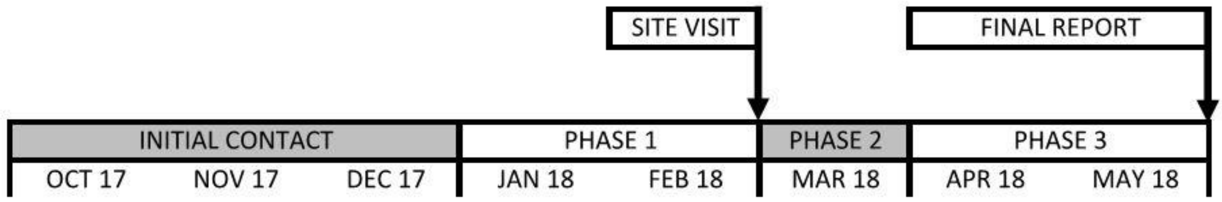

Figure 1. Creative Inquiry Project Schedule

Initial Contact

The project initially started with a request from the Freddy's corporate office to determine if there were any CI opportunities available related to the value engineering of buildings or projects similar to the Freddy's restaurant format. After several weeks of conversations between Freddy's and the ARE/CNSM CI team faculty, it was agreed that a client-specific CI effort was needed to yield the value engineering ideas sought by Freddy's and that these ideas could best be generated through the utilization of undergraduate CI students under the guidance of experienced construction faculty. Due to the timing of the initial conversations, it was decided that the commencement of CI would be postponed until the beginning of the following semester to allow for the selection of the appropriate team of undergraduate CI students.

Phase 1

During the first month of the project, the five students were provided with construction documents for two prototype Freddy's restaurants. The construction documents for each of the prototype designs consisted of architectural floor plans, wall sections, specifications, mechanical plans and electrical plans. The students performed an in-depth review of these documents to create an initial list of possible value engineering topics. Additionally, the students used their own first-hand knowledge of the local Freddy's restaurant in Manhattan, Kansas to develop several of the proposed topics. During the weekly team meetings, the students presented their individual topic ideas, which were later combined to create a larger master list of topics.

Once the initial topic list was generated, the students were given the opportunity to take a client-guided tour of two fully operational Freddy's restaurants in the area. During the tour, Freddy's managing owner, Scott Redler, and Freddy's Senior Director of Construction, Pat Sardo, provided insight into the many previous value engineering ideas that had already been implemented throughout the franchise as the business grew and evolved. The clients elaborated on other areas of the restaurant that they felt might benefit from additionally scrutiny. Throughout the tour, students listened intently, interviewed the clients through pointed questions, and documented the conversations and answers they received relating to the potential value engineering topics. During these tours, they also collected thorough photographic documentation of all exterior and interior aspects of the facilities and sites for future reference.

Phase 2

After collecting all of the necessary information from the site tours and client interviews, the students re-evaluated their initial value engineering topics list, making modifications and additions to incorporate the new information. The entire initial topic list was determined to be beyond the scope of what the students would be able to address within the time constraints of the remaining semester. The students decided instead to focus on selected topics that were deemed to have the most potential for value engineering impact.

Phase 3

After completing their individual research of each value engineering topic, the students began compiling a formal report, which would be presented to the Freddy's ownership group at the conclusion of the semester. For each value engineering topic researched, the students provided cost comparisons, product data, installation considerations and other pertinent information to allow the Freddy's leadership team to objectively evaluate each topic for potential incorporation into future Freddy's construction projects and renovations.

VALUE ENGINEERING TOPICS

The students organized the value engineering topics into a list of five main restaurant areas. Within each of these areas, selected topics were then assigned to individual students on the CI team. Over the course of the next several weeks, the students each researched their respective area and topics to determine if different material selections, alternative means or previously unknown methods were available that might provide improved value for Freddy's operations and long-term ownership burden. The students were then divided into two groups, with each group focusing on different topics. One group focused on modularization and exterior aspects of the prototype design and the other focused on the interior finishes. The division of topics was established by analyzing the students' current skill set and their personal interest in the various topics. This list of topics developed by the students is shown below.

Modularizing Building
- Tilt-Up Concrete Exterior Walls,
- Rotate Trusses to span shorter dimension,
- Awnings changed to awning with soffit,
- Rearranged Mechanical Room.

Front of House Finishes
- Plastic laminate on the checkout counter and drink station,
- FRP to replace 1x1 tile trim,
- Menu Board TV Monitors,
- Alternative Floor Finishes.

Back of House Finishes
- Interior Doors,
- Alternative Floor Finishes.

Restroom Finishes
- Toilet partitions,

- Rubber base along hall to the bathrooms,
- Interior Doors,
- Alternative Floor Finishes,
- Alternative Wall Finishes,
- Hand dryers to replace Paper Towel Dispensers.

Building Exterior/Site
- Picnic Table Substitutions,
- Triple Pane Glass.

Results of Student Analysis

For the purposes of this paper, only five of the above topics were included. Although the students provided design and construction recommendations for all of the topics, a selection of the items with the greatest potential for impact to the client are included in greater detail.

Rearranged Mechanical Room

One of the areas on which the students focused their research efforts was in finding ways to decrease the overall square footage of the prototype building. The students used Bluebeam Revu software to reconfigure the back-of-house space to propose a reduced overall square footage of 152 square feet. This reduction was accomplished by relocating the equipment in the mechanical room to other locations in the building's layout.

The roof ladder and hatch were removed from the existing storage area and relocated to the exterior of the building. This allowed the students to relocate the fire sprinkler system equipment from the originally designated location to the area the roof ladder had occupied. Additionally, the eye wash station, ice machine and water heater were relocated to the area adjacent to the mechanical room. The last proposed change involved the relocation of the electrical panels from the mechanical room to the area where the "Freducation" station and the bread racks were originally located. The "Freducation" station is Freddy's interactive, new-employee training station. To address the loss of space for the "Freducation" station, the students proposed converting the computer station to a mobile device that could be carried throughout the facility to improve training effectiveness. Provided in Figures 2 and 3 are the original prototype design of the back of house area and the proposed revision from the students.

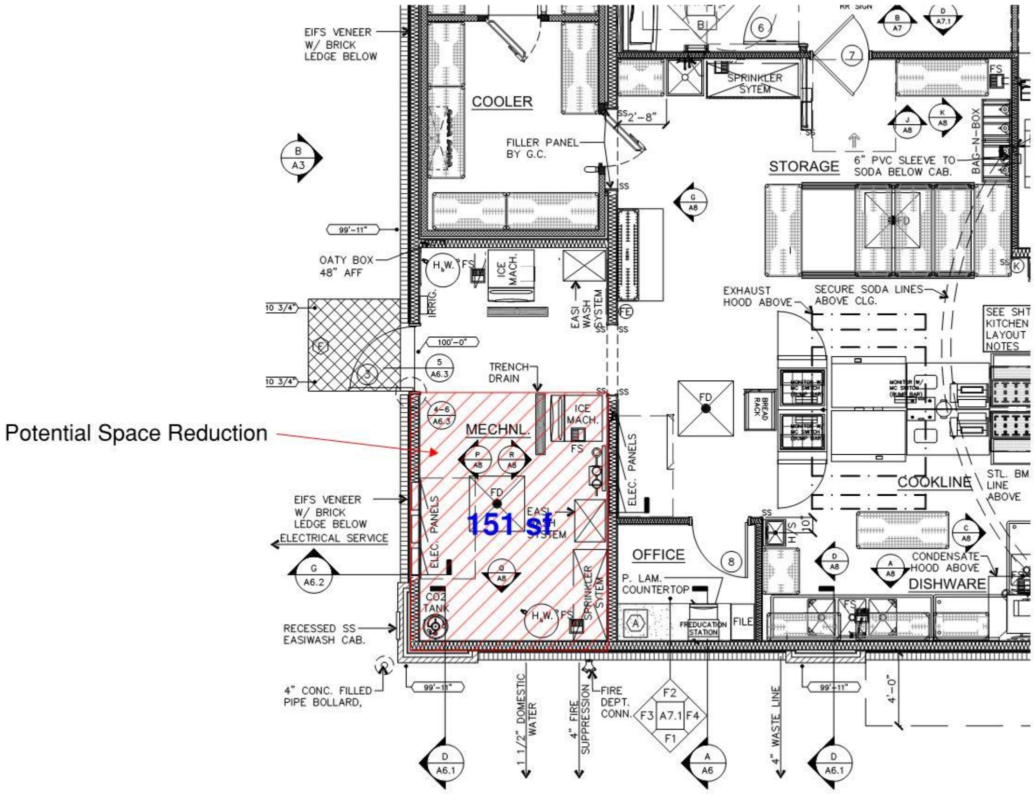

Figure 2. Original Floor Plan

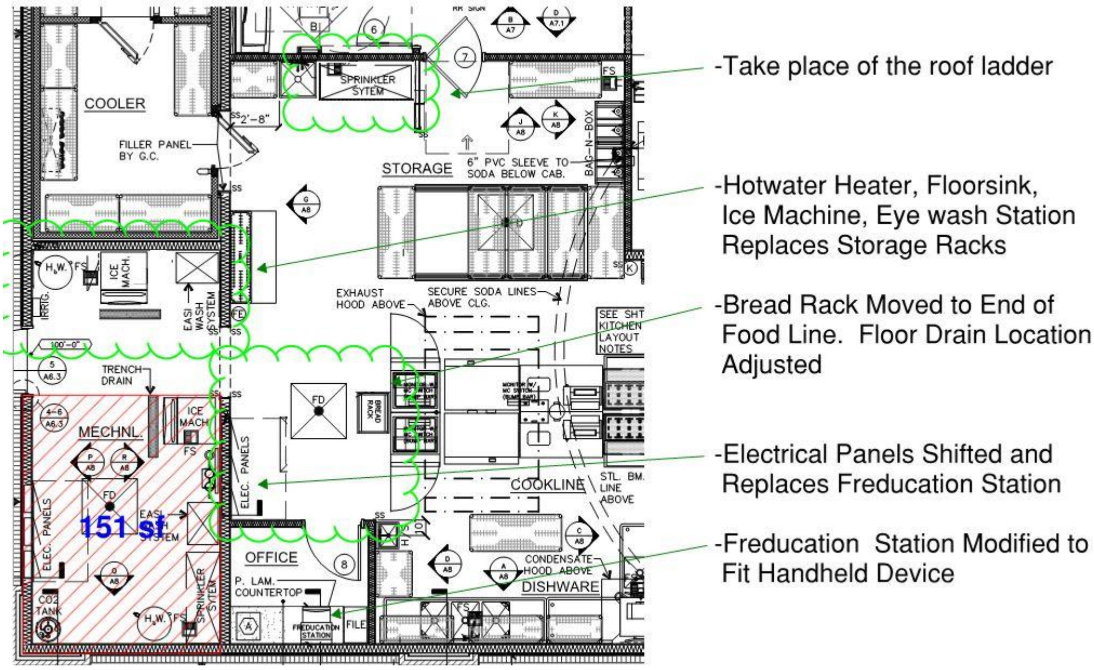

Figure 3. Annotated Floor Plan

Alternative Floor Finishes

The students tasked with evaluating the possible alternative floor finishes in the front of house areas identified several options that could potentially decrease the maintenance costs associated with the flooring system. The existing flooring in the prototype building and the site visit locations was a 12 x 12 quarry tile in a checkerboard pattern of black and grey tiles. During the site visits, the students noticed that in many locations there was evidence that maintenance of this type of flooring was a challenge. After making this observation, the students researched several different flooring products to determine the most appropriate solution that would address the durability, ease of maintenance, and aesthetic requirements of the Freddy's program.

The solution that the students presented to Freddy's was to change the flooring to a seamless urethane flooring system. This product would eliminate the maintenance of grout joints associated with quarry tile flooring. This product is also chemical resistant, stain resistant and available in a wide variety of colors and textures. The students analyzed the maintenance costs associated with both the existing flooring and the proposed flooring and determined that, although the initial cost of the urethane flooring was similar to quarry tile, the annual maintenance cost of urethane flooring was over 50% less than quarry tile.

Interior Wood Doors

During the site visits, the students observed that the existing facilities use solid wood doors for all interior doors. At multiple locations, the door faces showed significant impact damage due to extensive use. The students evaluated alternative solutions for replacing the wood doors to address this unsightly problem and developed two options. The first option was to switch all doors to painted hollow metal doors. This provides a more durable and lower maintenance product. The second option was to add a larger (half-door sized) metal kick plate in lieu of the standard-sized kick plate already in use along the door bottom to address the surface damage being inflicted to both faces of the wood doors.

Toilet Partitions

As a part of the analysis, the finishes within the bathrooms were also evaluated. Although many of the issues identified were similar to those found in other areas of the building, one issue stood out: damages to the toilet partitions. The existing toilet partitions evaluated in the site visits and specified in the prototype building were constructed of powder-coated metal. At the site visit, the students again observed that the panels showed significant signs of wear and were also damaged by graffiti. The students reviewed several alternative materials to substitute for the metal toilet partitions and ultimately made the recommendation to switch to a solid surface partition panel, which contained color throughout the entire panel thickness. This product has a significant initial cost increase of 200-300%, but the students proposed that the increased initial cost would pay off over time in the savings associated with maintenance and cleaning. Because this type of panel can be lightly sanded to remove graffiti and still maintain the finished color, the students suggested that the additional cost would be offset by the ease of graffiti removal and ease of similar maintenance processes.

Triple Pane Glass

When discussing the goals of the creative inquiry project with the Freddy's staff, the students realized that long-term appearance quality and superior energy efficiency was of high importance. As a part of their analysis, the students looked at ways to increase the overall energy efficiency of the prototype building. One component they elected to evaluate was the exterior glazing. Because the exterior envelope design called for a large square footage of glazing, this provided a meaningful opportunity to increase the overall energy efficiency of the building by focusing on this element of the design. After reviewing several options, the students opted to recommend triple pane glass in lieu of the two-pane glass specified in the prototype building documents. Although there was an increased initial cost in upgrading the glazing system, the return on investment related to the energy savings made this a valid option for the students to present to Freddy's.

PROJECT OUTCOMES

What the Students Gained from this Creative Inquiry (CI)

The students noted that the hospitality industry is one sector of construction that does not get as much focus in Kansas State University's CNSM curriculum as compared to other market sectors, such as commercial buildings. The students expressed that they found it interesting to gain insight into how clients in the restaurant/hospitality business think and operate. The students gained valuable experience through analysis of various building systems and equipment and by examining the costs and selections of many components of the project. The students recognized that, while one particular product may have lower initial first-costs, the element of customer satisfaction and reduced life cycle and ownership costs may ultimately justify spending more money at the front end of the project to achieve better results. The students felt that performing a value engineering examination for Freddy's was especially challenging because the client's design team had already thoroughly refined the project design through numerous iterations of previous trial and error during the growth of the franchise model.

Despite the challenge of second-guessing what seasoned professionals had spent years developing and evaluating throughout the history of the franchise, the students utilized this CI effort as an opportunity to improve their own critical thinking skills while using the value engineering process as a supplemental educational experience to the CNSM curriculum course work. Additionally, the students found it to be further beneficial to have direct access to the client-professionals and to the CNSM faculty. This direct access allowed the students more freedom in exploring potential value engineering topics, since they had the opportunity to bounce their ideas off the CNSM faculty. In response, the faculty provided the students with real-time feedback that helped in affirming the efficacy of a current approach or the need to pursue the next idea.

Finally, the students learned much from the experience of collaboratively drafting and consolidating their findings into a professionally written document. A document that would ultimately be submitted to an actual industry client for expert review, and potentially used as a guide for implementation of recommended changes into both existing restaurants and new locations through adaptation into future prototype formats and renovations. The students worked together to incorporate as much information as possible into the final document without overwhelming the intended audience or without confusing the client with unnecessary data or ideas. The students also recognized the importance of creating a professionally formatted report that was visually interesting yet did not distract the reader from the significance of the findings that were being presented.

What Freddy's Gained from this CI

The undergraduate students submitted numerous ideas to Freddy's for evaluation. The findings presented in the student's final report gave the Freddy's leadership team several tangible ideas that warranted deeper client examination for potential implementation into new construction projects and existing restaurant renovations. Excerpts from the report can be found in Appendix A. Freddy's Construction and Operations department could then selectively choose to dive deeper into the students' findings to determine how these proposed value engineering alternatives may provide monetary and/or other ownership value without compromising the Freddy's restaurant customer experience or the Freddy's brand.

Another unique and potentially beneficial aspect of this CI project was that Freddy's received the point of view from college-aged students/customers. This young CI team acknowledged being Freddy's patrons and brought some fresh perspectives to the Freddy's management that their existing construction and operations team most likely had not previously considered. From Freddy's financial perspective, this CI effort was a low-risk, high reward experiment to engage college students in performing review and analysis of Freddy's existing programs while providing benefits to both the company and the university.

CONCLUSION

Entering into a collaborative relationship with a creative inquiry team of experienced faculty and motivated students for the purpose of discovering new perspectives in the pursuit of continued improvement proved to be a beneficial investment for Freddy's. Freddy's leadership team entered into this synergistic relationship with no preconceived dollar amount of expected cost savings from the undergraduate value engineering exercise nor any particular outcomes that would define the ultimate success of this collaborative project. Instead, the mindset of the Freddy's leadership team was that, if the outcomes of the project yielded just one or two viable recommendations that had not been previously considered, the project would be viewed as a success from their perspective. This opinion would hold true even if those accepted recommendations resulted in higher initial costs but allowed for a reduction in the life cycle costs of its facilities. It is too early to determine the full financial and life cycle implications of the CI team's recommendations, as the Freddy's leadership team is still in the process of evaluating the report before making any implementation decisions. However, the leadership team expressed its satisfaction with the results of the final report and that they were impressed by the quality of the effort and results provided by the CI team.

FUTURE APPLICATIONS

Mutually Beneficial

From the perspectives of the client, Freddy's, and the academic CI team, the CNSM faculty and students of Kansas State University, this highly collaborative project was viewed as a success, as it provided tangible benefits to both groups. The academic side was presented with a challenging problem to solve and a real-life opportunity to apply practical analytical skills and learned knowledge through participation in a CI effort.

Kansas State University's participation was useful in helping an industry partner by providing objective evaluations and observations regarding practical ways to improve and enhance the efficiency of a successful business's operations. The ideas presented focused on employing suggestions that increased the longevity of specific capital investment expenditures relating to both new and existing restaurant locations.

On the client side, Freddy’s was able to benefit from fresh, outside insights that were identified and presented by the academic CI team. This collaborative and mutually beneficial partnership between private industry and academia may serve as a model that would be appealing to other private and public clients, as well as other public universities with construction management education programs. From the academic perspective, the project appealed to both the faculty and the students as an opportunity to provide both service and practical application of learned concepts and skills in a way that compliments and enhances the classroom experiences of the academic team.

Continued Outreach and CI Opportunities

The idea of collaborative CI between the ARE/CNSM department and an outside client is now being continued with a second project involving the same construction faculty, along with a new group of undergraduate CI students. In this new endeavor, the client is a State agency that is seeking assistance with preconstruction services by the CI team that will establish the project’s programming requirements, create a schematic design, and formulate a conceptual cost estimate for a new vehicle maintenance and repair facility to be located on university-owned property within the city limits of Manhattan, Kansas.

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Education, Design and Practice – Understanding skills in a Complex World

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HARNESSING THE PROLIFERATION OF SOCIAL MEDIA IN SPATIAL DESIGN DEVELOPMENT — FINDING INTEGRITY AND EXPERIENCE OVER TREND AND VISUAL REPLICATION

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INTRODUCTION

The global techno-cultural phenomenon of social media influences the design industries' end-products and user experiences as well as the actual processes used by designers to generate these. This paper discusses how a unit called *Spatial Experience and Aesthetics,* as part of Curtin University's Interior Architecture program, uses social media as a tool to inform spatial design development — harnessing, rather than resisting its pervasiveness in a bid to find unifying concepts to inform unique and appropriate design propositions. This effort is an attempt to equip students with the skills to avoid surface-level replication in design and engaging in 'trend', which are arguably inherent side-effects of being informed by social media. Students may contribute this new skill to existing design teams.

This paper covers in more detail, the pervasiveness of social media in the contemporary design studio and lists the potential pit-falls student designers might encounter when using social media. The paper elaborates on the *Spatial Experience and Aesthetics* unit structure and explains how it equips students with skills to harness social media as an informative design tool. Unit outcomes, in the form of student work and critical reflection are discussed.

THE PROBLEMS WITH SOCIAL MEDIA IN DESIGN DEVELOPMENT

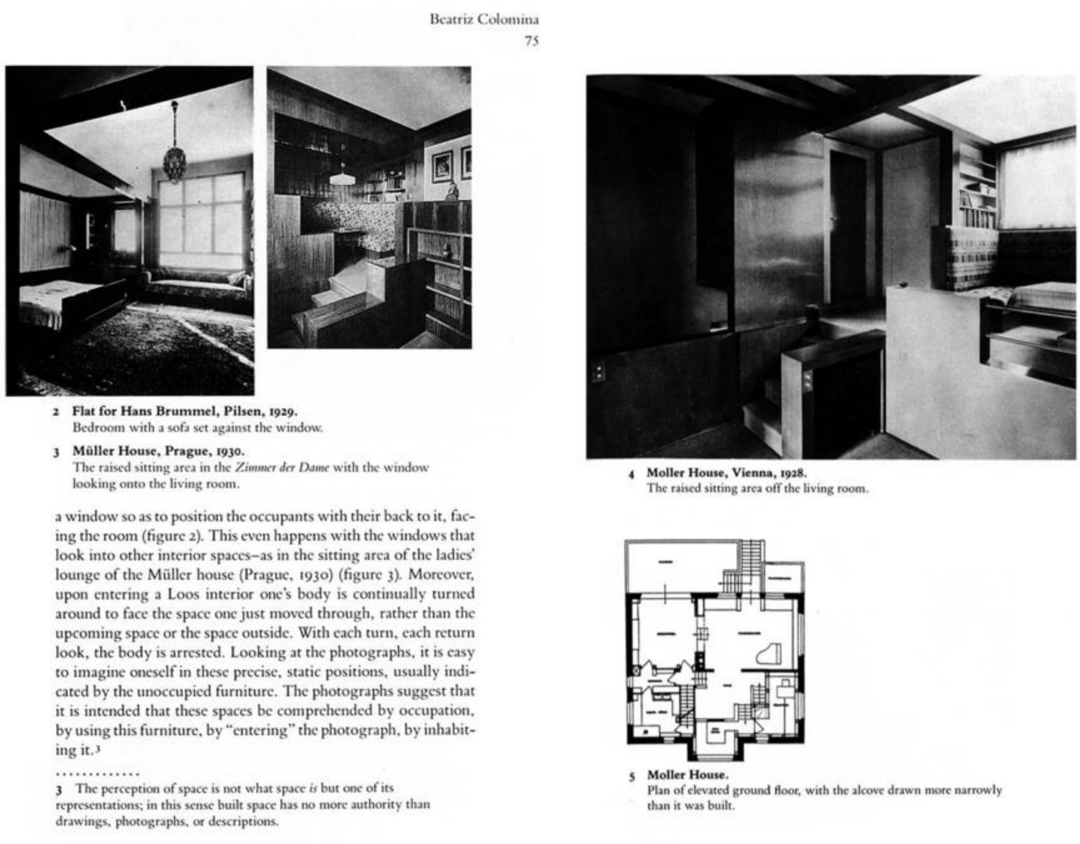
Students of design are in varying ways and to varying degrees using connective technologies to access social media in the design studio as a way to look for design inspiration. Platforms such as Instagram, Pinterest, Tumblr are some of the most typically accessed and the practice of using social media as a form of inspiration is now so common it has been dubbed 'inspo'[1] by many. This is not a problem in itself, designers have always looked for visual stimuli, but a question arises as a result of using this one in particular given its purposeful ease of accessibility, its prevalence and its inherent artifice:

Are students forgoing the rigor that should be the design process, in terms of both the analysis of inspirational material and in experimenting and implementing this into a considered and unique design proposal — instead sometimes adopting a replication approach translating inspiration from source to site?

At an anecdotal level, this question is asked in university design studios across the world in varying forms and languages and often the idea is to prohibit the use of connective technologies that enable such rapid and easy access to social media — *'put your phones away'*.

Traditionally, students and design practitioners drew inspiration from precedents that were peer reviewed in books or articles with sketches and quotes from the designer and critics discussing what experiences were intended for occupants, and how and why they went about doing this using aesthetic terminology. The photographs in these sources were also commissioned by the designers or authors to express the attributes of the space itself. They were, generally speaking honest pictures of the architecture/interior that complimented the accompanying written information like floor plans and sections, all helping to orientate the reader within the work. Students would find these precedents by reviewing indexes in the rear of the book or journal in the library or architecture library or by previewing online carefully before pressing the purchase button, all the time gauging the relevance of these projects to their own.

I recall going through this investigative process for inspiration as a design student no more than a decade ago and encountering the initially bland images displayed in Figure 1 of Adolf Loo's Moller and Muller houses in Vienna which, I found in Beatriz Colomina's *Privacy and Publicity: modern architecture as mass* media[2]. Colomina illustrates through a combination of media the varying floor levels in the house as theatre boxes for activities, staging more often than not the everyday rituals of the home and creating areas of voyeurism and consequently power relationships[3]. The explanation and critique of these homes and how they were designed in such a way to elicit particular social dynamics quite radically altered how I thought about space/design and its effect on people. Consequently, it would change the way I researched and practiced — even to this day. However, this type of rigorous approach to design research and inspiration is well-noted as becoming increasingly rare[4].


Beatriz Colomina
75

2 **Flat for Hans Brummel, Pilsen, 1929.**
Bedroom with a sofa set against the window.

3 **Müller House, Prague, 1930.**
The raised sitting area in the *Zimmer der Dame* with the window looking onto the living room.

a window so as to position the occupants with their back to it, facing the room (figure 2). This even happens with the windows that look into other interior spaces–as in the sitting area of the ladies' lounge of the Müller house (Prague, 1930) (figure 3). Moreover, upon entering a Loos interior one's body is continually turned around to face the space one just moved through, rather than the upcoming space or the space outside. With each turn, each return look, the body is arrested. Looking at the photographs, it is easy to imagine oneself in these precise, static positions, usually indicated by the unoccupied furniture. The photographs suggest that it is intended that these spaces be comprehended by occupation, by using this furniture, by "entering" the photograph, by inhabiting it.[3]

....

3 The perception of space is not what space *is* but one of its representations; in this sense built space has no more authority than drawings, photographs, or descriptions.

4 **Moller House, Vienna, 1928.**
The raised sitting area off the living room.

5 **Moller House.**
Plan of elevated ground floor, with the alcove drawn more narrowly than it was built.

Figure 1: showing pages 75 and 76 from Beatriz Colomina's Privacy and Publicity publication 1994. Image from https://dokumen.tips/download/link/beatriz-colomina-the-split-wall-domestic-voyeurismpdf

In contrast to peer reviewed sources of inspiration, social media allows almost anyone to exhibit their unique narrative of a space in time and individual context through ‘posts’ which feature any number of filters and editions. These are accompanied by hashtags and information that is not necessarily always reflective of the space itself but rather ones that gain the most audience engagement. More begets more on these platforms enabling posts to become popular and therefore engaged with by students and practitioners, without ever being verified as something that:

a) Is truly representative of the space as these clicks and likes might actually be about the architecture of the image than the architecture in the image, or the space might be a subsumed backdrop for some activity like a selfie or a picture of a pet[5].
b) Has correct accompanying information. For example, the hashtags and commentary might have nothing to do with the space, its design, or the experiences it might facilitate in real life, but rather align to the hashtag de jour[6].

Further, it is this contemporary media which have algorithms that create echo-chambers for users, typically showing only what they have seen and would like to see[7]. These points raise caution to the immediately obvious pitfalls of social media use as a source of inspiration — it can be quite surface-level and even uninformative — yet they are not outlined here to argue that social media is altogether not useful. It is a particularly useful design tool if students can find imagery that has been commissioned by the designers of precedents to capture the essence of what they designed with links to their websites and appropriate captions explaining how and why they created it. In this way, using social media as an inspirational tool in a more traditional/rigorous manner more aligned with my personal example of the Loo’s dwellings. However, given the democratic nature of social media outlined above, this is not often an available avenue to pursue nor is it a way students are inclined to use social media. The argument here is that like all media there are reliable and unreliable sources to be inspired by and there are critical ways to read and analyze them relative to our own agenda; designing a well-informed, context-relevant and well considered space/object/garment/user experience. This is in opposition to visual/surface replication and trend.

Being influenced by social media without adequate formal ways to critique and enquire into it, or escaping the material one is consistently exposed to due to algorithms that limit our exposure, can foreseeably lead to problems like; occularcentric design that does not address other ergonomic, choreographic and sensorial considerations[8] and homogenous design that lends itself to whatever is trending on media platforms[9]. In practice replicative design would leave graduates deficient in arguably our industries most valuable asset, which is to design for unique situations. Eventually these issues, and others not mentioned might lead to unsustainable ever-rapid trend cycles, a phenomenon now well noted in some design fields like fashion, and one that is gaining traction in others like interior and spatial design[10][11].

To illustrate how influential and reliant design students can be on social media as a source of inspiration, a recent survey conducted on a cohort of Interior Architecture students revealed that 77% used social media to inform or inspire most designs they work on and 21% claimed they did so occasionally. Students said that the advantages to using social media in design development are that, it inspires them, that they can take ideas away to inform their own projects, that it gives them a starting point, and that it makes designing easier. 82% also claimed that it played a significant role in their decisions to enroll in their degrees with hopes to become an interior architect/designer.

It is not only students that can adopt the practice of using social media as a source of inspiration without deep analysis and sometimes replicate what they've seen (subconsciously or otherwise), but it is students that are largely at risk of not learning rigorous design research analysis and design development skills. Further, it is the students who are going to be the next practitioners who will add to and shape our design industries.

Acknowledging the dangers of using social media as a source of inspiration including the ease of access and student dependence on it, has mandated the creation of the unit *Spatial Experience and Aesthetics*. In it, students learn how to critically analyze the abundance of social media imagery relative to a design project, finding depth through aesthetic theoretical analysis, and teasing out core experience and unifying concepts rather than visual trend, to inform design. While the unit is necessarily spatial given it is integrated into an Interior Architecture program, its fundamental structure and principles are easily translated by the reader to adjunct design disciplines.

LEARNING TO USE SOCIAL MEDIA IN DESIGN DEVELOPMENT

As illustrated in Figure 2 *Spatial Experience and Aesthetics* centers around a triadic relationship between theoretical concepts of spatial design, actual physical elements and expression of space and experiences of space from the first person's perspective.

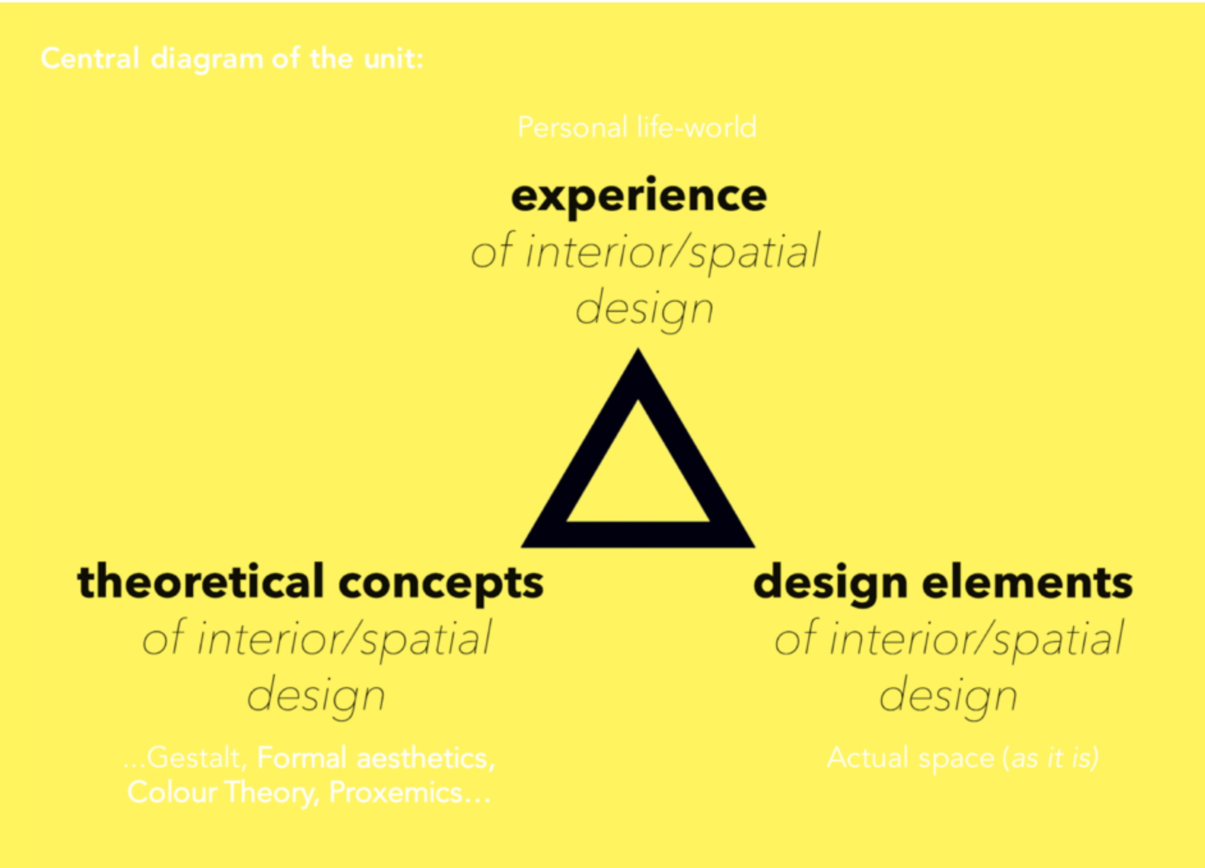


Figure 2: Central diagram of the unit Spatial Experience and Aesthetics illustrating a triadic relationship between theoretical design concepts, elements of space and the first-person experience (Author's 2019).

When referring to theoretical concepts (left), I am referring to concepts like gestalt principles, color theory, symbolism, formal aesthetics and other such theories or concepts that have been related to interior architecture or otherwise the design disciplines. When referring to the actual elements and expression of space (right), I am referring as to how it (the world/space around us) seems to express and compose itself toward us – its shape, its lines, its color and so on. Referring to the top of the diagram, this is the personal experience of a space someone has in a phenomenological sense.

Through this diagram and therefore the unit, students essentially investigate how space can be analyzed and even synthesized to generate occupant experience: how might a space increase appetite; make people more alert; facilitate contemplation; invite sorrow; elicit passion; provide a sense of tranquility, and so on. To get to this point, we must research into theoretical concepts of design, existing spaces and real life experiences and understand how the three interact.

To promote this understanding the unit runs over a 3-month period with class once a week and at the end of each month an assignment is due. Instead of lectures, a flipped classroom is adopted where students receive a reader prior to each class which introduces a design theory or concept. All contact/studio time is then used to do activities which solidify learning of the theory and its implementation as an analytic tool. The first month's readers are Formal Aesthetics, Gestalt and Color Theory and the students use these as the first arsenal to analyze an assigned set of photographs from a spatial precedent as to tease-out what experiences it might elicit. This analysis (shown through Figures 3, 4 and 5) requires diagrammatic explanation which essentially forms the first assignment.

Figure 3: Photograph showing students in class experimenting with color theory concepts as applied to an interior (Author's 2019).

The second month's readers include phenomenology and symbolism (including seeing architecture as a language and semiotics) and students are tasked to experience a local precedent through a site visit and take their own photographs as well as recordings beyond the visual, such as rubbings and sound studies. After assignment 1, this makes more apparent the difference between seeing and experiencing a space and allows students to engage with phenomenological theory, understanding that our life-world is more complex than the static image. Further, students visit in pairs to highlight that our life-world is to varying degrees, different to others'. Students are tasked to analyze this space, justifying why they may have had a particular set of experiences in it in accordance with all the theory learnt so far, trying to attribute experiences to aesthetic composition. As with assignment 1, this analysis is written and diagrammatic, yet allows students to build on the theory already learnt.

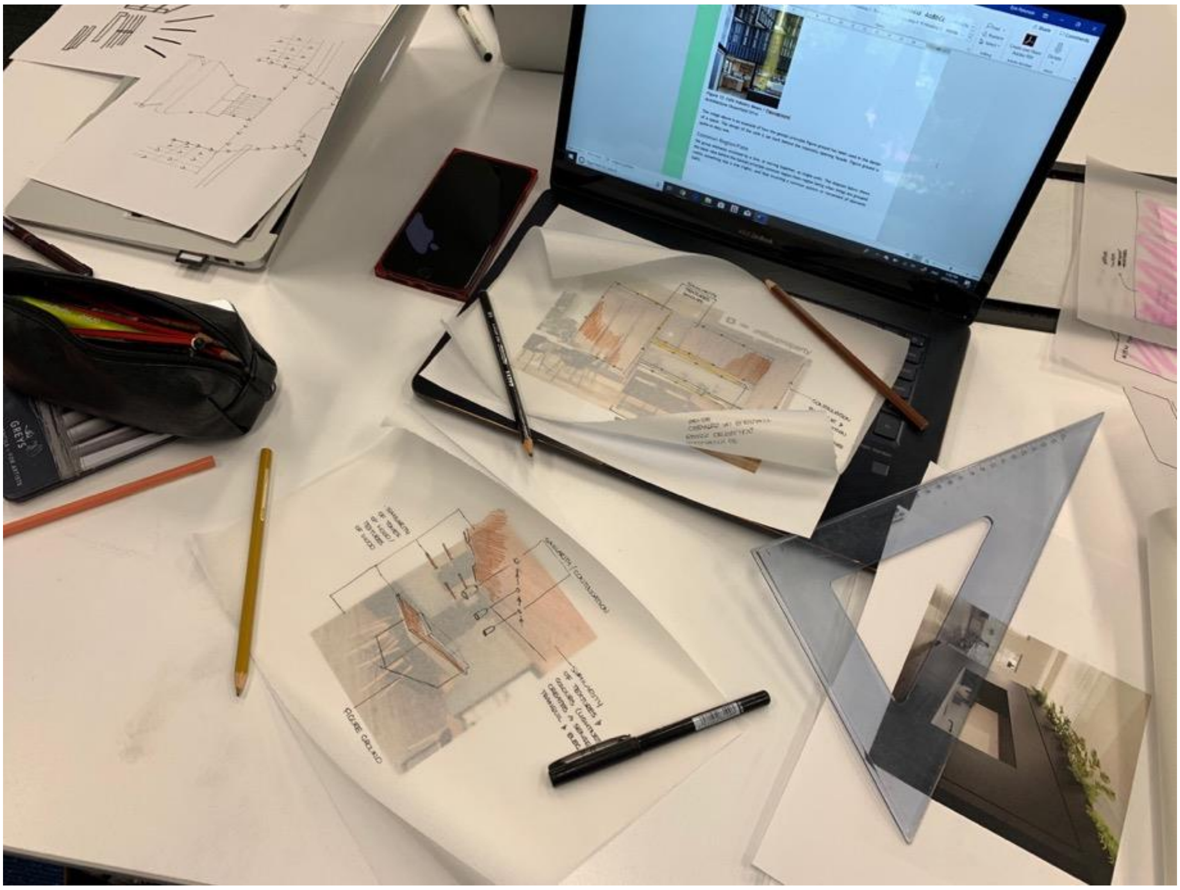


Figure 4: Photograph showing students in class experimenting with gestalt and formal aesthetic concepts as applied to an interior (Author's 2019).

In the third month, socio-spatial theory (including proxemics and surveillance theory) are introduced to consider another dimension of spatial experience — other occupants. Students are also independently tasked to find an additional theory or a spatial concept that they can use as an analytic tool, thereby demonstrating their fundamental understanding of how the parts of the central unit diagram interact and how they can find and use theory that has not been provided to them in the future.

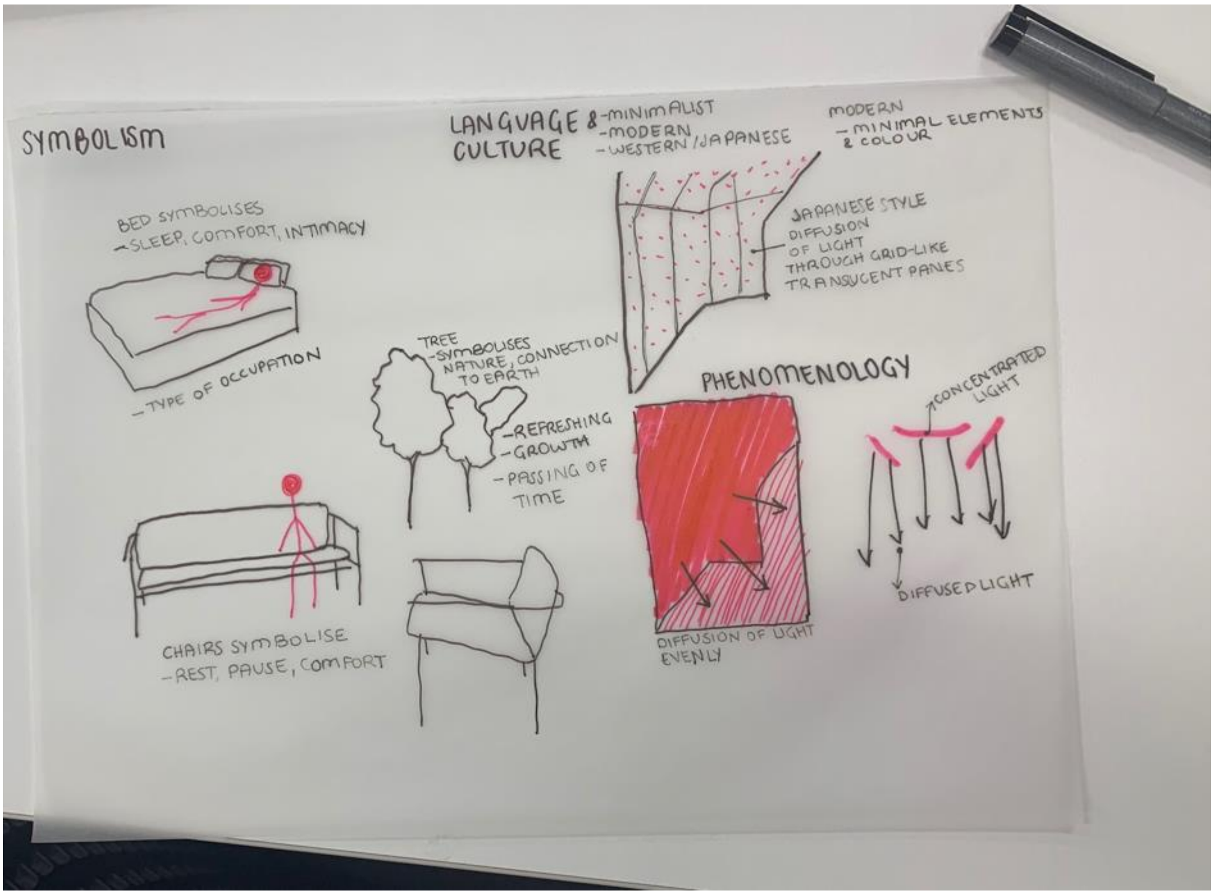
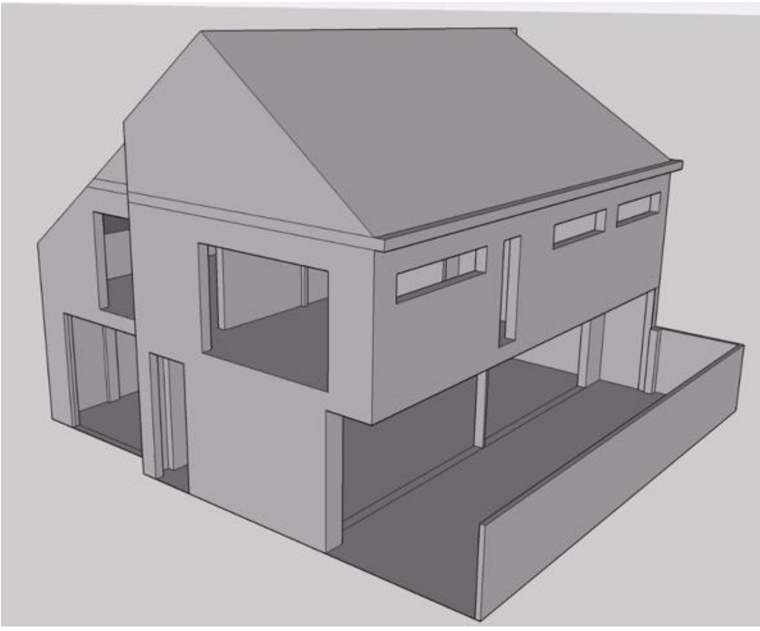
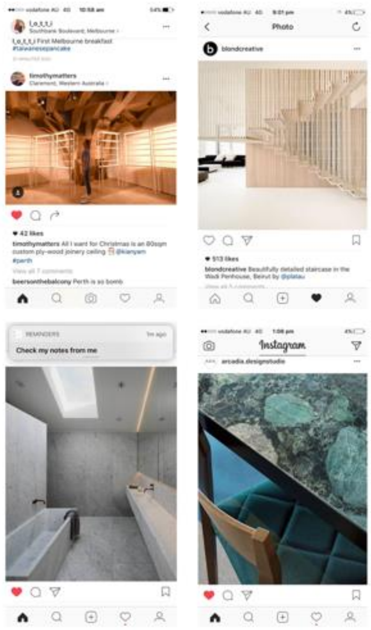


Figure 5: Photograph showing students in class experimenting with symbolic and phenomenological concepts as applied to an interior (Author's 2019).

It is this third month and third assignment where the social media comes into explicit focus. The students are provided with a private client who is building a 2-story house in Perth, Western Australia and has collected a large amount of inspo. A basic shell design of the house is provided (shown in Figure 6) that meets council regulation, energy, and other such requirements and students are tasked to redesign it using only inspo material and their aesthetic theoretical knowledge.

Students select an area of the house they wish to design and are given an inspo package (approximately 20 screenshots, examples of which are shown in Figure 6) the client has organized into a correlating folder. Some of these images are obscure, some provocative, and some of bathrooms that the client somehow wants their lounge room to look like. From this, the students conduct their theoretical analyses using all the theories provided (plus one they have sourced themselves) to tease out what experience they think the client wants — justifying through diagraming into the inspo, demonstrating how such things as repetitive line in the images provide a sense of direction, how gestalt's law of proximity might be identifiable in several images, and so on. They rationalize that such themes might produce such experiences as endlessness, warmth or tranquility.





Figures 6 (left) and 7 (right): Figure 6 showing the basic house 'shell' with which students are given as a base to design with. Figure 7 showing an example of the social media inspo given to students for analysis (Author's 2019).

Students are then tasked to forget the original inspo imagery and focus on the experiences they have concluded the client wants from their analyses and use the aesthetic theory as a tool to design a space as to elicit such experiences (relative to the context of the house/site project they have been given). I will outline through two student projects, how over three months the unit allowed students to amalgamate an aesthetic knowledge base with which they were able to engage in both the in-depth analysis and synthesis of design while using social media as a sole source of inspiration

USING SOCIAL MEDIA IN DESIGN DEVELOPMENT

In Amma Bunting's analysis of inspo (Figure 8) she identifies bold, moody, and sleek as the experiences the client wishes to elicit through the kitchen space. She rationalizes this through gestalt and formal aesthetics, identifying figure ground and hierarchy that is present through the mass and positioning of the kitchen islands — a common theme in her inspo material — which contributes to an overall sense of dominance and boldness.

Bunting also identifies the largely monochromatic color palette in the inspo which can be considered heavy, masculine and therefore moody and bold. She uses ritual theory and phenomenology to identify the sleekness featured in the inspo which shows kitchen appliances and amenities that would otherwise need to be obvious to facilitate the everyday rituals of food preparation, as being concealed and replaced with smooth textural surfaces.

Figure 8: A panel of student work presented for assignment 3, showing the student's analysis of the inspo material provided for the kitchen space (Amma Bunting 2019).

In order to promote this sense of bold, moody and sleekness Bunting describes her design through visuals (Figure 9) and text;
"A linear spatial configuration contributes to the kitchen's streamline and sleek appearance. While the kitchen itself uses long, linear forms and planes, I have repositioned it relative to adjacent spaces like the dining room and courtyard to discourage social interaction in these areas, so the kitchen and can be considered socio-fugal and therefore as creating a sense of moodiness.
The position and mass of the island counter which protrudes out in front of the main entrance to the kitchen, gives an immediate sense of figure ground and works to introduce a bold quality. This bold quality is also recognized in the homogenous mass of cabinetry which hides many of the traditional symbolic elements of the kitchen – by concealing oddly shaped appliances and other such items a modern sleekness is maintained. The push-to-open cabinets exemplify this sleekness beyond the visual and into the tactile.
The consistent use of a black color pallet symbolizes masculinity and therefore a sense of boldness, moodiness and sleekness. It is through the use of all of these aesthetic spatial concepts that the space has been designed to elicit a bold, moody and sleek experience for the client".[12]

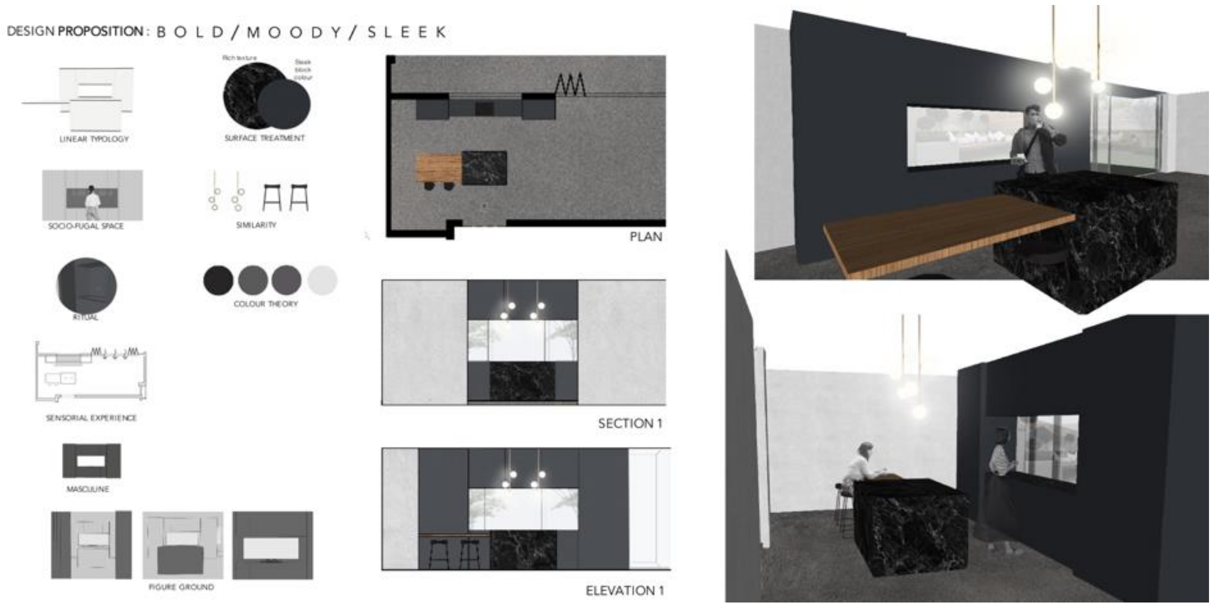


Figure 9: a panel of student work presented for assignment 3, showing the student's synthesis of design as informed by spatial theories and concepts generated from the design analysis (Amma Bunting 2019).

Camille Buononato's project demonstrates the transferability of the *Spatial Experience and Aesthetics* unit into other design disciplines as she analysis the exterior courtyard inspo and concludes the client wants it to elicit a crisp, sharp and endless experience (Figure 10).
In Camille's analysis she identifies that the inspo features a lot of line and repetition to create a sense of direction and typically this is done to draw the occupant's attention to an object. This is usually a tree or some other form of nature. She surmises that this natural symbolism combined with the formal aesthetics which frame it, provide a sense or order and therefore a sort of pointiness or sharpness.

She rationalizes the endless experience by identifying multiple images in the inspo that distort or play with Gestalt's principle of figure ground. For example, using permeable mesh structures to create a layering of floors and walls. This endless experience is also compounded by this type of permeability allowing air circulation to engage all senses beyond the visual.
She suggests the largely white color schemes, with tints and shades of brown and blue symbolizes the natural world and cleanliness adding to all three of her identified experiences, crisp, sharp and endlessness.

Figure 10: A panel of student work presented for assignment 3, showing the student’s analysis of the inspo material provided for the courtyard space (Camille Buononato 2019).

In order to promote this sense of crisp, sharp and endlessness Buononato describes her design through visuals (Figure 11) and text;
"The sharp experience is mainly created by using straight lines and geometric shapes. The repetition of these leads the eye toward the end of the pool to a phallic and masculine sculptural wall covered in mosaic tiles that mirror the pools endlessness.
Crispness is achieved through the use of a largely white color-scheme with complementary blue and brown hues in the mosaics and pool which symbolizes purity, cleanliness, and nature. Crispness is also felt by occupants who sit on or under the gabion patio who can look at the sky and be endlessly connected to their surrounding environment".[13]

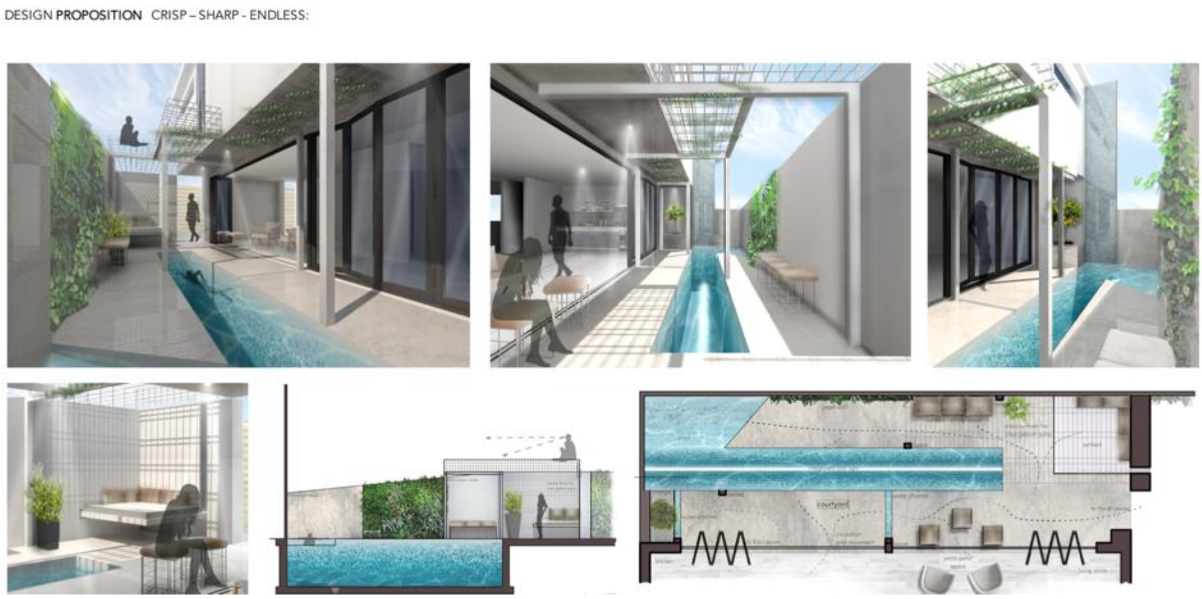


Figure 11: a panel of student work presented for assignment 3, showing the student's synthesis of design as informed by spatial theories and concepts generated from the design analysis (Camille Buononato 2019).

REFLECTION

Across a diversity of student projects there were significant correlations in what experiences were identified from the analyses of the inspo suggesting students were a) using a fairly standardized approach to the formal analysis as set-out by through the structure of the unit b) that students were genuinely identifying experiences that the client wanted in their home — pulling them out like themes in a visual narrative enquiry.
Generally, the solutions themselves are varied in terms of how they use theory to manifest the experiences and what they finally look like, albeit them the first iteration of many design cycles to come. This might support the argument that the unit is succeeding in its intention to move students beyond visual replication when using an abundance of social media inspo in their design processes. This is also something the students surveyed agreed with as 79% claimed that the unit had changed the way they would use social media in their design process in forthcoming design studios and their careers, with students noting they would be more critical, investigative and deconstruct and interrogate the inspo. 18% agreed the unit had changed how they would use social media in design somewhat with the majority of these claiming that they were already critical of using it as a source of inspiration.

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THE RISE AND THE SHORTAGE OF DANISH-TRAINED ARCHITECTS UNDER NEO-LIBERAL WELFARE STATE

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INTRODUCTION

It´s not rare to hear people educated in the discipline claiming that they are not architects for earning *money*: and this is exactly the point of departure. How architecture could be considered a profession if the architects are not considering themselves as professional figures? Architecture not to be considered a hobby[1], it has to be able to generate a turnover to sustain the lives of all the *professionals* involved in it, and it also needs a substantial amount of money to reify its outcomes. What contributes to so many disenchanted architects, might lay in the misleading use of terminology. The professional activity, the work, is akin referred to its outcomes, again the works, meaning the *œuvre*. While the use of the term *labor* and what differentiates it from the *work* is still an open discussion[2], Alberti already introduced what is at stake: *"in the reification of his work (…) the architect should be aware about the nature of the work is being hired for, which commitments he will take, which reputation he wants to have, how much labor he will sustain; which fame, which income, which gratitude and which glory he will get if he would eventually fulfil correctly the assignment"*[3]. While this opens to a shared condition of being an architect in a globalized economy, this article considers a peculiar national setting while researching on professionalism: the Danish Welfare State. In the discipline, this has not been a priority of scholars yet, whom instead have mainly framed a typological genealogy of the architectural *works* built along such political project (Lotz, Pagh, Braae, et al., 2017). On a European scale, instead, some scholars focused the role of architects in particular under the taking off of Welfare States (Avermaete, Heuvel, Swenarton, 2014) but still when considering Scandinavia, it is the Swedish case the most addressed one in regards to professionalism (Mattson, Wallenstein, 2010; Sigge, 2017). This paper is then occupying a niche, being part of a Ph.D. thesis that considers the Danish case, tracing the evolution of the contemporary modes of production under the Welfare State. I claim that, going beyond the Danish high reputation on professionalism, the neo-liberal shift has been detrimental for architecture. First the shiny Danish narrative is presented in a premise; second, I will introduce here few notions on a wider glossary on Danish neo-liberalism beneficial here to open a discussion in relation to practices and architectural education.

THE STEREOTYPE

Stereotype as a noun, meaning the "*set idea that people have about what someone or something is like*"[4], has widely been used with a negative denotation, and this, precisely, is what makes the use of such a term appropriate to establish this essay´s premise. However, etymologically[5] it derives from the recording and the perpetuation of an image without change; similarly, when talking about Danish professionalism, there has been an oversimplified image that arrived until today. This latter is not negative in its qualitative denotation, but it is so positive that risks to be deceptive. Such image, in fact, has guaranteed a high reputation to Denmark and it has regarded in particular the meeting of high standard for workers, and so this idea widely shared inside and outside the country that Denmark is *better than normal*. Scandinavia got to chronicles already in the 30s[6], however I argue that the recording of such a successful image, can be associated with the definition of its economic model given by the Danish sociologist Esping-Andersen[7]. Condensed in these five Welfare principles: first, its universal basis, so the entitlement to the benefits based on citizenship or contribution; second, a high level of de-commodification, and so a large independence from the market; third, a stratification, meaning a high focus on the individual as subject[8]; fourth, a strong equality between classes, characterized with a strong organizational integration; fifth, a prioritizing of full-employment[9]. The dissemination of his principles helped to shape the stereotype and high reputation of Denmark and Scandinavia all over the world, boosted by a popular "Scandinavian moment" that made a wide public aware of these *paradisiacal lands* just below the Arctic Circle. In regards to architecture professionalism, Denmark is depicted as a country in which gender equality is a reality and women often occupy high positions in architectural offices and each voice is given widely the same weight. Workers are mainly unionized and, in architecture, salaries are agreed upon by the representative bodies, based on seniority. Furthermore, this seniority is determined by graduation year, due to the wide understanding that the amount of time out of school is proportional to experience and capability. Higher education is tuition-free, and also covered by monthly stipends from the state, as long as some prerequisites mainly related to citizenship are fulfilled by applicants.[10] Therefore, when compared to a globalized architect´s condition, the Danish case has acquired a sort of "immunity" that has diminished any considerations on how the Welfare State overcame Danes at work.

GENERAL INTELLECT AND VIRTUOSIC LABOR: *HYGGE ARCHITECTURE*

Let´s start from here: there were two moments, in the recent history of Denmark, in which the government, in order to overcome international economic crisis, that had lowered internal consumption, invested substantial funds to strengthen export trade. Firstly, at the sunset of the Golden Years[11] when, what has been classified as one of the "Big Five" crises, hit Denmark.[12] Secondly, following the global subprime crisis of 2008, when in 2012 the Danish economy comes close to recession. Then, public investments to the sector were at a high level, seen in a historical context, and thanks to them the industry has witnessed the highest growth rates of the decade.[13] This flourishing moment has been baptized as the "new wave" (Weiss, Vindum, 2012) and labels as new Nordic has become the jargon to address architecture as a commodification toward export.[14] In fact, the inception of exporting as necessity for Danes[15], has gotten remarkably positive results, the building industry's export and turnover internationally increased to 54% (2014-15), when architecture firms almost tripled their turnover in foreign subsidiaries.[16] Since this is still the current agenda by development State agency,[17] what is at stake here is the relation language-capital. At large: what is this hygge-fever that using a precise lexicon has supported architecture to become a pillar of a florid export trade? This trend when referred to study on professionalism and political theory, could be referred to two notions: general intellect and virtuosic labor. According to Virno, the notion of general intellect *"manifests itself above all, as the communication, abstraction, self-reflection of living subjects (…) unfolding in communicative interaction, under the guise of epistemic paradigms, dialogical performances, linguistic games"*[18] *and* *it arrives from Marx as "the know-how on which social productivity relies on".* Virno, as also did Marazzi[19], refers to how specific linguistic performance are used to generate new forms of labor. He puts thought and knowledge in relation to political action (i.e. the promotion to the public), claiming the politicization of work *"when thought becomes the primary source of the production of wealth. (Then) it ceases to be an invisible activity and becomes something exterior, "public," as it breaks into the productive process"*[20]. Here Virno recalls also the Arendt´s position on the changed relationship between political action and labor[21], however Virno argued the opposite of her, saying that it is the labor (without distinguishing it from work, as she does) that acquired features of political action[22]. He said *"only when it (the activity of labor) has linguistic intellect as its barycenter, can absorb into itself many of the characteristics which had previously belonged to the sphere of political action."*[23] So, Virno claimed that it´s through the promotion to the public that labor is able to produce wealth and capital, becoming virtuosic labor. And this is particularly true in the architectural profession. Virno, refers to it as an activity that being without-an-end-product, in the understanding of Marx was a problematic case because not producing surplus[24], but now it´s the prototype of all wage labor.[25] Circling back, these are the theoretical basis to frame the hygge moment, where a specific use of the language by the architectural practices has boosted architecture as a commodification ready to be exported as an outcome of a cultural and political Danish specific economic system. Such argument here, is supported by a qualitative analysis[26] in which I observed a number of recurring phrasing deployed as Danish-jargon by firms in their self-promotional texts, that eventually, became a winning linguistic paradigm.

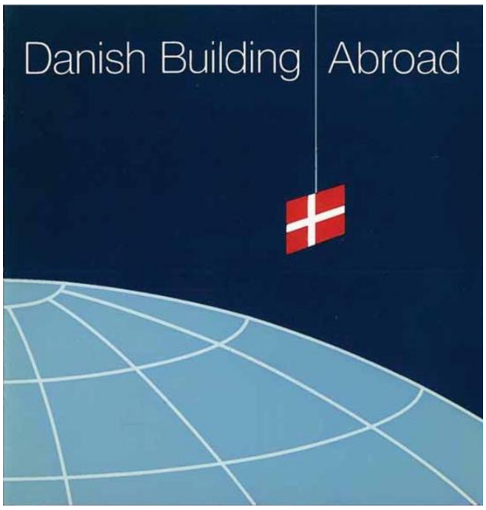

Figure 1. Cover, "Dänische Revue", a report in German of Danish architecture in the world. (Copenhagen: Ministry of Foreign Affairs, 1983)[27]
Figure 2. Cover, "Danish Building Abroad", a report in English of Danish architecture in the world. (Copenhagen: Danish Building Centre, Ministry of Housing and Building, International Relations Division, 1987)[28]

As mentioned above the Danish internationalization began in the late 80s (Figure 1,2) but it evolved from the promotion of *"works"* of architecture, intended as outcomes of few firms to the promotion of "words", by mean of persuasive texts. In fact, phrases as *"welfare architecture", "democratic space", "universalism", "humanistic architecture", "craftsmanship attitude",* and others are the refrain that accompanied Denmark beyond its borders. This shift, from *"works"* to *"words",* found once again a validation in my interviews, statements as *"before was the moment of architecture while now it´s the moment of architects"* have been very frequent. Here the architecture, meaning its built works, is downgraded in vantage of the architects, as thinkers. These latter, as Evans said, *"do not make buildings; they make drawings of buildings"*[29]. Therefore, they are in charge of their communication, through drawings or, if I may add, words. Following Virno, the workers, and in our case the architects, enter into production because they are "speaking-thinking". So, while Arendt, in her duality observed a downgrading of the reified "product" (i.e. the defeat of the homo faber, as she claimed it) in favor of the "process"[30]. Virno explicitly said *"this has nothing to do (...) with "professionality" or with the ancient concept of "skill" or "craftsmanship": to speak and to think are generic habits of the human animal, the opposite of any sort of specialization*."[31] So, it may sound as a bitter remark but continuing the quote above I might say that it´s no more the time of architecture and maybe not even that of architects, after all.

PROFESSIONALISM: THE SHORTAGE OF *HYGGE ARCHITECTS*

In regards to architectural profession in Denmark some peculiarity occur: first of all, it is not licensed. So, after graduation students automatically become architects. Those then, on a voluntary basis, can subscribe to the Danish Association of Architects to get the "Medlem af Akademisk Arkitektforening" (MAA) protected title, which is granted only if the applicant has graduated from one of the two Danish Schools of Architecture, or an equivalent school worldwide prior approval. Moreover, anyone is free to register a new business under the European Union architectural industry's code 71.11.00, so this means that those working within architecture may not officially be trained-architects. However, what is currently on the news[32] is a risk of shortage of Danish-trained architects, that in relation to the growth[33] of the field, it sounds like a paradox. The feared shortage is the result of a number of measures taken by the government since 2015, resulted in a risky gambling for architecture. The most recent is the *Opholdskrav*, the bill on residence requirements. Voted on December 20th 2018 with one only vote more in favor, it affects the international mobility of individuals. One must have stayed in EU/EEA for 7 out of the last 12 years in order to be entitled to Danish unemployment benefits. Doing that it prevents working abroad for individuals, weakening the personal welfare benefit of Danish residents, citizens and not. And, even worst, it does that on a retroactive basis and moreover on contributions that have been paid voluntarily by individuals. An almost evident clash: a fervent export trade policies outward, combined with a strict limitation in personal mobility, both inward and outward.[34] The second measure instead has been implemented since 2015, when the government decided to make some cuts to the Architecture Schools, both on economic resources and on enrollment allowance. As an answer to the unemployment of graduates, that under crisis was around 30% in the first year after graduation, the Schools have been requested to train fewer architects until 2023. This political decision was, immediately fervently debated and a number of intellectuals from the field published a press release, blaming directly the Education Minister, on how those cuts would have inevitably affected the flourishing of the sector on a long run.[35] However, the measure was not changed and now Denmark is facing a shortage of Danish-trained architects, caused also from the retirement of current architects who have not been replaced. By 2030[36] there will be not enough Danish-trained architects to cover all the demand. For the profession this echoes a defeat, and more a downgrading. The shortage in fact might have two effects: the practices hire more and more foreign-trained architects also for national assignments[37]; or they start using other professions (engineers and building constructors) even for architectural assignments. In both case the *hygge* feature, based on a know-how[38] inherited by one generations from another, is at risk since the representatives of such legacy[39] are fewer and fewer. Regarding the two above scenarios, the second one is definitely frightful because it goes back to the origin of professionalism and a hierarchy that architects established with neighboring professions, since the second half of the 18th century, with the foundation of the Royal Danish Academy of Fine Arts in Copenhagen (KADK). Since then, an intense dispute was fought, centered around whether architects should be educated as artists or, together with craftsmen, as technicians. Architects trained as artists would have been positioned as "mind" while the craftsmen would remain mere "hands," subjected to the architects´ will. The fight carried on until the beginning of the 20th century, when in 1911 a specific School of the Master Builder was established as a branch of the pre-existing Technical School, where craftsmen were educated in a variety of crafts without any training in building construction, separately from architects, beginning in the mid-19th century. As seen above, what today is at stake is the defense of the Danish-trained role as the bearers of a strong cultural craft tradition, neglecting the history of grievances that led them there. However, Danish architects cannot be named as craftsmen, since those architects fighting for education alongside craftsmen were isolated, and any technical knowledge was eliminated from architects training. The separation between technical and intellectual knowledge[40], sealed the birth of a new figure parallel to the architect: the building constructor. From the beginning, this figure was not meant to be independent from the academic architect but instead would respect the established hierarchy and carry out the production of the architect's design, using technical drawings. Instead today the same figure is one of those parallel educations feared to supply the shortage of Danish-trained architects. Is this a revenge, after one century of deskilling?

SKILLS: DO PRACTICES NEED WORKERS OR LABORERS?

I want to conclude from the notion of skill: *"You have talents, we give you skills"*[41] (Figure 3) claims one of the biggest Danish practice while recruiting interns. And, this is only one of the many job advertisements pinned on the Schools´ walls that wink to students, joking on the gap between how architecture is taught *versus* how it is practiced in profession. Moreover, the fact that practices are reclaiming their role in the skill-training, lays in favor of the government´s cuts. However, the blaming is mutual: the education institutions are criticized not to match the demands of practices in line with the government´ gospel for employability, in terms of both number and skills; while the Schools accused the others of not matching the specialization to which architects are trained, reclaiming a lack of skilled labor[42]. Thus the *lack of skilled labor* as mentioned above should be related to the practices´ *division of labor* and it sounds coherent to the above *speaking-thinking* workers needed by the *hygge architecture* production. Moreover, since such frictions between practices and education institution, are a globalized issue in architectural profession, to conclude I want to unfold the condition of "being an architect" that might beneficial to frame the glitches of today state of art.

Figure 3. Photo by Author. Recruitment Campaign by C.F. Møller (2019).[39]

In fact, such frictions could be framed using the distinction between *arbejdet* and *værket* (labor and work), forced by Arendt.[43] While, schools train students to *work*, meaning both conception and reification of architectural outcomes; they also shield aspirant-architects from the awareness of additional – *laboring* – activities. Especially, in a beaux-arts tradition as the Danish one, students would mainly develop their personal *talents*, learning the "culture of practice", unfortunately including also some stressful and painful activities (charrette, pin-up, critiques,…)[44]. However, any training on the ability of governing time and money in relation to projects is avoided, downgrading this as *labor* entitled to building constructor and eventually, a diversion from the artist-architects *work*. Moreover, the education is not leading the development of new modes of architectural production and not even matching the contemporary emerging ones (e.g. shared collaboration with other professionals; co-creation with citizens; guiding private and public developers; etc…), but it´s still anchored in the atelier master-based structure. Then, once the aspirant-architects enter in the Danish architectural practices, the hierarchy passed from being a pyramidal master-based structure to the promotion of an equal Welfare culture, largely implemented since a director and an intern could have the same say in the definition of a project. However, what is faced is that the proportion of *work* and *labor* of the architects varies in proportion to their conditions within the organigram, according to the time spent since recruited. The more recent is the employment of the architect, the longer time is deployed in the production of the *work*; while, the less recent is the employment, the longer time is deployed in *labor* activities to procure such works. This conclusion led: on one side, to my overall thesis argument that sees the architect´s position affected at all levels by a condition of bipolarity whereby exploitative labor is accepted for the sake of the reification of "work" as an earned reward, referring to this as the *laborification of work*[45]; while on the other, open to peculiar Danish asymmetry and paradox in which being an architect-employer versus an architect-employee make a difference, but this is something that deserve a longer discussion.

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[2] On the use of "labor" and "work" in architecture, see the introduction given by Pier Vittorio Aureli at the "Architecture and Labor: Space and the Production of Subjectivity" Symposium organized by the 'City/Architecture' PhD program at the Architectural Association – School of Architecture, on 13 November 2015 http://thecityasaproject.org/2017/11/architecture-and-labour-part-1/ (accessed 1 February 2019). In:
Pier Vittorio Aureli "Labor and Work in Architecture" in *Harvard Design Magazine* no. 46 (2019): 71–81

[3] Translated by the author, from the Leon Battista Alberti *"nel completamento della sua opera (...) dovrá riflettere sulla natura del lavoro che si assume, quale impegno si prende, quale reputazione vorrà avere, quanta mole di lavoro intraprenderà, quanta fama, guadagno, riconoscenza e gloria otterrà se avrà svolto in modo corretto il suo incarico"* . In: Valeria Giontella, ed., *L'arte del costruire*. (Torino: Bollati Boringhieri, 2010): 376

[4] in: Cambridge dictionary (Cambridge University Press, 2019)

[5] From Greek *stereos* "solid" and French *type* "type". In French *stéréotype* (adj.) "printed by means of a solid plate of type". Recorded meanings in 1798: "method of printing from a plate"; 1817: "a stereotype plate"; 1850: "image perpetuated without change"; 1922: "preconceived and oversimplified notion of characteristics typical of a person or group". In: Ernest Weekley, *An Etymological Dictionary of Modern English*. (Dover, DE: Dover Publications, 1967)

[6] See: Marquis Childs, *Sweden: the Middle Way* by (New Heaven: Yale University Press, 1936). During a press conference in 1936, Roosevelt said *"I became a good deal interested in the cooperative development in countries abroad, especially Sweden. I was tremendously interested in what they had done in Scandinavia along those lines*". In: C. Vann Woodward, ed. *The Comparative Approach to American History*. (New York: Oxford University Press, 1997): 302

[7] As he named it, the "Social-Democratic Welfare-State" as one of the three regimes of welfare Capitalism. In: Gøsta Esping-Andersen. *The Three Worlds of Welfare Capitalism*. (Princeton, NJ: Princeton University Press, 1990): 27-29

[8] This could be translated in numbers considering the high rate of feminist emancipation (in the 80s the 75% of the women was active at work) based on the principle that 'more workers' means more 'tax payers".

[9] The Danish welfare is financed by contributions, on a flat-rate benefit principle, and this condition creates a strong regulation of the labor policies and employment regulations

[10] I have developed more this in my contribution to ED: Normal, Paul Petrunia, Summer 2019

[11] Eric Hobsbawm, The Age of Extremes*: 1914-1991*. (London: Abacus, 1991): p.258

[12] Jørgen Goul Andersen, "The Scandinavian Welfare Model in Crisis? Achievements and Problems of the Danish Welfare State in an Age of Unemployment and Low Growth." in *Scandinavian Political Studies* 20, no. 1 (1997): 1–31, https://doi.org/10.1111/j.1467-9477.1997.tb00182.x
Eric S. Einhorn, and John Logue. "Can Welfare States Be Sustained in a Global Economy? Lessons from Scandinavia." *Political Science Quarterly* 125 (1) (2010): 1–29, https://doi.org/10.1002/j.1538-165X.2010.tb00666.x.
Per Kongshøj Madsen, "How Can It Possibly Fly?: The Paradox of a Dynamic Labour Market in a Scandinavian Welfare State." In Center for Arbejdsmarkedsforskning, Carma, Aalborg Universitet (2005)

[13] Swedish Federation of Consulting Engineers and Architects, "Sector Review: 'The Consulting Engineering and Architectural Groups. A Swedish and International Survey." (Stockholm: 2008-16)

[14] Jesper Pagh, "*Dansk Arkitektur Import-Eksport A/S*." *Arkitekten* (2010)
Katrine Lotz, "Dansk Arkitektur Som Velfærdseksport." in *Arkitekten* (2010)

[15] In Fall 2017 the author made a number of interviews to representatives from Danish architectural practices. (See note 27) Many of them referred on "internationalization" as a needed activity for procurement. Among the other, Mads Bay Møller (KRADS, Founder) quoting an anonymous colleague: *"being the size of the practice that we want to be, why don't we do the kind of projects that we want to do? Denmark it's not enough (…) so we have to go international; it's a too small country"*. (Interview by the author, December 2017)

[16] See note 14

[17] Torben Nielsen (Dean, Arkitektskolen Aarhus) said *"Government's initiatives, I think it comes much across the whole idea that we need to export even more: the agency just made some recommendations since they believe that we will increase our exports of the creative industries quite dramatically"* (Translated by author) in:
Bo Billeskov Grünberger, "Mangel på arkitekter vækker bekymring", 5 December 2018, https://www.faod.dk/mangel-paa-arkitekter/. (accessed 30 January 2019)

[18] Paolo Virno, *A Grammar of the Multitude: For an Analysis of Contemporary Forms of Life*. (London: Semiotext(e), 2004): 65

[19] Christian Marazzi, *Capital and Language*. (Cambridge, MA: MIT Press, 2008) :6

[20] See note 18: 64

[21] See note 2: 304

[22] Virno framed post-fordism and contemporary labor, things that Arendt cannot face in 1958.

[23] See note 18: 56-68

[24] See note 18: 106

[25] See note 23

[26] This method was deployed by the author during the PhD. In order to recruit respondents to conduct a series of semi-structured interviews part of a grounded theory method finalized to understand contemporary labor. The author analyzed more than 200 self-statements of existing Danish architectural practices, grouping them under 10 shapes that share common features in terms of mode of productions, from these 11 representatives were interviewed for data collection purpose.

[27] Preben Hansen, ed. "Dänische Revue." (Copenhagen: Ministry of Foreign Affairs, 1983).

[28] Danish Building Centre, ed. *"Danish Building Abroad."* (Copenhagen: Ministry of Housing and Building, International Relations Division, 1987)

[29] Robin Evans, *Architecture and Its Image: Four Centuries of Architectural Representation- Works From the Collection of the Canadian Centre for Architecture*. (Cambridge, MA: MIT Press, 1989): 369

[30] See note 1: 304

[31] See note 18: 41

[32] Knud Teddy Rasmussen, "Verden er vendt på hovedet – arkitektmangel truer vækst." in *Børsen*, 27 November 2018

[33] A recent tweet by Tina Saaby, the Copenhagen city architect, blaming the government for the shortage of Danish-trained architects mentioned *"architecture is an export product for Denmark and a brand that puts Denmark on the world map"*, 29 November 2018

[34] On this Flatau (insurance manager at Akademikernes A-kasse, the architectural insurance) said: "*it´s unfair and unthinkable and in future, one will consider carefully whether one will take on a job outside the EU, and that will put a damper on the recruitment of highly qualified foreign labor to Denmark."* (Translated by author) In:
Jes Flatau, "Lovforslag Om Opholdskrav Vedtaget." 21 December 2018, https://aka.dk/nyheder/2018/lovforslag-om-opholdskrav-vedtaget/. (accessed 30 January 2019)

[35] *"Therefore, we encourage to strengthen the best and most ambitious architectural and design education programs in order to maintain our global top position. The government gambles if it both implements general savings and targeted crops. (…) We ask for the courage to prioritize and to invest in Denmark as a leading design and architecture nation. Otherwise, the branch, growth, exports and prosperity can sit, break in the middle over"* (Translated by author)
In:AAVV, "Du gør skade, Esben Lunde Larsen." *Børsen*, (September 2015): 4.

[36] Source: Damvad Analytics (2015)

[37] Hansen (3XN, CEO) mentioned that her practice has about 70% of turnover abroad and currently employed one third of the company (approx. 120 people) who are not Danish citizens. See note 34

[38] *"it is necessary that there are enough Danish architects who can put a clear Danish impression - We need Danish educated architects to work on our Danish projects, but the same also applies to our foreign projects, as the Danish educated architects bring the Scandinavian tradition both in terms of architecture but also in relation to collaboration and working method. When we work abroad, it is a great part of our brand to be a Scandinavian design studio"* (Translated by author) See note 32

[39] Torben Nielsen (Dean, Arkitektskolen Aarhus) *"the problem is that the culture-rooted architecture (den kulturbårne arkitektur), which Danish architecture is an expression of, begins to crumble and mean less and less.*

And that is what we are exporting and selling, and that is what is recognized throughout the world and it is based on our two architectural schools" (Translated by author) See note 17

[40] Such separation dear to L.B. Alberti in De Re Ædificatoria (approx. 1450), happened more than 400 years later in Denmark (around the 1850s).

[41] This is the title of an "internship recruitment campaign by C.F.Møller. The founder of this practice, the architect C.F. Møller, whose name and legacy are still fundamental in today´s practice, was also the first rector of the Aarhus School of Architecture, when it opens in 1965. https://www.cfmoller.com/j/-da/bALL-bTalented-interns-wanted-i16703.html (accessed 1 February 2019)

[42] Uffe Hundrup (Responsible for quality and analysis, KADK) *"There is not only a shortage of labor, but a lack of skilled labor"* (Translated by author) See note 32

[43] *"the distinction between labour and work (…) is unusual"* See note 1: 79

[44] See Dana Cuff, Architecture: The Story of Practice. (Cambridge, MA: The MIT Press, 1992):118-129

[45] I want to acknowledge here the time spent at the Architectural Association – School of Architecture, London UK as Visiting PhD Candidate under the tutelage of Pier Vittorio Aureli and Maria Shéhérazade Giudici, and the fruitful conversations I had with them in regard to this.

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LEARNING ARCHITECTURE: A COGNITIVE APPROACH

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INTRODUCTION

“This will kill that.” is a line of Frollo in Hugo’s Notre Dame de Paris[1], historically associated with the fear of the new via a metaphor over modern printing press and traditional edifice. Through this metaphor, it is seen that architecture was comprehended as a communication tool, a language, even before its professionalization[2]. The printing press was the new form of spreading the word, and therefore, a threat to the function of the edifice as the medium of formed architectural sentences. Yet, the book did not kill the cathedral. The two, and many of them, remained as the products of languages. While an obligation of choice is valid in a pre-modern consideration, now it is clear that dichotomies exist together, and enable each other, by modernity[3].

Treating as a language widens the perspective to analyze the inner mechanics of architecture. Similar to architecture, natural languages are one of the most primitive masteries of human history evolving through ages. Philosophers have been primarily interested in the characteristics of natural languages to understand how human beings relate to the outer world. However, mostly by the Chomskian revolution, the underlying structure of natural languages are deeply examined to put forward a transparent mechanism that connects surface-form and semantics. Through this survey, learning mechanisms of the brain, language learning, and interfaces of such mechanisms are closely investigated. Such studies are beneficial to understand learning to combine, creating meaningful structures, namely, those architectural sentences mentioned above.

Linguistics in theory

To scientify modern linguistics as a discipline, Saussure describes language as a system of *signs* whose natures are “arbitrary”. This arbitrariness is also seen in the relations between the concepts to be signified and the linguistic expressions signifying them.[4] The denial of any intrinsic relationship between the signified and the signifier historically enables Derrida to process that “there is no outside-text”.[5] The text, through reading it, does not refer to any outside reality because no signifier is insignified. Coevally, Sini evaluates sign, speech and writing as objects of the practice of logical mind, reversibly.[6] This reversibility is originated in the language’s being a system of differences between the signs which are operating that system, acquiring meaning through these differences. Looking from the outside of the mind, according to Foucault, it is structured through the “intermediary space” of speaking and thinking,[7] which are accumulated by either the philosophy of language or that of mind. However, Chomsky looks from the inside of the mind and insists on an innate knowledge of grammar that is a simple mechanism creating complex products[8], which are languages/architectures. Chomsky proposed the Universal Grammar Theory of humans learning to combine correct categories of words (the atomic meaningful structures) using a dedicated language-learning device in mind. This innatist approach is followed by a cognitive approach arguing that the innate structure in mind is more a general processor rather than a language-specific device. This view enables us to consider learning from a more general perspective, evaluate our skills in language, and project it to a similar human skill, n, architecture.

Architecture as a language

To profess that architecture is a language, and therefore, may be learned as a language, the parallelism between these two in/disciplines should be clarified. One of the most noticeable approaches to grasp the meaning of architecture is through the narrative it tells.[9] This cultural approach towards architecture, spatial cognition and meaning ease to state that the concept of the architectural product is neither merely physical nor cultural, like body and mind. A form is an expression at the same time.[10] However, we should first learn a language to grasp a cultural meaning out of a text written in that language. In that case, it is needed to ask how the language of architecture is being learned.

Fischer proposes to understand one communication system upon another one by defining architecture as a system of language. This system includes products of different types, orders, junction and disjunctions, elements (words/forms) and binding rules (grammar/space and construction), typologies, and social dialects.[11] This definition is in a strong relationship with that of Norberg-Schulz, professing that architecture is a system of signs which qualitatively leaps from Gestalt units to meaningful structures.[12] Sedlmayr, on the other hand, considers architectural design as the syntax of the (architectural) elements and their relations.[13]

In architecture, as in the phenomena of language, limitless expressions are coming from limited elements and rules, and semantic leaps. In terms of meaning, context and content should not be reduced into the syntactic structure of sentence trees. Paradigmatic relations with the existence of background knowledge and syntagmatic relations are also seen. Like language, out-of-order articulations do not have a meaning or cause a semantic shift. The semantics of an architectural space does not come into existence in the system, but in the mind of an architect through her personal, individual, and creative act, offering an architectural solution as a decision. In this manner, students do not learn *the* language; they learn multiple architectural orders to understand architectural *languages*.

Referencing to Saussure's two types of time relations for language as diachronic and synchronic,[14] a system section may represent a holistic logic for a building. When a section is taken through the architectural presence at the end of the 20th century, there are architectural practice, theory, and language for sure. However, post-modern historical influences result in the product of architectural education. Students have learned the words and grammar through the architectural syntax[15] of four dimensions such as space, form, structure, and function, but they were isolated from the context and relationships between each other. Here, Jencks, mentioning the crisis in architecture, introduces architectural parts as "words" and architectural systems as "syntax" with attention to the historical patterns in architectural history.[16] With these analogies, an analytical framework is proposed metaphorically to discuss the communication between the architectural product and its users. In this sense, the claim of the *plurality of styles* are still seen under the rules of mechanics, as their syntax, and generated with available materials, as their lexicon.

ARCHITECTURAL EDUCATION TOWARDS A SHIFT

Being served as one of the oldest professions in the world, architecture as we know it is not detached from its contextual definition. While the architectural history studies the products, beginning with the ancient ruins and the archeological inferences, the producers of these products were not professing themselves as architects. The profession, like the other modern professions, is defined and redefined through the last centuries[17].

A challenge of learning, before the early institutionalization in Renaissance Italy to the accelerating decentralization currently worldwide, had been a claim of the profession. By the mid-17th century, the need to train the modern professionals gave birth as a French institution: Académie Royale d'Architecture. The working principles of this institution and its Beaux-Arts successors determined those of architects in a wide geography from the UK to the USA. The advent of the German Bauhaus in the 20th century changed this situation, concerning the rising discourse on self-education. After Bauhaus, architects are expected to play an industrial role in coordinating the *architectonics*, that is, all the basic components in the totality of the production process.

Under the thumb of the age of institutionalism, the 19th century brought a necessity of educational enrollment for a professional license to perform the discipline. It is a fact that the two world wars and the modern *starchitects* changed the atmosphere during the 20th century. Besides, it is not surprising to detect new searches for a multiplicity of architectural educations and performances in the webs of decentralization in the 21st century. This shift from the educational institutions to learning practices should not be limited within the scope of the profession. However, its dimensions may provide a wider understanding of the language of architecture: how it works, and how it goes into the cognitive processes.[18]

Previous Critics

The pre-modern understanding is criticized for serving things as they are because they *meant to be*. Their being in a way means that they always were and always will, even, they should. This total acceptance gives no opportunity to understand the language of architecture, it is more like the very early steps of learning a language, such as memorizing the phrasal verbs.

Modernism, on the other hand, is mostly criticized for its eliminative approach towards the rich wording possibilities that the language of architecture offers. It may be beneficial to understand the working principles of mind as a method to find the principles since the cognitive approach also develops simple structures to understand complex behavior. However, it is dangerous to make this sterilization a new way *to form*. In this situation, there is the risk of creating a language like Esperanto, produced inorganically. Mechanics may help to understand the organic structures of languages, but do not develop living languages.[19] Mechanic architecture is possible as seen in Le Corbusier's five principles, but is not a language reproducing itself in the being.

Postmodernism, however, is criticized on arbitrariness while problematizing this so-called "lost" language with its tradition, despite the valuable intent. It needs to be realized that the denial of history does not put the denial itself outside of history. Postmodernism cannot be read unrelated to the rising notion of the superficiality of its time.[20] Despite this manner, the learned simple mechanism of architectural language is tried to be interrelated as a return to the complexity.

Today it is accepted that architecture *is* a practice, but not *just* a practice. It has its context, relations, and meaning outside of itself, referencing to other parts in the text of architecture. The attempt is, without denying the multiplicity of architecture, to understand the common mechanism of the language.

Research

Considering the history of professional education, learning is not accepted only as realized in the educational institutions, or only by the institutional methods. There is a rising tendency towards

individual cognitive learning in higher education in many fields.[21] Architecture, specifically, gains an even more multi-disciplinary approach with higher levels of technology use[22] to fulfill the market demand. While cognitive science is being a vital research area of the 21st century[23], studies on architectural education are also beginning to shift towards the cognition of architecture students.[24]
The reason to study architecture as a language lie behind the structure of the language itself. Being exposed to architectural sentences/spaces[25], producing them socially[26], and analyzing them syntonically, students make sense of structures and their parts. As learning of a language, architectural education is the mastery of a profession that a human is already capable of: mastering on the instruments and knowing how to use them. To discuss learning, it is needed to focus on to the parallelism and connection at low-level mechanisms. A combinatory meta-grammar with powerful syntax enables emergent behaviors in planning, language, and architecture to create complex action sequences, complex sentences, and complex structures.

COGNITIVE LEARNING

"We are our memories."[27]

Learning may be briefly defined as encoding the representations in an integrated manner to memory. In this sense, the memory system has a crucial role that enables human beings to store and use these representations through a lifetime. Humans are exposed to various kinds of data through their cognitive sensors. They process them in a way with limited resources, dump most of the raw data for efficient operation, and reconstruct representations like a summary (gist). To enhance learning at the metacognition level, it is required to use the *tricks* of the system for effective learning. Extensive research is made on learning, human memory, and mechanisms of these systems. In-depth processing is one of the key concepts, highly correlated with semantic connectivity of the *learned* with *self* via the vividness of the available memories.
The working-memory concept proposed by Baddeley, in relation, is composed of the episodic buffer, visuospatial sketchpad, phonological loop, and the central executive mechanism where all are connected to be coordinated.[28] Sensor data are processed in this system in real-time, where episodic buffer acts as short-term memory and encodes the viable information to long-term memory. This *viability* decision is not made by intention in the meta-comprehension level; therefore, cannot be selected consciously whether the information is viable or not. Visuospatial sketchpad allows humans to resolve complex scenes, identify objects and positions in the scene, create a cognitive map, and resolve the discourse. Depending on the vividness of the experience, human creates a richer, comprehensive and solid representation in the long-term memory (Figure 1).

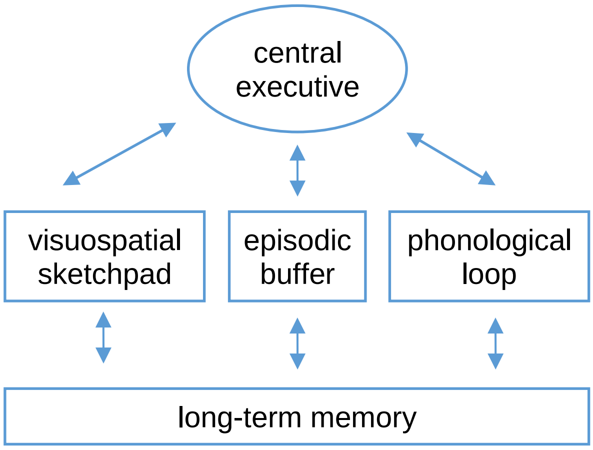

Figure 1. Diagram for the working-memory

There are different learning types mentioned in the recent literature on cognitive science.[29] In this study, language acquisition is taken as the infants being exposed to adult sentences in stories since their birth, as metacognitive learning. Infants have a highly active perception system for such data exposure, especially when interactive. They first learn nouns, then verbs (vocabulary), and then combining them (syntax) at the age of 18-24 months. Such interactive experience enables human beings to resolve a highly complex structure as the language. In this sense, successful comprehension of exposure to whole surface form in a partitioned sense is a series of deconstruction and reconstruction processes in mind to generate *meaning*. Moreover, production is also a series of processes to generate forms by using sub-forms, integrating the meanings at the surface level, a.k.a. *construction*.

The key concept in both comprehension and production mechanisms is the combination, building connection both in surface form and meaning. The visual system of humans has innate feature detectors since its birth[30] that allows the infant to discriminate specific objects. Until some level of cognitive development,[31] infants tend to see complex structures as complete objects. At further stages of development, complex objects can be parsed. Therefore, the components of objects are identified.

2-year old infant can memorize 2 consecutive numbers, whereas it increases to 6 (the adult level) at the age of 6.[32] The growing capacity of working memory allows humans to combine, where at 18-24 month age, infants can generate simple sentences with the power of syntax. The development of this skill is significantly affected by Child-Directed Speech as well as environmental adult speech exposition. Child-Directed Speech has a simple syntax, basic sentence structure, and basic vocabulary provided by a close circle of characters around the child. In this sense, interaction and exposition are key priorities. In this way, infants create a correspondence between semantic concepts and sounds, and visually expressed gestures. In this sense, the correspondence language is mainly learned, created and understood not individually, but under an interactional environment, namely, a discourse.

To understand *discourse*, humans use scripts and schemas, which are sort of patterned structures for discourse resolution both visually and linguistically. Background knowledge allows us to make top-down processing, where physical stimuli are processed with a bottom-up approach. These simultaneous processes enable us to resolve discourse smoothly and make humans *learn*. Moreover, this mechanism makes them competent in the context. Thereby they create mental models and cognitive maps, re-construct the information gathered, update previous knowledge, and integrate the information. In this way, humans make inferences while vocabulary development is a lifelong process in language with no hard limit.

Linguistic mechanism

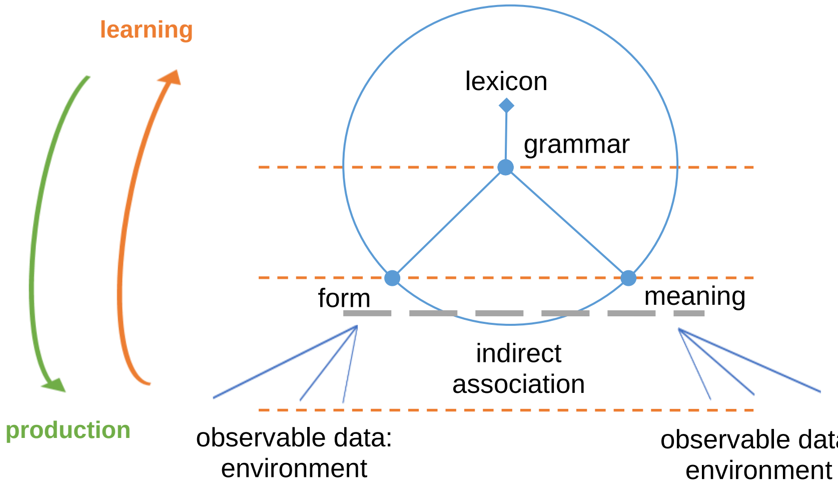

Figure 2. Learning and Production mechanism of language

A high-level mechanism of language learning and production can be summarized as depicted in Figure 2. The mind interprets/reproduces form and semantics of words as structured observable data within the power of syntax fed with a word lexicon. In a linguistic sense, observable data are utterances of words that are laid out in the discourse. The surface form and meaning is not directly linked themselves, but associated throughout the interpretation and production processes. One crucial component of this mechanism is the input, the source. Input of the learning process is *being exposed to* the meaningful data environment.[33]

Common mechanism

Materials, the component *arches*, are the lexicon. Structures, the buildings corresponding to the observables, are the surface forms accessible by our cognitive skills. We are looking for a common mechanism to understand the hundreds of natural languages around the world, how they are produced, or how the mind works with them. The essence of the mechanism is its regenerative capacity; we can generate infinitely many different meaningful sentences with the power of syntax. Syntax is being able to combine in a structured sense, within the rules of it. The same low-level mechanism may well apply to architecture: The mastery of the human mind is *to combine*.
A two-year-old infant can memorize two numbers and build simple sentences. A two-year-old infant can also construct building block pieces together. Our memory and learning skills that enable natural language skills, possibly also enables our architectural skills. A newborn child with only reflexes and instincts gains "existential foothold" via the social aids and personal action.[34] This foothold covers all communicators to be used such as bodily, speaking, written, or architectural languages.
The 21st-century computer-aided design systems need and ease the cognitive studies on architectural languages[35] due to the tools to understand and to create architecture are similar. This rise can also be seen in the studies on the Darwinian approach to the relationship with nature[36] as a "new foundation" for architecture's parallelisms with other mechanisms that humans developed. On the other hand, books on how to read the architectural products[37] are still popular among the students. Courses of Building Science to *teach* students how to design user-friendly buildings still has a place even in the Bologna

Process of standardization[38]. Therefore, it is not revolutionary to state that, whether classical[39] or modern[40], we need to learn languages to speak, read, and write architecture.
Searches for the future of the profession show the vital significance of developing strong bonds with the related fields.[41] Cognitive science is one of the most interrelated disciplines among them, considering the learning processes. A shift to the experience, relations, networks and, at the same time, individual cognitive skills, is happening in a wide range of disciplines. The professionals of architecture cannot be educated ignoring this shift. We are all amateur architects as humans. When *trained* well, we can mastery it: we can generate infinitely many unique structures.

CONCLUSION

In this study, architecture is professed as a language, and the architectural-linguistic processes are briefly examined from a cognitive perspective. To support, language itself is placed in linguistic theory to see the possible parallelisms. Then, learning and generating/creating mechanisms of these phenomena are discussed. Clarifying, the history of architectural discipline and education is covered with previous critics and following research question whether architectural educations can have a cognitive-linguistic approach. For this, linguistic mechanics are briefly introduced per recent schools of cognitive sciences. Learning mechanics of the human mind are also reviewed where particular examples will be provided regarding natural language acquisition and production. Therefore, learning in cognitive science is studied through linguistic and common mechanisms.
There are possible critics which could not be covered in the scope of this study. One of them may be a question on architectural literacy. While every child learns their mother language but not every child becomes a writer, reading architecture is not exactly speaking or writing it. However, this is the problem of learning in the 21st century with further studies on "learning by doing",[42] and similar structures can still be studied in similar scientific methods. Furthermore, architecture is not merely a documentation of the architect's architectural knowledge. The multiplicity of relations, buildings, and dialects are not ignored by synthesizing the grammar principles used in every one of the words.

Learning architecture as a language – a propose?

Studying architecture as a language widens the approaches that institutions develop. In the 21st century discourses on the crisis of politics, of architecture, or of education, such a perspective may lead to enhance the effectivity of architectural education practices. For an experimental shift in architectural learning, a strong need for a cognitive approach towards experience and exposure is seen. Ultimately, to form new sentences, new sentences need to be heard.

Figure 3. Logos of TAA and ATS [43]

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EXPERIMENTAL LEARNING IN ARCHITECTURAL TRAINING – EXEMPLIFIED IN BUILING ON A SCALE OF 1:1 AT THE UNIVERSITY OF LIECHTENSTEIN

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INTRODUCTION

The architectural design and realisation process is long and complex. Many individual parts must be taken into account in this constructional interplay before a new whole can arise. Materials act like small cogs in a large machine. They must meet the technical, physical and aesthetic factors of the newly built architecture.

Construction on a scale of 1:1 is the ideal solution for familiarising architectural students with this complex design process and for preparing them for their future professional lives as architects. Hands-on building offers many opportunities for students to learn design, aspects related to construction, and teamwork. Furthermore, construction on a 1:1 scale combines aspects of manual skills in a very simple way. This is a crucial and important factor for learning construction in an academic context.

Construction in an academic context is not new. Three aspects have been characteristic of every hands-on project realised at the Institute of Architecture and Planning at the University of Liechtenstein in the last twelve years. The first characteristic is that the process of designing and implementing material awareness is based on the constructive and design logic of the material used. The second characteristic is that the materials used to this end are added to a new tectonic whole. The third characteristic is the manual skills aspect in cooperation with regional workshops.

Material awareness

The whole endeavour of an architect to provide high-quality and sustainable architecture ultimately depends on curiosity about the material. It is important to inspire joy in the interplay of form and construction. This interplay must be understood as a symbiosis of art and technology. In other words, the material is to be seen as a driving force, as the architectural origin of form and construction. This enhances awareness of materials and knowledge of the properties and potential applications of materials. We reach this necessary material awareness by sensitising students to it already during their architectural education. In addition to possessing theoretical knowledge, students must also be able to work with the material and design with it.

In his book *Handwerk*, Richard Sennett breaks down material awareness into three phases. The first phase he calls metamorphosis – the transformation of the material. For him, this metamorphosis is the further development of the material into a type form, reaching a judgement about its mixture in a combination of forms, and thinking about its area of application.[1]

He calls the second phase of material awareness “presence”. For Sennett, presence arises while working on the material by leaving a manufacturing mark, or by marking the material, or by virtue of the fact that manufacturing processes are visible. In other words, presence arises on account of the particular way the material is worked and how we combine different materials.[2]
Anthropomorphosis, the third area of material awareness, is what Sennet calls the attribution of human qualities to raw materials. When one speaks of material being “real” or “beautiful”, that is, when human traits and characteristics are assigned to constructed forms. [3]
According to Sennett, in order to achieve material awareness, students must become familiar with various materials and their different states of aggregation during their architectural education. Students must know both theoretically and practically how the respective materials behave in a raw state and how they can be processed. The Institute of Architecture and Planning at the University of Liechtenstein cultivates students’ material awareness at annual workshops. In these workshops, students explore the properties of different materials such as brick, concrete and wood and test them on a scale of 1:1. In addition, students learn how the respective materials can be processed. What traces manual work leaves behind depends on the tools used. These traces play an important role in these workshops, which are carried out in cooperation with a number of different European partner universities. The traces not only include the marks of the tools themselves but also traces of structural manufacturing. These arise during processing and also during the joining together of different materials in order to meet the various, interrelated requirements of the building process. The traces have, so to speak, a ripple effect from small to large. They thereby characterise the appearance of the constructed object. This process occurs for every kind of material. Sennett conceptualises awareness of materials as emerging in three stages.

Figure 1. Brick Workshop, Azewijn NL 2008

Figure 2. Concrete Workshop, Bornholm DK 2010

Tectonics

Our built architecture consists of many different layered materials that are combined together in complex ways in order meet today’s technical and structural requirements. These requirements result in a cramped architectural scene with many different actors and experts. As a result of this development, individuals' understanding of material and thus of material-specific joining have been lost, a fact that is visible in the often questionable use of materials in contemporary buildings. Here building materials are no longer selected based on their properties but rather primarily based on their appearance. Over time, starting with industrialisation and continuing in the era of computerisation, the art of joining materials in a sensible fashion from individual parts to create a new whole has been lost. And we continue to feel its absence today. On account of this loss, the interplay of shape and construction is often no longer fulfilled according to the properties of the materials. For this reason, in addition to material awareness, it is also important to bring back into focus the joining of materials in architectural education, to revitalise it, to concentrate on the interaction of materials with one another and to sensitize students to this subject.

Tectonics, with its implicit hierarchy in construction, the joining of coarse to fine, offers itself as a means to achieve this. Currently, tectonics is a widely discussed field in architecture. At the University of Liechtenstein, the term tectonics is understood and realised according to the theories of Gottfried Semper. For Semper, the joining of rigid, rod-shaped parts to an intrinsically immovable system is undoubtedly the most important and at the same time most difficult aspect of tectonics, as he explains in "Style in the Technical and Tectonic Arts".[4] He divides the basic purposes of tectonics into four areas: a *framework* with an appropriate filling; the *lattice*, a complicated framework that arises from the joining of rod-shaped structural parts to a surface-forming system; the *support*; and the *stand*, which is formed by the interaction of the supporting structure with the framework.[5]

According to Gottfried Semper's conception of tectonics, which is expounded upon in the following, construction is intrinsically multi-layered. Semper argues that, in the practice of tectonic joining, architecture always consists of both structure and cladding. The use of the materials is constructive and thus design and construction are brought together in unity. Appearance therefore equates to both construction and technology. Adolf Loos writes: "The principle of clothing, which was first articulated by Semper, extends to nature. Man is clothed with a skin, the tree with a bark"[6] This analogy of tectonics to human anatomy reveals that skin as a garment is always constructively connected to the inner of the human; it is part of the human body. Significant for Loos is therefore that clothing not be confused with clothing materials.

Semper's definition of tectonics and Loos' analogy to the human body demonstrate the interplay between constructive availability and visual appearance, or in other words, the relationship between the constructed and our perception. These tectonic and material-specific aspects are important components in the design and construction process and are the focus of hands-on projects at the University of Liechtenstein. Cultivation and integration of tectonics into the creative design and design process are key parts of the new model workshop for architectural students at the Institute of Architecture and Planning at the University of Liechtenstein.

The launching point of this design process was a five-day workshop under the Erasmus+ strategic partnership program, in which students at three universities developed wood support structures with rapid material experiments, built and erected them on a scale of 1:1. The only parameters given to the students were for the tunnel-shaped outer shape, as this fulfilled the building regulations in the provided space. Eight supporting structures were built. These formed starting points for the further development and construction process, which was continued by two design studios within the framework of architectural theory over a period of 15 weeks.

Figure 3. Construction process of the model workshop, Vaduz LI 2017

As a first step, the design studios analysed four support structures that they had selected from the existing eight and built prototypes of them with names such as *Christmas tree*, *starry knots*, *fish belly* and *basket arch*, A small jury of lecturers and students chose the structure *fish belly* for further work. The selection criteria were that the structure should constructively form the support structure and also visually form the final wall, therefore fulfilling the requirements of tectonics. Further criteria were that the structure be designed and used according to its material properties and that it can be constructed by students themselves without significant input from a computer or specialists. The students could therefore realise the manual skills aspect of the work.

For the manufacturing process, the students built formwork into which the wooden boards could be inserted and fixed as segmental arches. These individual parts were assembled on site and connected with horizontal planks. After the supporting structure was relocated on site, the development began of various architectural themes such as floor construction, façade and skylight. It was a rolling process in which the students in different teams solved different constructive parts. The project was further developed in joint presentations, while all the time the students were building. This rolling process was supported in the decision-making process by a 1:10 scale model that a student group produced in parallel to the construction process. All decisions could be checked using this model before building them in the real world and vice versa. This created an exciting interplay between model and construction site, that is, between design and implementation.

Figure 4. Model workshop, Vaduz LI 2017

The construction process was carried out as teamwork. In total 62 students, three lecturers and various specialists took part. For the interior design, for example, electrical pipes were laid by the students, while the connections were made by skilled workers. The windows and door elements were also constructed by the students under the guidance of skilled workers and finally put in place.

After 15 weeks of intensive construction and design, the model workshop was close enough to completion at the end of the semester that it could be officially opened. The final small tasks, the relocation and connection of the machines then took place during the summer holidays. The workshop then went into operation for the first time for the winter term 2017-18.

The use of the model workshop has so far proven itself and has been enthusiastically received by the students. During the rolling process it was very exciting to see how strongly invested the students were in the building task. It was also satisfying to see the students gaining experience and confidence as the construction progress moved forward. They learned to switch between the different scales confidently and to examine the constructive aspects in a real setting. A great addition to teaching.

Manual skills

In all our 1:1 projects trade skills are of great importance.

The term 'trade' designates an independent, artisanal professional activity that is learned in the context of a traditional apprenticeship and consists of manual work using tools.[7]

Although trade skills are important in architecture – for a long time the most important skills – our understanding of the term has changed in our time and is defined quite differently depending on the discipline, whether social history, history of technology, art and design theory or sociology.

For Richard Sennett, manual skills "point to a permanent basic human desire: the desire to do a work for its own sake. And it is by no means limited to qualified manual jobs. Skills of this kind can also be found among programmers, doctors and artists. Also in our capacity as citizens, we can improve ourselves by engaging with trade skills"[8]

Sennett's focus is therefore more on the executor himself, not on the product of the work. He describes having manual skills as a way of life, as a skilled activity with an inherent ethos. This aspect is present in the hands-on workshops at the University of Liechtenstein, which cultivate manual skills and encourage students to work with their hands. Of course, students are not yet able to practice manual skills with the precision and professional skills of a skilled craftsman. But achieving such skills is not the primary aim; rather, students should cultivate the traditional trade skills that long defined construction and design, that is, the trade skills that are under pressure due to digitalisation. In the 1:1 projects we therefore try to work with students in such a way that they can build the realisation process themselves with their hands without much computer production. This is important for us because we want to cultivate manual skills again in architectural education.

This is done by practising manual skills. Through this process, traditional, manual skills are cultivated and strengthened. This is achieved under the guidance and in collaboration with local craftsmen at workshops.

At the Institute of Architecture and Planning, we are fortunate to have companies in the Liechtenstein University region that support our construction processes in a variety of ways. Depending on the task or project, students can produce and work at their company premises. Alternatively, their companies can send their craftsmen to our locations. The students' knowledge acquisition is therefore practice-oriented and up-to-date in terms of construction practices and technology. In addition, students learn to communicate and work with craftsmen, which is a good preparation for their future professional lives. The workshops are therefore real construction sites. They are no artificial university laboratories where the students work in a closed environment.

The influence and importance of craftsmanship played a major role in a two-week workshop held in the Liechtenstein mountains that was funded by the EU as part of the Erasmus Intensive Programme series. This workshop is part of a series that experimented with different materials on a scale of 1:1. The workshop participants consisted of eight European partner universities, their lecturers and four students each.

Figure 5. Building site, Tuass LI 2014

The construction site of the workshop was in Tuass, an old hay settlement located at an elevation of 1,500 meters. In the past, hay cut in summer was stored here in the huts. It was transported down to the valley on sledges the following winter. Today these huts are used purely as holiday cottages. Logistically, the site was a challenge, as all materials and tools had to be transported by helicopter. To get to the site, the workshop participants made a forty-minute walk daily to and from the nearby alp.

The task was to develop and find replacement buildings for three old hay huts used as holiday lodges using a constructive interpretation of the traditional log construction or knitting method of construction, as it is called in Liechtenstein. The tectonic and skilled manual use of the wood materials stood in the foreground. Over the first three days, rapid material experiments with interesting constructions took place. With the respective clients judging the process, the selection and definition of the construction was made, the realisation of which we began in the next step.

The constructions were very different. For the first hut, wooden boards of the same dimensions were stacked horizontally and vertically in a lattice. Two vertical boards were used for reasons of stability and only one horizontal board. The offset of the boards at the corners created an exciting analogy to the surrounding log construction buildings of the settlement. A simple but intelligent design.

The construction of the second hut provided a marked contrast. The second hut had a complex system that overlaps and interlocks with itself circumferentially at the corner nodes. Only in the fourth layer does the structure begin again. Seen from the side, the pattern is always the same, consisting of a thin board and a high board. Only the corner joints, with their overlapping and notches characterize and enliven the structure.

In the construction of the third hut, different beam dimensions were used. This makes the system look alive and uncontrolled. The different height beams are joined together with tongue and groove joints in such a way that they repeat after the fourth layer.

As the time span for the completion of the huts was very short at two weeks, it was agreed before the workshop started that a carpentry company would accompany the workshop and its apprentices would then finish the huts. Our task was primarily to develop a new log construction. The unexpected onset of winter in the middle of August slowed down the construction process. The close cooperation with the carpentry company sensitised the students to the traditional woodcraft and also made it possible to reinterpret the tradition log in a contemporary fashion for the 21st century.

Figure 6. Hut 1, Tuass LI 2014

Learning through experience

It is not absolutely necessary to finish an object or project. The many years of hands-on projects at the University of Liechtenstein at the Institute for Architecture and Planning have shown that material experiments in 1:1 combine theory and practice in a lively and experimental way. As a result, the subject matter is not abstract. Students instead discover it themselves, or as Josef Albers remarked in the Weimar Bauhaus: "Learning is better than teaching because it is more intensive; the more we teach, the less students can learn."[9]

Learning through experience can also be understood as a didactic method that can be optimally implemented with hands-on projects. This aspect and the positive feedback from the students at the Institute for Architecture and Planning at the University of Liechtenstein emphasise this optimal learning situation for prospective architecture students. The results from the teaching of 1:1 projects carried out at the University of Liechtenstein clearly show this. This approach should be taken up by more architectural schools.

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INTERIOR ART LEARNING SPACES—WHERE INSPIRATION MEETS CREATION, AN ART PROFESSIONAL LEADERS' SURVEY

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INTRODUCTION

The teaching of art in today's classrooms is mostly the result of teachers' experience and pedagogy, as mitigated by the ecology of the school building, its funding, teachers' biases and social attitudes to art, which help to shape students' work. In the art field, where imagination and creativity are important desired student outcomes, work produced by students is, for the most part, unsurprising and within the range of what they were taught. This is in opposition to the recent direction taken by contemporary art. The art landscape has witnessed radical shifts and an expansion of repertories borrowing from interdisciplinary practices (hybrid practices, installation art, new media art, etc.). Also, pedagogy in higher education has become more innovative. New thinking has allowed space to be incorporated into pedagogy and to become part of an integrated strategy of teaching and learning. The purpose of space pedagogy research is to make propositions that combine teaching and a more judicious use of space to enhance the dynamics of learning. The development of this academic topic is seen notably in publications such as Journal of Learning Spaces. However, there is limited research on the use of space for pedagogical purposes in art education. This study gathered the opinions of art professional leaders who consider space a major tool in classroom teaching.

LITERATURE REVIEW

While the interaction between art and space is not a new topic, its implementation in the classroom is still in its infancy. In their quest for an ideal pedagogy, the founders of the Bauhaus placed space at the center of their teaching. Since the 1930s, the *Bauhaus Vorkurs* (Foundation Course)—a model for combining art, design, and architectural studio education—was incorporated into the American K-12 curriculum.[1] The spiritual heirs of Bauhaus ideas immensely influenced the teaching of art and design in leading U.S. higher institutions. Around the same time, Victor D'Amico, the educational director of the Museum of Modern Art (MoMA), initiated a number of key educational space initiatives to generate profound interaction between modern art, the public, and schools through the use of designated spaces, furniture, and motivational games.[2]
The next stage in art-space thinking relates to installation art where space becomes part of the artwork and spectator experience. Installation Art creates an experience for the spectator through a specific, mixed-media construction designed by the artist, in which space itself is part of the work.[3] In RoseLee Goldberg's (1975) article "Space as Praxis," events, performances, texts, and concepts generate physical encounters within architecture, while architecture transforms into a process.[4] This concept of allowing

the object to collaborate with its environment was explored by prominent artists such as Joseph Beuys and Allan Kaprow, who opened up the freedom of relationships that enact artwork within its larger physical and social context.[5] In Relational Aesthetics[6], the usage of space becomes art. Many of these Post-Minimalist and Fluxus traditions are being implemented in today's studio design as well as the practices of students, teachers, artists, and art educators. It is the author's aspiration that artists' broad embrace of interaction and communication through space can also find a parallel in teachers' daily implementation of teaching activities and managing space.

Interest in researching the impact of learning spaces on teachers and students is a relatively recent trend. Prior surveys in art education advocated the use of space and visual information as normative recommendations[7] to foster students' creativity. However, empirical research on the positive effect of art teaching and students' creative performance in relation to space is limited. Results from non-art-related disciplines are mixed on early childhood education.[8] In secondary and higher education settings, research has shown the positive influence of well-implemented space strategies on learning outcomes.[9] Innovative space implementations at MIT and North Carolina State University combined with an active learning curriculum and student-centered pedagogies improved student behavior, participation, and problem-solving skills in science classrooms.[10]

Over the past decade, there has been extensive research on the influence of physical learning spaces in Active Learning Classrooms (ACL) or informal learning classrooms[11] on instructors' and students' behavior and performance.[12] In ACL classrooms, active interaction and participation were enhanced when students' interest in the content and communication with the instructor increased. Students also tended to share more, create ideas, exchange and accept different opinions, and create new perspectives with their peers.[13]

Brooks[14] suggested that space influences instructor behavior and classroom activities. He recommended that educators adjust their space approaches to instruction since different spaces are better suited for different types of learning activities. Researchers also found that a physical space within a classroom/studio should be used flexibly to promote students' creativity.[15] Other research has shown how physical environment attributes such as light, sound, openness, flexibility, and sensory qualities may impact creativity.[16] Improper lighting, noise, low air quality, objects, and wall décor influence student achievement.[17] This research conducted by the author aspired to provide some insight into art experts' recommendations about the use of space in art pedagogy.

RESEARCH DESIGN AND METHODOLOGY

Description of Study

This exploratory study consisted of in-depth interviews with experts in the fields of art and art education who represent diverse perspectives on contemporary art and art education. The vision of art professional leaders has guided trends in art and art education. Artists are innovative thinkers and advocates of cultural advancements;[18] art educational leaders are promoters of progressive art education[19] and art-education researchers give insights to art learners about new art directions and social change with experience in monitoring educational quality.[20]

Multi-Grounded Theory as Theoretical Perspective

This research used grounded theory (GT) as its theoretical framework.[21] GT, developed from the seminal work of Glaser and Strauss in 1967, has systematized the analysis and abstraction of data into categories and theoretical constructs. This once polemical work promotes inductive forms of theorizing and opposes prior mainstream research that relied on deductive forms of theorizing and "the discovery of theory from data."[22] Methods are systematic procedures for data collection and analysis.[23] Building theory from data (i.e., inductive reasoning) "automatically" grounds the theory in empirical data.[24] Like GT, the author aimed to provide good support for discovering new ideas and relations among categories and properties. This research specifically used an extension of the GT approach called multi-grounded theory (MGT), which considers prior literature and advocates the use of existing theory to support the empirical data forming the new emergent theory.[25]

Participants

Table 1

Interviewee Code	Gender	Qualification	Artist Experience
Artist Teacher 1 (AT1)	M	Teaches and conducts workshops in poor neighborhood in San Juan, Puerto Rico	Yes
Artist Teacher 2 (AT2)	M	A.D. White Professor at Cornell University, Professor at a leading art institution in Beijing, China	Yes
Museum Leader 1 (ML1)	F	Senior Associate Curator of Public Education, teaches K-12 groups, directs teachers' professional development at a leading gallery in Connecticut	No
Museum Leader 2 (ML2)	F	Director for Education at a leading art museum in New York City, Adjunct Professor at NYU	Yes
Art Education Researcher 1 (AR1)	F	Research Fellow at a leading art museum in New York City, teaching artist at D'Amico's Art Barge	Yes
Art Education Researcher 2 (AR1)	F	College Professor at Université de Québec à Montréal (UQAM), prior experience as a K-12 art teacher	Yes

Data Collection and Treatment

The researcher used interviews to gather data; relevant facts were collected, then examined to reveal emergent themes. Those themes addressed the quality of art learning space and its importance and role as one of many pedagogical tools. Following MGT, the researcher derived semi-open and open-ended questions from the literature that revolved around art pedagogy and space to understand the following:

- use of visual information that best educates the art learner in an art learning space;
- initiatives from the art learning environment that have helped to foster learning;
- various ways to implement space as part of pedagogy; and
- the content of visual information that would best educate art learners.

To ensure rigor and efficiency, the researcher adopted a two-stage approach. The first stage utilized a website transcribing service that provided text transcriptions. A native Chinese and French speaker translated two interviews in their language and each written transcript was reviewed to verify additional fidelity to the original interview. Next, NVivo was used to make sense of the data and analysis, ascertain the representation and structuring of all ideas discussed, and generate understanding.

ANALYSIS AND FINDINGS

The findings of the interviews post-transcription were classified under four main emerging themes: (a) Basic Conditions and Attributes of Art Learning Space and Their Outcomes; (b) Creating an Empowering and Inspiring Art Learning Space; (c) Recommended Learning and Spatial Settings; and (d) Desired Impact of Learning Space on Its Participants (Figure 1).

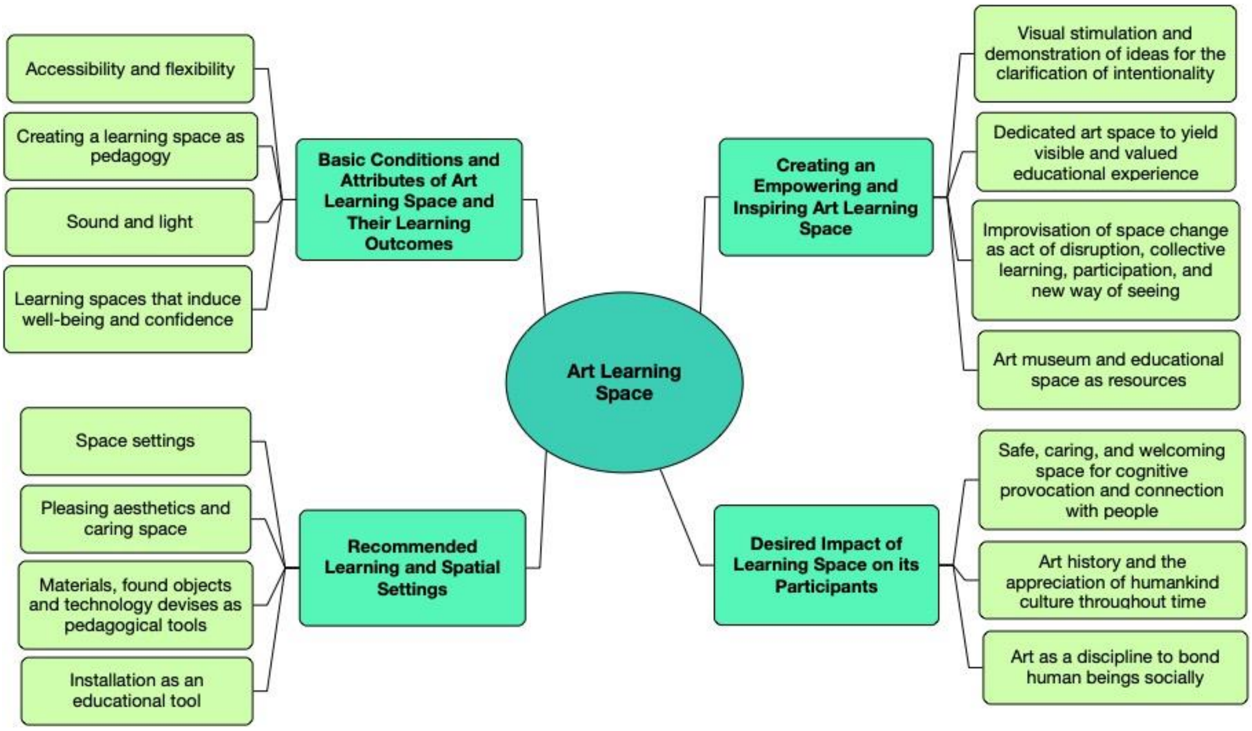

Figure 1: Summary of interview findings

Basic Conditions and Attributes of Art Learning Space and Their Learning Outcomes

Basic conditions and attributes of spaces serve the goal of having an art classroom that allows accessibility, flexibility, and modifiability of the furniture and lighting to help learning and teaching, thereby fulfilling basic learning and ergonomic conditions. Such conditions and attributes not only provide a safe learning environment that nurtures confidence, independence, and risk-taking, but they also foster participation, interaction, idea exchange, sensual stimulation, and sense of community. For example, a bookshelf or poster enables students to see the images automatically. When learners feel at home, they want to work longer and return.

Teachers need to create a space where visual examples on the walls serve the pedagogy. A well-designed space minimizes the teachers' management tasks and maximizes their teaching. Related visual information, such as contemporary art examples, can provide a reference to a demonstration of formal aspects of art.

Space needs to provide physiological and psychological safety.[26] When space induces a sense of well-being and confidence, students are fulfilled and engaged; they can focus and work effectively and independently. The classroom setting helps teachers to "satisfy the youths' fundamental needs of recognition, stability, security, and belonging."[27] Furthermore, dedicated learning spaces allow teachers to deal with uncertain situations and self-questioning, encourage initiatives, respect individuality, and account for learners' complex and personal emotions.

Creating an Empowering and Inspiring Art Learning Space

It is important for teachers to design memorable and stimulating experiences, and so art learning spaces can become a powerful pedagogy when their intention is clear. Dedicated art learning spaces reflect classroom philosophies and values. As illustrations, the aesthetic correspondence between the institutional façade and the interior reflects values, while a non-gendered bathroom promotes equity. Additionally, being in an art environment cultivates learners' criticality and promotes a sense of freedom.

Spatial improvisation stimulates creativity and activates collective learning through the act of disruption. For example, the placement of chairs in the middle of the room "humanize[s] experience and bring[s] people together, and ha[s] people focused and engaged"; this allows freedom of choice in the way that students "form themselves."[28] Moreover, interviewees strongly agreed that contemporary art should be part of art pedagogy.

Proximity to art resources provides specificity to the art context. This becomes more powerful for underserved students who have never seen art or had art lessons.

Recommended Learning and Spatial Settings

A circular or "horseshoe" setting was recommended to promote communication and gathering as students face each other. Also, studio-type workshops were recommended for participation, interaction, and collaboration. A space that cares for or welcomes people allows emotional security and eliminates distractions. A quality art space can be enhanced by aesthetically pleasing surrounding landscapes or proximity to nature.

Findings suggested that creating unexpected visual/sensual stimulations with materials such as found objects impel students' visual and sensory thinking about their own physical situations and relationships with people, objects, materials, and space. For example, AR2 used student-favored art examples like Banksy, projections, and quotes, creating conditions to develop creativity. All interviewees utilized technology in their pedagogy. Having Internet in the room enlarges the physicality of art-learning spaces. For shared classrooms, creating a micro-environment within a larger one was suggested.[29] Teachers are recommended to create games and small prompts. Additionally, art installation can be used as a method to promote communication and represent materials dramatically.

Desired Impact of Learning Space on Its Participants

The positive impact of satisfactory learning space has been well documented in the literature. Interviewees pointed out the success of these implementations by referring to the social impact of active learning through art and the artistic, pedagogical, and instrumental consideration of space and human relationships bonding through planning, collaboration, and innovation.[30]

Art classrooms enable students to discern art's relationship with other disciplines so they can understand society. Art reinforces how people learn differently from one another and reduces the distance among individuals to find common bonds and facilitate social engagement. Through art, the museum becomes a framework for social change. Interviewees highly valued the creation of a safe space, while elements of provocation invite learners to create the unexpected. It was indicated that art learners stayed twice as long when they were greeted. Hence, a welcoming space makes learners feel connected and be heard.[31] Lastly, there was a general consensus on the value of appreciating ancient human culture and the traditional connection between two-dimensional works in painting, sculpture, and architecture.

DISCUSSION

The interviews clearly showed how spaces create a positive dynamic learning cycle and generate psychological conditions that develop autonomy, confidence, risk-taking, and creativity. The reasons why art-dedicated spaces are valuable—and why this research is of practical significance—derive from two justifications: (a) well-designed spaces enable inspiration to meet creation and a flexible classroom accomplishes this mission; and (b) space-related pedagogy research is important because a recent trend for the pedagogical philosophy seen in art-teaching classes leads the way for other disciplines to be more satisfying and participatory.

Context determines what kind of art is being inspired and produced;[32] thus, it is important to adapt space to users' needs. In addition to having flexible space, I suggest the implementation of three alternative options of K-12 classroom settings: (a) a hybrid setting between presentation style and studio style; (b) a loose lecture style on one side of the room that allows varied configurations and flows into an adjoining spacious area; and (c) setting desks in groups of four to six in classrooms with a limited budget, leaving a larger area in the front/middle. Teachers can negotiate with school staff or "hack" space creatively. Meanwhile, it is recommended to utilize a collaborative and interdisciplinary curriculum with contemporary art visuals that change periodically.

A finding not discussed in prior literature was the idea of reducing the social hierarchy between museums and schools and between teachers and students. This was reflected through interviewees' descriptions of students/teachers as "humans" and "life," as well as the conceptualization of art installation as classrooms/social space. The first type of de-hierarchization parallels the second type of de-hierarchization. An engaging space reduces the managing and pedagogical tasks of the teachers, therefore, reducing the reliance on the teacher to provide instructions and knowledge. Specific consideration of physical relationships in space is crucial today because of its inherent impacts on multiple aspects—pedagogical, behavioral, psychological, aesthetic, and artistic. Three participants suggested expanding pedagogy and the physicality of space through technology. Equally important to me is how our mindset of space can be freed from the physicality of the classroom.

CONCLUSION

Art-learning spaces are spaces of vitality that cannot be discussed without considering the dynamism of the students and teachers actively performing within them. The art teacher's role is not only to collaborate closely with students but also to create constant optimal spatial considerations in sync with lesson goals. Careful consideration of visual elements and facilities promotes learning and reflects intended pedagogy and aesthetic precision. Art classrooms could become inspirational sources, incubators for art-making, and lively spaces that promote creation and collaboration.

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BETWEEN PLAYING AND REALITY, THE ARCHITECTURAL DESIGN STUDIO AS A "POTENTIAL SPACE"

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PROLOGUE

The design studio, in the school of architecture's cognitive map[1], lays between the fields of learning and practice. In this framework, students acquire professional tools and learn how to hone these skills. Psychological and mental aspects are only secondary.
In this article, we intend to shed light on the architectural design studio's psychological and mental aspects; bring them into light and demonstrate the key role they play. Exploring “Potential Space” as a psychological zone of experience shows how the assimilation of practice of play into the architecture teaching routine and studying process not only provides students an additional effective tool to use in their professional life but also has the power, by reducing anxiety levels, to improve students' results and satisfaction in the studio.

FOREWORD

In the architecture schools of Israel, the design studio is the beating heart of the curriculum and the backbone of the syllabus[2]. However, most of the attention is directed toward a plethora of courses that teach and provide technology-related knowledge and tools. Little attention is devoted to the psychological phenomena and processes which take place at the studio in regard to its social configuration and student-instructor relations. Architectural instructors are chosen for their professional and academic achievements. Schools prefer to employ proficient architects that are specialized in the practice of specific fields. Yet the instructors are not provided training in order to prepare them for the special social, emotional or psychological dynamics in the studio environment. Trial-and-error becomes a major part of their teaching experience, and their didactic achievements assessment is determined mostly by students’ satisfaction.
Accordingly, this paper suggests a brief acquaintance with unconscious and subconscious psychological activities that take place in the studio, (both by students and teachers without knowing or being aware of doing them), their influences on the process of studying architecture, and proposes ways to improve the educational environment for architectural students.

BACKGROUND

In the late 1960s the British pediatrician and psychoanalyst Donald Winnicott coined the term "Potential space"[3], referring to a hypothetical interim space between the experiences of reality and fantasy[4]. This space originates from a potential physical and mental space between the mother and the infant. In this space, Thomas Ogden identifies a few layers, including ‘playing’, as well as Transitional Processes and Objects[5]. Understanding play is, in a way, rather easy while transitional processes and objects have a greater degree of opacity and unclarity. Initially referring to the process of separation from the mother (environmental-mother[6]) and the formation of subjectivity which takes place in the early life of infants and spans over time[7], this process forms a "Transitional Space" in which "Transitional Phenomena" and "Transitional Objects" appear. Transitional phenomena imply various behaviors (mainly repetitive), which together with certain objects adopted (embraced) by children (transitional objects), assist them to cope with the change, and above all helps them keep calm[8]. Play, when repeated, becomes a very important transitional phenomenon itself. This idea, in much wider respect, affects many other types of relations between individuals and their environment (physical and mental) in every phase and aspect of our mature life. In this manner, acts such as students 'lining' the studio with an old discarded armchair or with shelves in a niche may be interpreted by the beholding psychoanalytic eye as meaningful unconscious or subconscious mental activities.

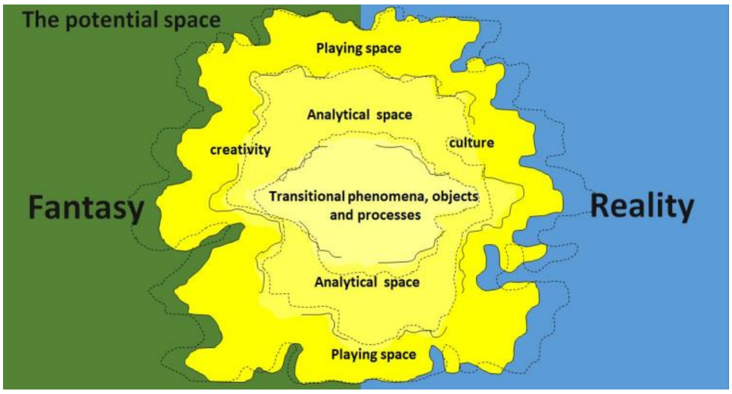

Figure 1: The Potential Space

Now we can better understand Freud's claim in terms of which every human act carries a psychological meaning[9]. There is a clear connection between students' actions and their will to create a comfortable and 'containing'[10] environment. A more personal and protective space that reflects their mental and emotional state and which defines a reciprocal relationship with their studio.

THE ARCHITECTURAL DESIGN STUDIO PSYCOLOGICAL ARENA

Every studio instructor knows that students experience 'ups and downs' while working on a project as it is never a linear path with a steady rhythm forward. Students experience stressful moments when they feel 'stuck' and unable to move on with their work. Our students' mental state is usually rather easily recognizable by simply observing their faces and body language, and many of them also verbally express it. Asking students how they are doing is a very important custom. This question should not be implicit, as it carries a message of interest and respect, empathy, attachment, and comradeship. It allows students the time to share their inner state, reflect on it, feel connected and under supervision.

Today we know that anxiety, anger, and envy are emotions that are very common among freshmen in the design studio[11]. These feelings indicate distress and show the fragility of the students' mental state. Among other rational and external reasons, students feel vulnerable and exposed mainly due to their extensive mental and emotional involvement in their (creative) work and the fact that it is under constant watch and evaluation.

Nowadays we are much more aware of the mental and emotional processes which accompany the study of architecture. We know that working on a project takes much more than the allocated time, talent and 'good-enough teachers'[12]. We only scratch the surface to uncover a vast opportunity range available for us as architects and teachers, to comprehend our students' mental and emotional world. It is crucial to understand this process and our key-role in our students' success. As soon as we put on our 'psychoanalytic glasses' we start understanding environment and space in a much wider sense and see our studio in a new intense light as a "potential space" (or at least a place where a potential space exists).

THE ARCHITECTURAL DESIGN STUDIO AS A "POTENTIAL SPACE"

The minute we gather a group of freshmen students (ten - twenty) with their ambitions, expectations, and hopes in one room with one or two instructors, a potential space is formed.

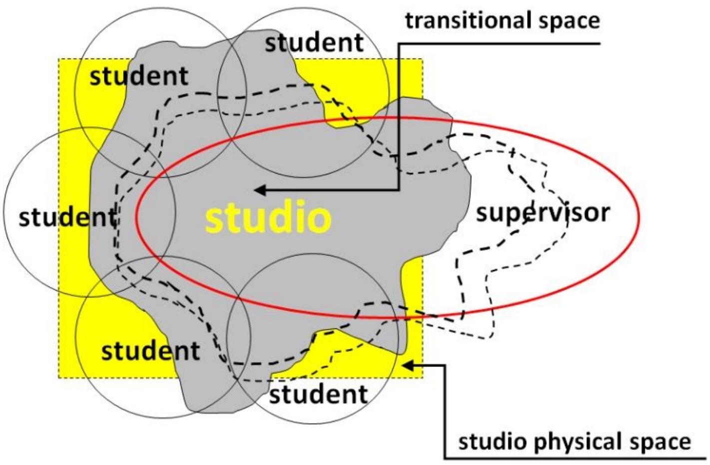

Figure 2: Studio Dynamic Space

By analogy to Winnicott's theory in regard to the 'Mother-Infant unit', we suggest that the space between the mother and the baby as proposed by Winnicott appears in the studio in a much more complex form and includes three components: the instructor, the studio space and the students.

Based on this analogy of a single mother and a single infant, we may extract initial ideas regarding the role held by each participant in the studio system. Like the mother, instructors portray the "significant figures[13]" for their students, providing them a stimulating environment and primary basic skills to deal with reality in the professional world. Like the environmental mother, the instructor sets up 'constructions'[14] for order, discipline, balance and other relations with the world outside.

The students, both as individuals and as a group, are a fundamental factor in the formation of the potential space in the studio. They form the potential space by means of their dynamic presence, communication, bonds, and relationships with the instructor and each other. By analogy to Winnicott's 'Parent-Infant Relationship' theory[15] freshmen in the studio are equivalent to a newborn baby in the arms of its mother. But the students, are not as helpless and as dependent as a baby, reacting to the world and acting in the studio. They use space both physically and mentally to locate, shape and establish their position, stand, and status within the group. The work on projects demands them to go back and forth between reality and fantasy and constantly operate between imagining and executing. Through that process of constant search, they shape and define their own identity and the unique character of their group.

The role and meaning of the studio space are quite elusive, especially when following Winnicott's ideas about the 'potential space'. The studio space integrates physical and mental spaces both social and educational as presented above. We discern personal and interpersonal, abstract and concrete spaces; however, this is only the beginning, and being partially hypothetical the studio's space is also a psychological space of experiences. It would be correct to say that the studio space provides environments that contain all types of activities taking place in and at the studio. This space may expand or contract to make room for dynamics and changes, for mental movements between, in and out, between reality and fantasy, and for actions of integration and separation, objectivity and subjectivity.

The power of fulfilling this natural potential is in our hands. Understanding that, we can no longer act as ordinary teachers and we can no longer treat our students as just students. We need to adopt a new attitude and new skills. This attitude focuses on a higher level of attention and sensitivity to nuances, as well as using 'active listening' and 'cognitive empathy' skills. By immersing ourselves in the teaching experience, we as instructors can prolong the "moment of illusion" and comply with more of our students' educational, professional and emotional needs, apparently even before they formulate them. As a result, students would feel empowered and more satisfied as if the solution, direction or way was their own from the very beginning. To assist as many students as possible in this process, we suggest intentionally utilizing the potential of the space. We propose using two of its most significant characteristics, Transnationality and Play. Transitionality enables mental and emotional flexible movement on the axis of experiences back and forth between reality and fantasy and play has the power to be experienced as if it was a reality, while we know (understand) it is not.

Based on our understanding that the architectural design studio is a 'potential space' the question is how we can promote creative processes in this space.

PLAY MODE

We offer using play in the design studio as a powerful and productive tool. 'Play' has many forms and qualities that we constantly use throughout life. Wrongly for many, playing is kept for the lesser serious and important aspects of their life in which livelihood is not involved. Today, we witness wide use of a range of play in modern life, where many people, all over the world, play for a living. Players in Professional sports fields, cinema actors, in the huge scene of video gaming and many more.

Before the beginning of the twentieth century when psychoanalysts started thinking and exploring play activities part in children's life and their significance, philosophers such as Kant[16], Schiller[17], and historians such as Huizinga in his book 'Homo Ludens'[18] wrote about the nature of play and its role in meaningful human life. With the introduction of psychoanalysis, the philosophers' discourse about play as a human cultural phenomenon shifted towards the individual and the group mental fields. Play in various contexts has been the focus of theorists' work ever since[19]. Play became a psychoanalytic instrument for identifying normal mental development and pathologies[20]. Psychology offered additional points of view and interpretations regarding the relations which the ability and inability to play have with various situations and mental states[21]. Freud's assumption that the urge to play is being replaced during puberty with one's ability to imagine has long been laid aside[22]. As his disciple, Melanie Klein followed Freud's description of play as a symptomatic act of primary expression of the subconscious mind. She used it as an interpretive instrument to diagnose anxieties and reactions of the defense mechanism. In therapy, she pioneered using play alternating with free associations to communicate with the introvert world of children[23]. Yet the most important contribution was made by Winnicott who emphasized a great standalone value in one's ability to play. He addressed this ability and associated playing with creativity[24]. According to Winnicott, playing could bridge between the inner mental life and outer reality. As a pediatrician, he used this knowledge to communicate with, diagnose and treat his patients. Among other virtues, play includes inherent elements of pleasure and tension relief. It helps to calm down when anxious and to relax when stressed[25]. By playing, we can be creative and discover our weaknesses and strengths and encounter hidden sides and characteristics of our personality (e.g. competitivity, determination, loyalty, indecisiveness, audacity, etc.) When playing, certain physical and emotional skills are developed and practiced, enabling flexible responses to different challenging situations we experience throughout life[26].

As for its powerful nonverbal expressing abilities in the potential space, we harness play as a didactic instrument. We add 'learning by playing' as a method to 'learning by doing'. As instructors, we find it very important that our students learn how to use play efficiently as a professional tool whenever they wish or when they feel in need. To reach this goal we need to maintain an open and ongoing space of play in our studio. Using this method enables us to develop alternative ways to communicate with our students and assist them to advance their work. During crits, we keep encouraging them to lead as 'open study process as possible', which

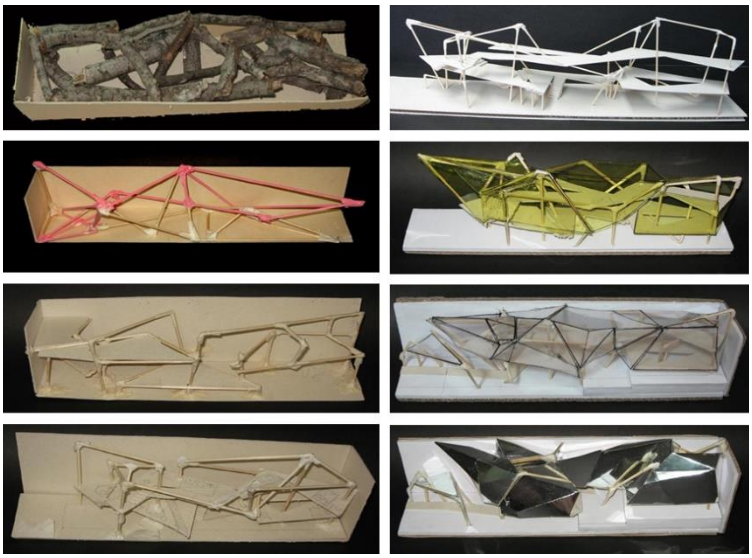

Figure 3: Action Models.
"Finely when I looked at the Series of the models I understood that it's like I was telling a story. Maybe the evolution of a structure came out of me. Now, in retrospective I was moving forward and backward, in and out following the way felt right in those moments of creating them. Now, I can explain what I was doing. I was just playing and it became a building, my own design." *(Freshman student)*

should be continuous and not necessarily end at the final presentations. We encourage students to work in a territory that is beyond words. We drive them to explore their stance toward their project (in terms of ideas, taste, esthetics, wishes, feelings, etc.) by playing, allegedly without a direct purpose or a clear direction. We offer them to put rational actions aside for a moment and follow their instincts and intuition. Play comes to life in the act of drawing sketches and building models somewhat mechanically using inner implicit know-how. By means of defining lines, shapes, forms, colors, and materials students may accurate relations and proportions in compositions that replace words and descriptions. Drawing and erasing, cutting, folding and gluing which flow intuitively allow the body a higher degree of action freedom[27]. This freedom also makes it easier to more fluently perform manipulations such as adding and removing, shifting, arraying, rotating, etc. Therefore, we push students to act 'horizontally' and produce more and more models and sketches. This horizontal operation is enjoyable and sets out a wide range of options and opportunities, giving room for ongoing reflection and release from paradigms. The physical product of this prolific play is of architectural and aesthetic quality.

Displaying it for examination helps to extend the ‘surface area of experiences[28]’. It enables students to check their work from several points of view, sort it and make choices by eliminating and promoting options in a much more precise manner than the analytical way. In that sense, we help them remain unattached[29] to their work, remove fear and concern barriers. Students that in other occasions would behave defensively feel much more comfortable to expose without feeling inept or incapable.

On the individual student level, play enables students to remain in touch with their original, natural sources and resources. On the group level, play breaks routines, decreases internal borders and promotes using resources as "teamwork" to improve cross-fertilization among the group members.

Play, being a creativity catalyst has great importance and significance in the architectural studio which aims to be prolific, creative and critical. The wider our use of play the greater the creative potential and larger the number of students able to fulfill it.

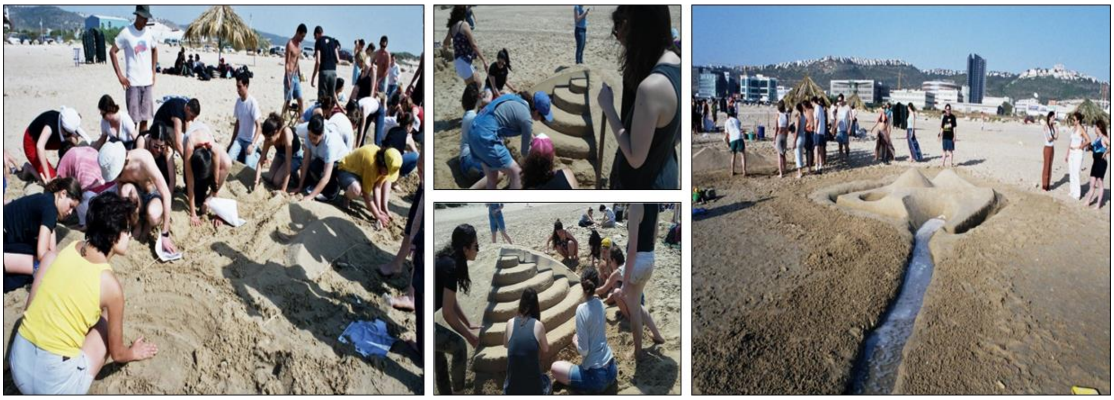

Figure 4: Out-Of-the-Sandbox experimental studio activity on Haifa beach

TRANSITIONAL MODE

Potential space is always a transitional one, it must be dynamic and constantly changing to maintain dialectic psychological movement between both poles of the mental experiences. This movement demonstrates itself with transitional phenomena and objects.

Transitionality might be described as an in-between state in the process to achieve subjectivity. An in-between state on the journey from where we believe to where we know, from fantasy to reality, from an idea to a building. It consists of Integration and Separation reactions that act as motivators and as defense mechanism. Integration makes the students' process and their project more personal. Separations help students define the limits of their intervention in the existing environment and create 'un-attached' stand towards suggested alternatives.

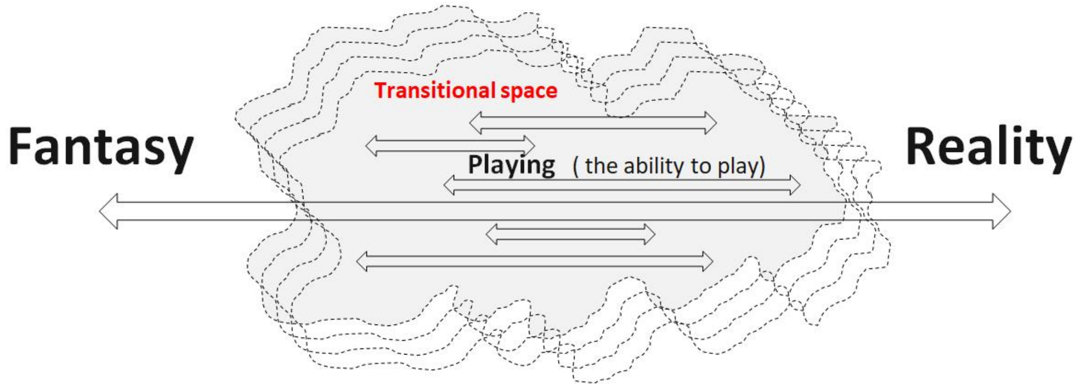

Figure 5: Play activity as a training of flexible movement

We found out that extending the time students operate in the transitional mode and stay "with one leg" in a transitional space may assist them to calm down and be more productive. In this space, they put the explanations and need to interpret their work and actions aside and 'simply' work in a productive mode. This is made possible by shifting energy from anxiety towards action (creative action).

The components of physical product produced during a prolific process of play may take the role of transitional objects. It helps students reflect on what they already did, assume a position and conceive the next move. The wider the product (in terms of quantity) the wider the transitional space which enables deeper contemplation in search of direction, meaning and order. Transitional space is kept in a 'dynamic equilibrium of potential' in which powers dictated by reality are kept in balance with powers endowed by fantasy and vice versa. Keeping this balance ongoing promises endless potential.

CONCLUSION

In the studio, Student-instructor interactions are based on an expected level of trust that forms and evolves throughout the semester. This conditional trust level is crucial in order to sustain a design studio. Many students face great hardship and difficulties getting into a creative mode where they can freely express themselves and act creatively. Occasionally, critiques, comments and even objective conditions of reality push them to entrench[30]. In that state of mind, they are less productive and perform only rational, mechanical or bureaucratic actions that have almost nothing to do with their inner-self. Trust provides the atmosphere which enables students and instructors to lead a creative process of planning and designing in the studio environment. The higher the trust level the greater the potential of transcending 'comfort zone performance', breaking-through familiar borders and playing freely and more naturally. Students' trust in their instructors as guides and providers of a supportive and secure environment enables instructors to base students' trust in themselves. During our experiences, students who embraced play as a modus-operandi show much more courage to experiment, they face challenges more willingly and come up with creative and original productive outcomes.

While playing we draw on the mental powers (by using our imagination or intuition) to go back and forth between reality and fantasy. This movement helps us to channel more energy towards productive activity and realize our full potential.

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"PUSHING BOUNDARIES": THE ADU-TUW STUDENTS WORKSHOP IN AL-AIN, UAE AS CASE STUDY OF COLLABORATIVE KNOWLEDGE EXCHANGE

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INTRODUCTION

From 31st of January until 6th of February 2019 the Al-Ain Campus of Abu Dhabi University (ADU), Department of Architecture and Design, hosted for the first time a Student Workshop organized in collaboration with Vienna University of Technology (TUW), Institute of Architecture and Planning. The workshop completed a shared educational experience between the two universities initiated during Fall semester 2018-2019, and specifically between the 5th year's undergraduate course of ARC540 Sustainable Design held at ADU, and postgraduate course 253.C88 Master Design Studio at TUW. The goal of such shared experience was to provide participating students with a full design project experience from concept, drafting and planning to on-site verification as a proof-of-concept. In order to compensate the discrepancy in knowledge, requirements, and outcomes for the two courses, the site project was selected in Al-Ain and ADU students allowed to work in groups of three, whereas TUW students elaborated their projects individually.

Third in size and population, and differently by other UAE's cities, Al-Ain still retain the characteristics of a desert community, blessed by the presence of underground water resources which favoured the development of urban settlements and farmlands since the 3rd millennium BC. The presence of archaeological sites, historical heritage and seven ancient oases characterized by an ingenious system of irrigation called *falaj* - dated back in this region to the 1st millennium BC – have promoted Al-Ain as UNESCO World Heritage Site since 2011.[1] Therefore, due rising popularity of the city as tourist destination, and recent built development carefully managed in order to preserve its identity, Al-Ain represented the ideal place for a project experience integrated into an urban context which is still preserving traces of original vernacularism as cultural identity, in marked opposition to the international allure of globalized cities such as Dubai and Abu Dhabi.

The common exercise consisted in the elaboration of a hypothetical project located in Al-Ain central area regarding a "*Walking-Cycling Pathway connecting the oases of Al Mutawaa, Al Mutaredh, and Al Muwaiji*" (Figure 1), where both courses called to design installations, urban furniture, shading devices, and sustainable facilities in order to improve walkability and enjoyment of urban spaces of Al Ain city centre by residents and tourists alike. Projects would have been initially developed separately by the two groups of students, working remotely in UAE and Austria/Vienna, then their assumptions would have been verified on site through a common workshop. The aim was to foster a collaborative knowledge exchange between the two groups of students who didn't met before and who belonged to a heterogeneity of ages, nationalities, and cultural backgrounds.

Figure 1. Project Site: Al-Ain's urban area connecting the three oases (source: Google Earth)

Below, the excerpt from the design brief distributed to students which has been shared between the two courses at beginning of Fall semester 2018-2019:

Topic

Welcome to the desert, Al-Ain, the garden city of the United Arab Emirates at the border to Oman is characterized by a network of low raise block structures, clean roads and seven oases. Known as an area which can't be associated to the iconic architecture of Dubai and Abu Dhabi.

The studio project, which will be held in cooperation between Abu Dhabi University (ADU) and Vienna University of Technology (TUW), aims to show a diversified view on Al-Ain, the desert, and the built environment of UAE region in general. On behalf of a seemingly impossible task, the question of how to design a walkable cityscape is addressed. The aim of this design studio project is to reflect planning approaches from the drafting table to the on-sight experience.

Task

At beginning of the project, students will get an insight into cultural, environmental and architectural characteristics of the UAE. This initial phase helps to emulate a personal outlook for the task and design approach. Accompanied by weekly meetings and initial webinars, the participants elaborate a stepwise project idea following a three-pillar approach:

1. OFF-GRID: the absence of a supplying grid, tightens the connection to the climate, building tradition and context.
2. DIGITAL INQUIRIES: current and future technologies promise a slightly different approach to planning, using and readapting urbanized spaces.
3. URBAN "MACHINOEKI" – the human station: a Japanese concept of paths, shelters and places for gathering, in order to boost the pedestrianization level.

The three-pillar approach helps to outline a design proposal for the walkable connection of Al Mutawaa, Al Mutaredh, and Al Muwaiji oases by considering the surrounding areas, the regional context and the nearby Oman border. A reflection of car-driven-society and the cultural impact of the proposed solution will be subsequently evaluated with proper design ideas.

Excursion + Workshop

After the final presentation of projects, students have the chance of a proof-of-concept on site at the beginning of February. During the workshop in Al-Ain between ADU and TUW, a similar task, like the earlier design project will be posed. The working method during the fast-and-dirty workshop is limited to analogue techniques such as sketches and working models. The public presentation involves guest-critics from the academic and practice related field.

This paper illustrates narratively the outcomes of this shared experience between two distant universities as case study, with the aim to systematize and possibly replicate this experience in future. Main characters of this narration are the students who participated to it. The opportunity for a workshop, which presume availability to travel and get a full immersion into a different context, otherwise distant and alien, is a thorough personal and educating experience per se, but not immune of hidden difficulties. Apart trivial considerations about subject, timing, location, climate and logistics, a particular focus on personal traits of participants, in terms of adaptation to different customs and social habits, predisposition to collaborative team working, group cohesiveness and cultural openness to the hosting environment, represents by itself the discriminant between a successful educating experience, or a frustrating failure for both participants and educators as well. Beyond any other type of distant collaboration, it’s the personal contact and interactive relations which should be firstly established in between participants and organizers as well. Personal acquaintance and interaction, acceptance and cohesiveness, proactiveness and team working attitude, once deprived from any comfortable communication filter given by remoteness, would represent the real-life conditions in which any aim of collaboration would express its pros and cons.

PROS AND CONS OF DISTANT COLLABORATION

During Fall semester, the two courses interacted via a series of three videoconference classes, in which TUW students asked their ADU colleagues in order to acquire as much possible of information about Al-Ain’s urban structure, its climate, history, social and cultural context. Since such information could be easily found through literature or simple web searching, the true scope was to put in contact the two groups, which would start knowing each other, inviting them to question how they live and use their space and time, move and adapt to the physical urban structure and the environment, and how they get within the net of social and cultural relations which integrate or supersedes the urban realm.

It was supposed that, encouraged by the remoteness given by videoconference, students would be felt themselves free to ask whatever they considered would have been useful for their project, sometimes even provocatively. However, some cultural differences emerged and some students felt uncomfortable to interact remotely with their colleagues abroad.[2] Videoconference sessions proved to be tremendously useful as direct means to expose and compare ideas, request additional information about site and documentation, early provided in form of maps, photographs and videos, but remaining impersonal anyway, especially regarding cultural and social aspects which remained largely unexplored. Since the project site located in Al-Ain, the first videoconference was mainly used by

TUW students to address technical questions, most of them concentrated on environmental issues about design strategies and building technologies adopted to cope with the extreme hot-arid climate characteristic of the region. The second and third videoconference revealed to be more interacting and involving more participation from both sides, especially during the third one where students presented their design concepts followed by joint discussion about ideas.

During these sessions students from both sides were encouraged to freely express themselves, debating fairly and politely, opposing strong argument if necessary, however avoiding withdrawing themselves from discussion or keeping silent. Basically, all students enjoyed the experience and managed their presentations and discussions very well, with only minor issues related to language communication.

Despite videoconference sessions fulfilled successfully the scope, their relevance mainly remained confined to technical aspects, sometimes trivial, but barely scratching the surface of an accepted formality in investigating the intimate relations between built environment, culture, traditions, and social customs. In fact, this type of investigations is at least arduous, if not impossible, to be conducted at distance especially when analysing a different cultural context. In this regard, a personal immersion into physicality of the place, and direct experience of intangible web of values which have shaped this one, it's an irreplaceable experience that any other sophisticated means of digital communication can never replace or substitute.

For these reasons, the joined workshop would have represented not only the on-field verification of design proposals as a proof-of-concept, but also the completion of an educational experience otherwise crippled into one of its main objectives: offering the opportunity for a collaborative cultural and knowledge exchange between the two distant groups of individuals with different backgrounds.

PRE-WORKSHOP EXCURSIONS

The two groups joined on 31st of January 2019 for an initial four-days stage of visits and excursions, preliminarily agreed by instructors in order to provide students with a shared experience of UAE's heritage, history, culture, and traditions before the workshop. The visiting group from TUW composed of 7 students, 1 faculty, and 3 teaching assistants, the hosting ADU group composed of 14 students, 2 faculties, and 2 teaching assistants, for a total of 21 students and 8 supervisors.

Needs to be noted that, while participation to workshop and connected activities was considered compulsory for TUW students, as part of their Master Design Studio course and accordingly credited, whereas ADU students' participation was on voluntary basis only, since this type of activity is considered extra-curricular in Architecture program. This fact would remark that ADU students were strongly motivated and very keen to have this collaborative experience with their colleagues from abroad. Their motivation resided only partially as academic prosecution of their project experience – since they already credited at completion of the course - and once questioned about the reason for their participation, all of them highlighted the opportunity for personal enhancement, improving their knowledge through cultural exchange.

The programmed joined excursions aimed to foster a collaborative spirit between the two groups, who had acted and elaborated independently until then, and an opportunity to make personal acquaintance of each other. As hosting group, ADU students played the role of cultural guide, mentoring the guest group about social customs, habits, and traditions. Visits and excursions provided as much as possible an insight about environmental, traditional and cultural aspects of UAE region, other than visiting heritage buildings, museums, and recent urban developments.

However, a certain "coolness" and detachment by Western students was perceived and ADU students complained on this regard, worrying that perhaps they were acting improperly despite all efforts spent to make their colleagues feeling welcomed. Apparently, the heterogeneity of the group and their belonging to different nationalities seemed to suggest the contrary, aiming instead to a multicultural exchange. Almost surprisingly, even students who had behaved openly and friendly during videoconference sessions seemed restrained and blocked with their hosting colleagues. The occurrence of this sort of "cultural shock", and defensive strategies to deal with, could be explained by the fact that it was first time in a Middle East country for most of them, and despite already accustomed with imagery of Dubai and Abu Dhabi as global tourist destinations, they weren't with Al-Ain's, which conversely presents an unexpected traditional aspect. It should be added also, that persisting mind-sets largely diffused by popular mainstreams play a role in this cultural misunderstanding, insisting on outdated clichés about Arab people and the Middle East still belonging to colonial era. The UAE is nowadays recognised as an advanced modern country extremely tolerant towards cultural and religious diversity, with almost 80% of population composed by Eastern and Western expats employed in all fields of activity, from industry to research and education.

In this regard, this preliminary phase of excursions proved extremely useful in experiencing first-hand the UAE's social and cultural backgrounds from a privileged point of view, very different from the imagery usually associated to an artificial paradise conceived for affluent Western tourism. Such full immersive experience reached an epiphany in coincidence with a desert excursion, originally programmed as last pre-workshop activity. Remembering Baudrillard's desert of simulacra[3], the emptiness and remoteness of the place, paired with the tabula rasa of visual stimuli, apparently acted as sort of breakthrough experience, leaving students with a mind-bobbling effect. Departed quite exhausted by intense activities of previous days, students returned energized and motivated, behaving as a cohesive group, displaying a completely different attitude between each other, and positively engaged toward the incoming task requested for the coming workshop (Figure 2).

Figure 2. Desert excursion (photo credit by Olivera Milosevic)

THE WORKSHOP

The three-day workshop held from 3rd until 6th of February was arranged at Al Qattara Arts Centre in collaboration with the Department of Culture and Tourism of Abu Dhabi, which gave an enthusiastic support to this project in the person of the Director, Mr. Ahmed Barzaiq. The Centre is located in the lush context of Al Qattara oasis, within the recently restored Binʿ Ati Al-Darmaki House, a traditional mud-brick tower and residence dated back to beginning of 19th century AD and currently used as art gallery, exhibitions, and studios for art classes.[4] There, students attended a series of introductory lectures held by Mr. Mohamed Khalifa and Mr. Mohamed Al Dhaheri (DCT Abu Dhabi) about Al Ain's archaeology, history, and architectural heritage; by Ms. Diane Thorsen and Ms. Julijana Mitic (Perkins + Will ME) about current trends and sustainable architectural projects in UAE and abroad; and by Mr. Stephen Goldie (Al Ain Municipality, Town Planning Sector) about current improvements in Al-Ain's urban planning and design enhancing city walkability. Seven working groups of three students each, mixed between the two universities, were therefore formed and briefed, requesting to elaborate in the following 24 hours, and without any support from digital devices, an original project proposal for an improvised off-grid urban installation, to be located within the site previously analysed for the Fall semester's project, and realized with materials locally sourced and environmentally sustainable. Finally, the abovementioned spirit of collaboration and cohesiveness emerged during the design process, internally to each working group and in between groups as well, fuelling a positive healthy atmosphere of competitiveness and mutual support alike. (Figure 3)

Figure 3. ADU and TUW students at work in Al Qattara Arts Centre (photo credit by authors)

Their final seven projects and scale models, presented and critically discussed with the examining committee composed by the paper's authors, Mr. Al Dhaheri, and Mr. Goldie, revealed a successful heterogeneity of knowledge and cultural backgrounds, showing insights from which emerges the understanding, assimilation and re-interpretation of UAE's physical, cultural and social context, mediated through the collaborative work and cultural exchange intervened between participants.

Therefore, the Workshop experience officially ended with a visit to ADU Abu Dhabi Main Campus for the final presentation of workshop's outcomes, attended by all faculty and architecture students.
As conclusive gift, TUW's students felt to thank ADU's colleagues with an additional presentation, narrating through pictures their emotional experience.

CONCLUSIONS

During the workshop, students established friendships that are enduring till today. We are quite sure that the deepest memory that our students will preserve of this experience, and actually the most important one in our opinion, is that nothing can substitute the personal experience of places and peoples to understand and accept their uniqueness and diversity. Professionally and academically, this is the one and only basis to establish a fruitful and positive collaboration. Nowadays, where boundaries which should be physically removed yet still tangibly existing in worldwide society, can be overcome and superseded through such kind of activities. Sharing experience and getting introduced to each other culture is the most meaningful and significant way in pushing boundaries. Furthermore, the international workshop represents itself a powerful educational tool that deserves to be integrated as curricular activity in architecture and design programs, both at undergraduate and postgraduate levels.
On 15th of December 2018, H.H. Sheikh Khalifa bin Zayed, President of the UAE and Ruler of Abu Dhabi, announced that the year 2019 would have been celebrated as the Year of Tolerance, remarking the UAE's role as global capital for tolerance since its inception on 1971. As organizers and supervisors of this educational experience at beginning of 2019, the message of engaging enthusiasm and cohesiveness transmitted from this heterogeneous group of 21 students belonging to 16 different nationalities from Europe and Middle East, has represented for us the most encouraging and positive example how much knowledge, cultural exchange, and mutual understanding of traditions and social customs can work not only for the betterment of the tangible built environment, but also in fostering and hopefully improving the intangible values of our globalized society as a whole.

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NOTES

[1] Paolo Caratelli et al., "Al-Ain's Cultural Landscape: Identity, Innovation and Sustainability in a Challenging Economy", *IRSPSD International*, Vol.7 No.3 (2019): p. 50
[2] Actually, in between students missing to interact during videoconferences very few decided to drop their participation to the workshop.
[3] Jean Baudrillard, "Simulacra and Simulation", *Selected Writings*, ed. Mark Poster, Stanford University Press, (1988): pp.166-184
[4] https://abudhabiculture.ae/en/experience/culture-centres/al-qattara-arts-centre accessed on 05/08/2019

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GEODESIGN AS ITERATIVE ANALYSIS AND DESIGN/PLANNING PROCESS TO FACE PRESENT AND FUTURE CHALLENGES OF CLIMATE CHANGE IN THE FIELDS OF URBAN AND LANDSCAPE PLANNING

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INTRODUCTION

„Professions should profit from each other in an age increasingly troubled by the blinkers of specialization. Designers and renewers of cities, especially, must have curiosity and peer into many procedures.“ [1]

To face an omnipresent and overarching process of climate impacts and climate change, we need to understand, design and plan our environment in a holistic way. But professions are not omniscient. Architects, landscape planers and designers are experts in their scientific field of work. Thus, we need a workbench to improve our perception to understand the space we plan in context of climate and climate change.

Within the research center "Climate Dynamics, Space + Object", we start to build an iterative analysis and planning process, considering the dependency of environment and design.

Climate Dynamics

Climate is a dynamic and an omnipresent part of our environment. The term climate dynamics is a linear planning response to climate change while using individual geographical and scaled assignment. The understanding of climate dynamics as a process enables the individual and local assessment as well as spatial translation of climatic principles of actions and influencing factors. The term dynamic expresses the possibility to change climate conditions in a positive (or negative) way, while the term climate is not under isolated consideration. Climate must be understood as an integral parameter of the planning and design process and not as an upstream or downstream links of a chain of measures. The handling of climate dynamics should create quality habitats.

With the importance of regarding the omnipresence of the climate, it is not any less important to understand that climate change and climate adaption are not fixed events or effects, rather they are dynamic processes.

Design

The design process in architecture and landscape architecture, with its recursive and reflective decision-making intervals, is capable of transforming multi-layered target dimensions into shape.

"The design process integrates experiential science and artistic elements […]". [2]
The basis for this is an interpretation and prioritization of the individual target dimensions, which makes it necessary to synergistically intersect non-comparable contents. Not immediately measurable contents, such as atmospheric or aesthetic elements, are thus negotiated with data records. Successful examples can be found in the intersection of rainwater management systems with open spaces, such as on the object level the Tanner Spring Park in Portland, on the level of a master plan, the „cloudburst strategy" of Copenhagen.
To process the entirety of the target dimensions, the Design process uses rules from other disciplines.
If we design a path construction, then we recognize and respect the material, the thickness, statics, foundation and much more technical and not pure design aspects. So, why does it seem so difficult to integrate climate aspects into our design process? What is the difference to other aspects and disciplines?
We summarize that for technical aspects like statics, foundation, etc., we have rules, which were defined by technical experts and derived from experiments or their expertise. Thus, we can or have to use these rules within our design process without having the specific expertise. If we plan with variables, like static calculations, we work closely with a structural engineer to combine form and construction to reach a high-quality result.
However, outdoor climate conditions are never the same, which makes it nearly impossible to define climatic rules we can easily use in the design process. Thus, we need a workbench, to include dimension of climate dynamics into the design process.

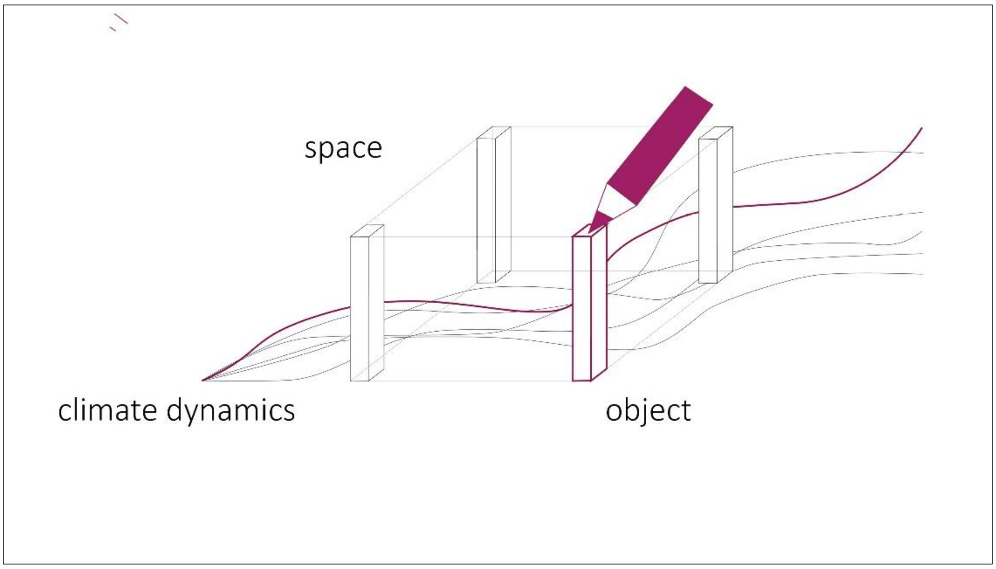

Figure 1. Interaction - Climate dynamics as an omnipresent dimension of various planning and design scales. Furthermore, structural intervention means influencing the climate.

Space & Object

Fields of action arise from various scales, from regional planning, through district development to the detail of object planning and choice of materials. This is necessary because scale levels are planning constructs. Rather, object and space are interdependent. Objects create space through their arrangement. Spatial planning forms the location for an object. Therefore, climatic effectiveness does

not only arise on the urban planning level, but also on the planning level of the object. For example, you can influence the dynamics of the climate by vary the material, the surface structure and the arrangement. That is only the climatic point of view. The planning of space and object includes a variety of factors that are incorporated into the design. Thus, the material question is not only subjected to a climatic perspective, but in turn also influences, for example, freedom from barriers, the expression of value, and orientation or the genius loci.
The challenge is to transform the climatic impact to a positive effect, but at the same time we have to estimate how strong the climatic impact actual is. This requires a reflective, cross-scale planning process.

Planning Scales

Derived from the first background topic of climate dynamics, translating climate relevant information into the “Space” must always regard and respect the typical planning / design scales.
Depending on the point of view, this means determining on which scale we operate – the climate scales and the climatic issues can vary. To avoid scientifically incorrect decisions, different climatic planning scales don´t have to be mixed but must be reviewed in consideration because of their interdependencies.
For example: A meso-climatic analysis like the Urban Climate Map, which gives us information about the citywide overheating potential, cannot be zoomed in into the building or block level, which are located on the micro-scale level. Because the spatial resolution is very high, this leads to misjudgment, because the urban climatic issue is changing.
Not mixing the scales does not mean that there are no interactions or dependencies. On the contrary, the climatic scales have strong linkages to each other, which need to be respected within the planning and design process but also during the climatic analysis.
With an increasing detail level or smaller scales, the climatic questionnaires focus more and more on human-specific issues, like outdoor thermal comfort.

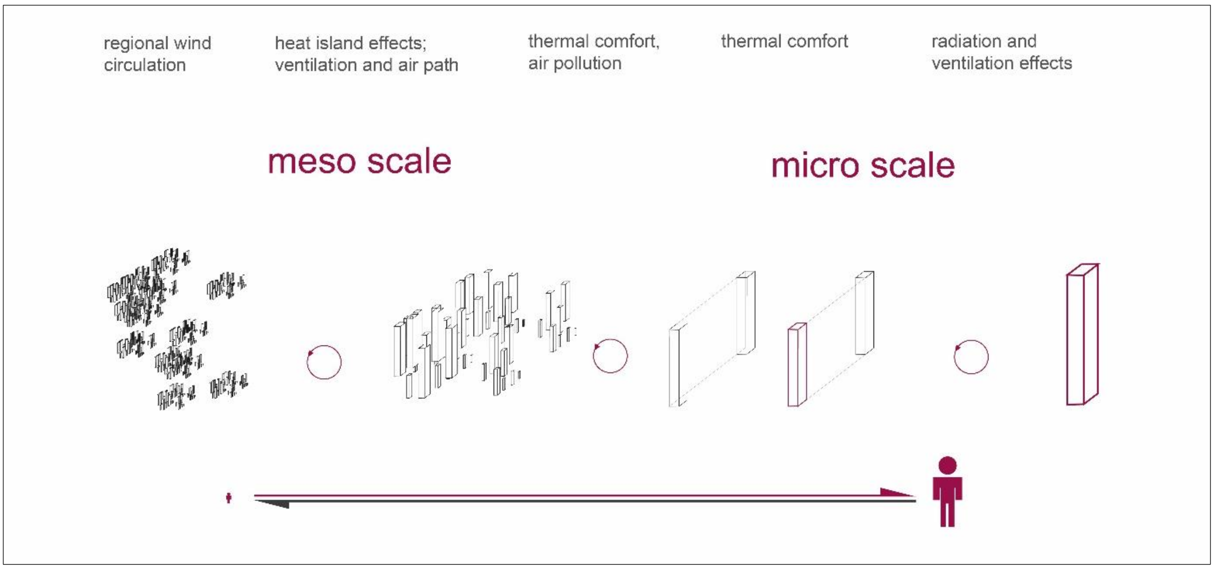

Figure 2. From region to object. Mutual relation of space and object in built environment and their climatic meanings.

Questionnaires & Goals

This leads to the question of how empirical results of research can be translated into an individual space or object. For example, is any vertical building greening per se good, because vegetation binds fine dust and regulates the climate of the façade? What relevance does the resource consumption of material and water have? Is radiation always negative and shading positive in urban areas? We think such statements cannot be generalized. Rather, it should become the goal to use the complex and broad data situation and to negotiate and reflect it locally. We need processes that enable such a planning culture and systems that facilitate such data analysis.

The sectoral separation between the disciplines is a common process in Germany and many other countries, which can ensure a bright and high professional expertise but also runs a risk of losing information about interdependencies and interactions or leading to misjudgments. In other words, the sectoral process supports the parallelism in planning and design, which can curb scientific exchange and increase the potential for conflict. Furthermore, design projects are (usually) detached from the specific climatic factors which are prevalent at the planning locations.

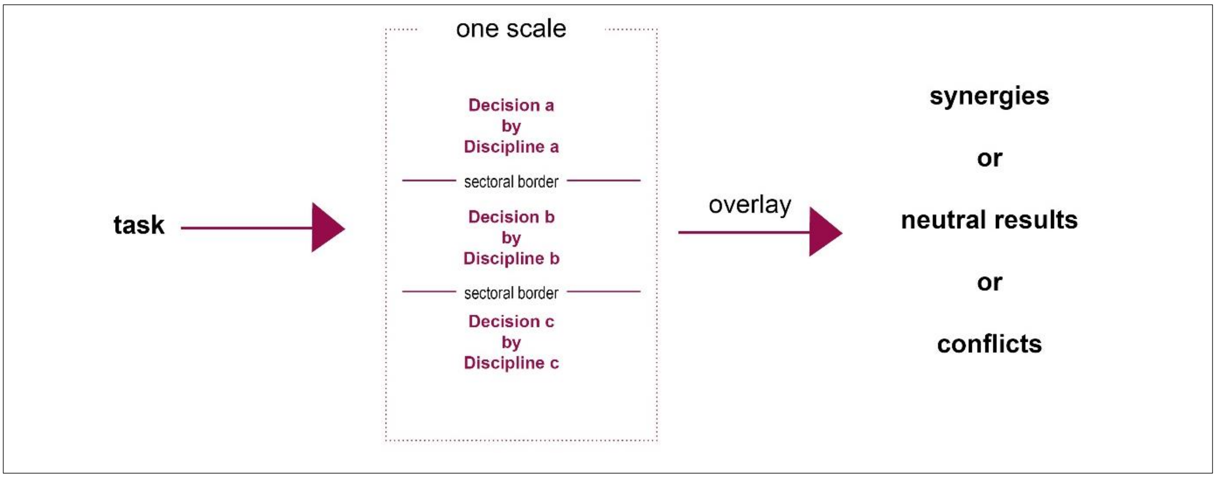

Figure 3. Sectoral separation between disciplines can ensure a bright and high professional expertise but also runs a risk of losing information about interdependencies and interactions or leading to misjudgments.

In order to be able to work adequately with the changing climate-induced framework conditions and plan for them in advance, methods and strategies for sustainable planning and development of urban and rural areas are needed, which take into account the dynamics of the climate as a decision-relevant factor of planning and design. This view leads to the question of how, instead of a reactive and segregating planning process, an acting and connecting planning and design method can be created. We need a workbench to improve our perception and to refine our senses to understand the space we are planning for in context of climate and climate change!

If it is possible to establish a strong linkage between the disciplines, conflicts should be detected in advance or, in a best-case scenario, synergies can be generated and improve sustainability.

Which leads to our main objective to intersect design, object, climate and the space dimension within a geographic information system to utilize and visualize complex planning content.

METHOD

At the Department of Landscape Architecture we examined a solution path for an integrative consideration of climate dynamics in the design process, based on a dual teaching system.

The experiment started with two student groups. One focused on design, and the other focused on climate and spatial aspects. The main objective of the design project was to develop additional vegetation related constructive design solutions, which were not bound to the need of direct surface access. The objective of the second project group was focused on the detection of local- and microclimate hotspots as well as areas with spatial planning relevance. In the beginning, both groups didn´t know about the future cooperation between each other, and they were free in their way of spatial analysis. Both projects were fixed to the same research area, the campus of the University of Kassel (Germany). The area is often used as a real-world laboratory for the integrative project work. The newly emerging North Campus of the University of Kassel and its linkage to the South Campus, which was developed in the 1970s, provide an exciting field of research.

After a first phase of separated and parallel work, both projects were connected to each other to establish redundant analysis and design iteration phases among the students.

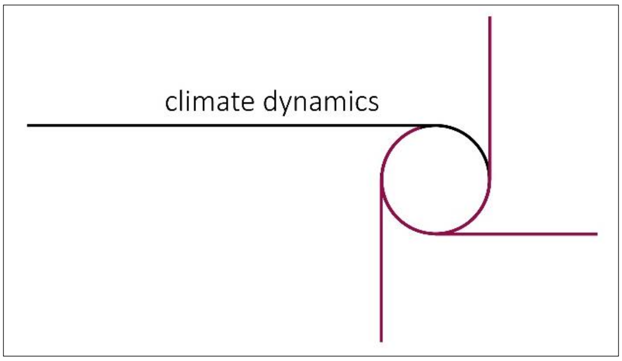

Figure 4. Climate dynamics as integral part of iterative design process.

Employing modern geographic information systems (GIS), we explored how to interlock the expertise of environment with the planning and design process. The combination of the two student projects served as an experiment to anchor and implement this way of sustainable planning and design in our manner of thinking. Thus, basic design decision-making scenarios, such as the positioning and alignment of the design draft, were jointly reviewed and optimized through GIS-based queries, while climatic requirements, like the choice of plant leaves in response to the radiation, became decision-making parameters in the design process and were negotiated in the team.

In the further course of the experiment, the students were shown the possibility of integrating the query mask to deepen the iterative design and analysis process. By nesting multiple "If-Else" dependency functions, the query masks allow the selective capture and presentation of complex causalities from large and divergent datasets.

In summary and to capture the effect of the method of operation, the experiment was divided into three phases.

Table 1. Summary of project / experiment phases

First Phase	Subject-based analysis and evaluation; required an analysis from the respective subject-related perspective. No exchange between project groups and of project objectives
Second Phase	Starting of interaction by iterative cycles as a part of planning process; Students were bundled together in small groups, and common planning goals were defined.
Third Phase	Evaluation of work results and workbench Evaluation phase after the end of the semester to evaluate the work results and the work process

Iteration loops are a well-known approach for matching and interweaving the expertise or goals of different actors or in our case of disciplines. In time-recurring sequences, work states and goals are repeatedly reconciled, reflected and renegotiated. Problems and potentials are recorded and addressed in subject-related individual work until the next exchange. The effects of this approach were considered as suitable to anchor climatic objectives in the design process. The project work of the two student projects served as an experimental field for examining this approach.

RESULTS

Regarding the first phase of the experiment, the following aspects were observed. Different design ideas interact with the campus space. Mainly they were attributed by sociocultural and ecological points of view. Meanwhile, without any restrictive rules the results of the climate group primarily focused on typical climatic issues, like wind and solar radiation without considering a potential planning context. These results seem to be similar to the separation of planning and analysis mentioned before.

As interim result between phases one and two, the climate group was invited to give a guest review on the first design ideas and a short introduction into climate-related issues. Depending on their basic expertise, both groups made design and analysis decisions. Later on, the meaningfulness of the decisions (e.g. tree shading) was refuted (see phase 2). Based on the guest review, the design group had to present their further developed designs. For the students, it was quite difficult to integrate the singular notes on climate-relevant issues into their design objectives. However, the climate group only focused their reviews strictly to climatically optimized goals, without considering the evolvement of the design ideas.

Based on that, the independent workflow of both groups was dissolved. The second phase started. Due to the problems in the starting phase, the groups started to work together to create common goals. The students of the climate group transferred the design objects into digital models, which were integrated into the GIS. This first task concerns the understanding of the design idea and a clear communication of the design goals and contents. The geographic information system immediately became a communication and work platform, as decisions could be tried and made visible during the conversation. The cooperation was characterized by recurring meetings and individual work packages. It seems that we can interpret this behavior as an iterative planning cycle. We have recognized phenomena that seem to be relevant for an integrative approach of climate, dynamics and open space design. Ostensibly, climate-relevant design decisions (tree setting, artificial shading) have no influence on the climatic situation of suburbs. Conversely, it has become clear that in some cases climatically conspicuous situations (e.g., increased radiation exposure of parking areas) are in some cases only active in microclimates and play a minor role in the correlation with landscape architecture goals. To clarify this planning relevant statement, the results of one merged sub-project group seem to be exemplary of this finding.

Both groups focused on a wide-open parking lot area. While the climate group identified the problem of the high solar impact on the parking lot next to the campus buildings, the design group tagged the aspect of orientation as the main issue and wanted to construct structures with visual axis to each other, as a portal for this campus side and as landmarks for guidance. Under climatic aspects, a high shadow percentage is needed to reduce the overheating risk for the parking cars. But exchange in the group shows this was not compatible with the original design and would lead to loss of parking space. Thus, a simulation of climatic effects helped in the further process. Because the climatic impact of the high solar radiation is limited to the parking lot area, the climatic aspect was not planning and design relevant regarding this design idea. But, because the constructions should be used for orientation as well as a meeting place, three iterative analyses were performed. The first one calculated the best location for the constructions to reach the highest number of sightlines. The second one calculated the best location for the construction to reach the best shadowing effect. The third one was a GIS-based network and reachability analysis to calculate the walking distance in minutes and the catchment area. Finally, for this design, several GIS analyses played together to find the optimal locations for the constructions. Through the iterative loops between design and analysis questionnaires of position, orientation and dimension of the constructions could be solved. Again, the calculations were performed for summer (the 21st of June), winter (the 21st of December), and for spring and autumn during the equinox. The iterative loops helped to get the optimal position, size and alignment for every structure. Intuitive design-focused decisions were reflected by geodata analysis. To summarize the work process, we can state that the students began to intuitively develop goals and intentions as information and thus finally translate them into data as decisive step to use the geographic information system not only as a cross-cutting analysis tool but also as a design tool.

With our design, every time we change outdoor climate conditions, these effects must be analyzed again. Now it seems obvious why climate dynamics cannot be found in the classic planning and design process.

Scientific expertise is needed to interpret the locally specific climate characteristics and to estimate the interactions with the design idea. Now, how can we provide climatically relevant information for a design process so that planners and designers can use them?

CONCLUSIONS

Increase interdisciplinarity between university departments – from students to professionals. Sometimes it is much harder than it seems. Because of the strong scientific expertise which is bound to a specific discipline within the university departments, the normally clear responsibilities become unclear at the outset. But a well-functioning interdisciplinarity generates immense added value, which can be used in education as well as in acquiring third-party funds for new research projects.

Broadens the scientific horizon of planners and designer and sharpens the awareness of their own environment – both indicate that the more we take into account our environment the more sustainable knowledge we can generate. Especially the acknowledgement of outdoor climatic issues enables an even more complex view of the space, because the strong environment interdependencies are linked by the climate.

> Regarding the assumption put forth in this paper, the results of the experiment indicate that the integration of climatic effects in the design process requires at least two fields of expertise and should not be done only by a designer himself. Maybe in addition to digital application development we have to train planners with a climatic and GIS focus as an independent group to promote a common design language.
>
> The iterative process should not be understood as a "one-way street". The redundant phases of the iteration are indicated as a more effective approach to this research question. The geographic information system appears as a suitable tool to accompany the interdisciplinary iteration. The overlay analysis of design and climate data as well as the visual presentation of (intermediate) results validate the iteration process. Due to the proposed model an intersection and negotiation of the individual aspects can take place.
>
> However, the climate effects must be integrated but should not determine the design process. A negotiation or a thematic intersection is not always possible. Under certain circumstances, decisions must also be taken that lead to losses of planning factors in the planning result. This aspect is not new, but an essential content of the heuristic decision-making cycles of the classical planning culture. Rather, the system ensures that planning-relevant factors are not excluded. This is possible because the geographic information system can link complex and large data sets, which cannot be captured and analyzed in a pure analog workflow. Furthermore, many designer scenarios and decisions can be simulated semi-automatically in a short time and support the planner in his decision-making.
>
> We need to develop tools that help to integrate complex data into the design process, without losing relevant information because of a strong simplification of relationships.
> GIS can be a useful tool to override the multi-layered target dimensions and to support the design decisions through simulations. In order to avoid linear and technically separate decision sequences, this also results in the requirement to integrate design aspects into the digital system. In addition to the fact-based decision, influencing factors of the metalevel always play a role. For design content to be part of the climatic analysis (digitally automated), it must be translated into data. The landscape architectural expertise and decision-making is to be understood as a data package / or must be converted into a data set. In our experiment, this was done intuitively within the common iterative feedbacks. In order to be transferable and valid, it is necessary to develop comprehensible and transferable approaches and methods for this step.

In summary, a clear need for research can be formulated. Only if one succeeds in transforming essential design content into data sets, the possibility described here of a simultaneous, cross-cutting and data-supported analysis and design process can be transferred to other complex planning objects. A promising approach could be the correlation of content and dependency queries with a geographic information system.

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Education, Design and Practice – Understanding skills in a Complex World

AMPS, Architecture_MPS; Stevens Institute of Technology
New Jersey / New York: 17-19 June, 2019

EXPLORING COMPLEXITY IN DESIGN: AN ARCHITECTURAL STUDIO EXPERIENCE

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INTRODUCTION

Architectural design education has a complex structure consisting of various components. Its requirements are in a continuous motion of change, being influenced by the social, cultural and technological developments in the society. According to Combrinck (2018), balancing the design process with a grounded knowledge base that responds to research engaging daily issues at their core has become imperative. For architectural education it is indeed crucial to maintain balance between providing the skill development and creativity augmentation of the students and supporting their pedagogical evolution related to real world practical problems. For this reason, educators have the responsibility to generate novel methods and approaches in the design studio which is the heart of architectural education.

Salama (2005) criticizes that most design studio teaching continues to provide students with little understanding of the value of design as a technique, a process, or set of purposive procedures. In an attempt to provide a better understanding of the value of design, authors of this paper formed a design studio program where the students were introduced to different aspects of design in a holistic manner. An integrated approach in the design studio education was embraced as the teaching method where the different components in design such as building program, urban and historical context, sustainability, and structure were merged into each other to come up with a productive learning process for the students throughout the semester.

INTEGRATED APPROACH AND ARCHITECTURAL DESIGN EDUCATION

Integrated approach in education basically imitates the complicated nature of daily life with its multi-faceted structure bringing together different aspects of a given subject. Integrated approach can also be observed in design itself, bringing various aspects of design together when dealing with a design problem. Bashier (2014) describes the design activity as a process based on positive theory and implemented through rational thinking and creative skill. Jones (1992) aimed to reconceptualise the design process, so that intuition and rationality could co-exist instead of having one exclude the other. Grout and Wang (2002) suggested, the integrated design paradigm can be understood as a system of inquiry within which a specific design strategy is framed.

One of the important notions in architectural design and planning is to simulate life with all its complicated nature. Therefore it is important to integrate necessary aspects of the design problem into each other within a convenient frame. Teal (2011) states that the simultaneity of situations and their inherent relational ambiguity affect the way we think about design and the environment, as the groundwork for architecture to become an ethical undertaking—one that is connected to life in its fullness.

Considering architectural education, integrated approach turns out to be an appropriate methodology as it coincides with the dynamic and multi-faceted structure of architecture and design. Architectural education is not restricted to physical building design, it also incorporates value system, philosophy, sustainability, technologies and other related areas (Ibrahim and Utaberta, 2011). Design education requires a structure that directs the student designer toward multi-dimensional and dynamic thought processes (Ketizmen and Turgut, 2017). The design studio as the core of the architectural design education, needs to address these necessities about that structure within its contents, as well as its environment.

Integrated approach in architectural education may emerge through different approaches such as the integration of different disciplines related to architectural design; merging theoretical and practical knowledge into each other; employing conventional sketching techniques and computer aided tools when dealing with a design problem; or the integration of various aspects of design like functional requirements, context, structural issues and sustainability concerns. The reflections of the use of integrated approach in design studio courses are visible on various studies: Salama (2005) employed integrated approach in the studio within the context of a process oriented design pedagogy. Another example is the research-by-design studio, which is a design studio formed by Devisch et al. (2019) that aims to integrate education and research into each other. In another case study, Iordanova et al. (2010) used the strategy of interdisciplinary team learning in the context of an integrated design studio.

In the case study conducted within the scope of this paper, authors interpreted the integrated approach in architectural design education through different aspects of design which create a complex design problem by intersecting with and overlapping onto each other. The studio process was available for integration through the design topic and its functional requirements, urban and historical context, sustainability issues, and problems about structure and the construction process.

COMPLEXITY IN THE DESIGN PROBLEMS

Design problems are complex and ill-structured, and the nature of ill-structured problems is difficult to describe using traditional theory because they are less definable, and more conditional and problematic (Wilson and Cole, 1992). These kind of problems require a complicated process of thinking consisting of phases such as analysis, interpretation and synthesis. Components that compose the complexity of the design problem are either related to context (such as complexity of the city, and functional requirements), or the design process (such as complexity of structure, construction methods, and sustainability).

Complexity of cities

Complexity of cities, has been a major issue in design and design philosophies, especially in post-modern approaches, in the age of globalization. Developments in urban thinking and city complexity, starting with 1960s, can be followed through studies of theorists like Jane Jacobs, Robert Venturi, Peter Blake, Colin Rowe, Kevin Lynch, etc. Theories of complexity in architectural and urban areas, often combine the city and the nature / biology, as in the example of Jacobs's approach. Jacobs argues applicability of the notion of complexity developed in life sciences to urban philosophy. In her theorization of the city, relationships of part to whole, new to old are also significant concerns. Similar studies in the domain of "complexity of cities", demonstrate that properties of natural complex systems can be used to understand and evaluate the properties of cities, in terms of being open, complex, bottom-up and chaotic (Portugali, 2016). Venturi however develops the consideration of multiple readings involving literary criticism, pop art and the gestalt theory (Laurence, 2006). Architectural features, incorporation of pop items into architecture, functionalism, are all acknowledged while questioning the issue of city complexity in Venturi's studies.

Complexity of Functional Requirements

Determining the functional requirements of a building is one of the keys to design. According to Kelly et al. (2003), it is the process of gathering, analyzing, and synthesizing information needed to support decision-making and decision implementation at the strategic and project planning stages of the construction process. Architectural programming is a complex process in its nature with different components and determinants. Nowadays, it is getting even more complex under the effect of flexibility and temporariness of functions. According to Zwemmer and Otter (2008), today, architectural programming is considered to be an iterative and social learning process about an organization and its spatial needs. Accordingly, design processes are getting more complex, depending on the amount, diversity and interconnection of functions expected from architecture.

Complexity of Sustainability

The profession responsible for the design of every built environment, architecture appreciates sustainability as a primary requirement in design. Morelli (2013) recognizes sustainability as a condition of balance, resilience, and interconnectedness that allows human society to satisfy its needs while neither exceeding the capacity of its supporting ecosystems to continue to regenerate the services necessary to meet those needs nor diminishing biological diversity. The definition describes the complex nature of sustainability. Furthermore, the three-pillar model of sustainability which brings environmental, economic and social aspects of sustainability together, provides a comprehensive understanding of sustainability with its complex structure. In architecture, endeavoring to adapt the principles of sustainability into the design means significant increase in the complexity level of the process.

Complexity of Structural Issues

Summarizing the relationship between structure and architectural form, Viollet Le Duc stated: "Impose on me a structural system, and I will naturally find you the forms which should result from it" (Bressani, 1989). Structure has a big influence on architecture, defining the limits and form of the space. Using structural elements as design tools in a building also refers to the holistic nature of the discipline by bringing the three important principles *venustas*, *utilitas* and *firmitas* together. Different types of structures such as ribbed structures, arches or framed structures help with creating the general form of a building frame. Within these structural models, architectural elements and supporting glazing elements as smaller structural modulators, may aid further with the creation of the building form.

Additionally, modules and prefabricated components may also be utilized when designing the structure together with the form of a building. Prefabrication supports the design and construction process with ease of application. Modulation generates patterns that potentially introduce variety, rhythm and hierarchy, and generally increases visual interest (Charleson, 2005).

All these models and components of structure as design elements serve well to emphasize complexity in the design process.

ARCHITECTURAL STUDIO EXPERIENCE

This study presents 3rd year architectural design studio work as a case study. The aim of this architectural studio is to raise awareness on mixed use building design approaches in an urban context. In order to involve the students in the multifaceted structure of a complex design problem, the principles of integrated education system is adapted to the architectural design studio process by using various resources and experiences.

The students are expected to design a mixed use complex, bringing together commercial, recreational, cultural functions and facilities. Each student is encouraged to develop his/her program according to the site, concept and proposed scenario.

Complex Nature of the Project Site

Cities and city spaces are continuously changing systems, involving material components and human components, tangible and intangible cultural elements that are closely related with architectural and urban design. The city of Istanbul, almost throughout its whole history, has housed citizens of different origins, keeping the city culturally and economically related to the outer world, and reserved a potential for variety and continuous change (Tanyeli, 2005). It had absorbed and reflected a heritage of multiple identities, cultural traces, urban and architectural features rooted in its long history of settlements. The physical environment of Beyoğlu (Pera) region, especially Istiklal axis, was characterized as an important center of modern life, mainly in the 19th and early 20th centuries, a period in which the dissolving power of the Ottoman Empire, the growing dominance of European capital, influence of Westernization, reforms and efforts for the new regime, metropolitan growth, were all parts of the setting. New building types, new functions, eclectic and new styles, and new technologies were brought together in the architecture of Istiklal Street. Rows of richly ornamented facades, in Neoclassical and Art Nouveau styles, first appeared on “Grande Rue de Pera”, with the early version of its name. This architecture, these buildings were produced as the requirements of a modernizing society, as the outcome of chaotic modes of social and economic life of the period. Beyoglu had developed into a centre of social, cultural activity, entertainment, and shopping, besides the residential buildings it housed. Some deteriorated buildings have either been restored or replaced with new ones in time. In its present stage of growth, the area still acquires a cosmopolitan, complex nature, holding potentials and conditions that attract people; citizens and tourists.

Beyoglu provides a medium where a variety of forms, styles, historical features, orders, colors, textures in the physical sense, and modes of life, culture, arts, fashion, history in social and sensual means meet one another. Commercial, residential, work, leisure functions, all mixed, in order or orderless, finished or unfinished, old and new, inner, outer, public, private spaces and buildings, in an environment of contradictions, borders, tensions etc, are all experienced together, creating a setting of complexity.

The project sites given to design students are located in Istiklal Street in Beyoğlu, Istanbul, Turkey as shown in Figure 1. Urban infill as a design strategy is required in this context. The design problem involves managing complexity in the city. Four project sites are selected along Istiklal Street that reflect the complex nature of the district including contemporary as well as historical elements within a wide range of building functions, and an immersive social and cultural structure.

Figure 1. General view of the project area and site locations (source: googlemaps)

Phase 1: Reading the place and the design theme

This phase starts with the analysis of the urban setting in general and within the defined limits of the site. The process comprises reading the genetics of space, the conceptualization of the ideas and their presentation.

Throughout phase one, the students received input from different related disciplines regarding the theme. Three main points of the design process were introduced to the students by lectures from professionals: "Infill design in an urban heritage area", "Prefabricated modular structures in construction", and "Sustainability in urban environment".

In one of the lectures, the students were informed about two similar contemporary urban projects were: The Peek&Cloppenburg department store in Cologne, Germany by Renzo Piano Building Workshop and Tamedia Office Building in Zurich, Switzerland by Shigeru Ban display extensive use of engineered wood, a carbon-negative material, in combination with steel in their structure. Their modular and prefabricated structural components helped minimize construction site area as well as site waste. Both projects displayed optimization of materials and structures. In particular, modular prefabrication techniques employed in both of them were emphasized.

Additional exercises such as a design vignette, a workshop on sketching, and an opinion survey were also utilized in this experimental studio.

The project sites are located within a historic setting under the threat of heavy speculative development. Therefore the instructors on one hand kept a more phenomenological view, on the other were aware of the development that could be described as "the generic city" discussed by Rem Koolhaas in the chapter "XL" of the book "S, M, L, XL." (1995).

Initial tendency of the students was to approach the context of their project with an emphasis on mimicry of the existing historic buildings. However, the instructors introduced other points of consideration which would lead to more holistic solutions reflecting the spirit of our time.

The studio instructors encouraged their groups to make shared efforts in documenting the state of their project context. As a crucial instrument of documentation a sketch seminar took place in mid-semester, in which the setting of the design was given as Istiklal Street.

Phase 2: Students' design proposals

The second phase starts with a volumetric proposal on the chosen site. Having become more aware of their project environment, students were lead to come up with proposals which contained space programs reflecting specific functions relevant to the documented facts about their sites. They were expected to realize the impact their projects would have on the existing urban fabric during their construction, occupation and public use. Effort was made to make the students' works both physically and socially sustainable. In other words, the spaces created would fit into the context convincingly and reassure the end-users' comfort. Finally, the submitted student work presented 3D illustrations, planning of spaces including the furniture layout, environmental and structural issues and response to the site requirements.

Survey

At the final stage, the students were asked to fill a questionnaire expressing their preference of primary project requirements that dominated their design decisions. The survey included criteria about the complexity of design. These criteria are listed as in Table 1.

Table 1. Survey questions about design decisions (source: authors)

Relationship with social structure	a	Cultural diversity
	b	Safety and security
	c	Gender equality
	d	Education level of the society
	e	Social innovation
Relationship with built environment	f	Date, style and construction techniques of existing buildings
	g	Scale and form of existing buildings
	h	Street and subdivision patterns
	i	Views, vista points and skyline
	j	Relationship with the surrounding buildings
	k	The building's overall form, shape and volume in your design
	l	The site use and setbacks in your design
Relationship with structure	m	Material and colour use in your design
	n	Structural system
	o	Prefabricated element use in your overall design
	p	Modular system use in your overall design

	q	The structure of your design to be observed / perceived on through the façade
Relationship with ecological sustainability	r	Building orientation
	s	Daylight use and control
	t	Natural topography and landscape elements
	u	Passive solar strategies
	v	Passive ventilation
	w	Recycled materials
	x	Rainwater / greywater reuse
	y	Alternative energy production

The results of the survey showed that one of the most important criteria for the students throughout the design process was "relationship with the surrounding buildings". 63% of the participants mentioned that the relationship with the built environment was an important criterion for them. "Cultural diversity" (56%) has been another criterion that was given importance by the students in terms of social structure, as the relationship with the natural topography and landscape elements was also a determinant for the students (52%). Regarding the structural issues, the most important criterion according to the students was "modular system use in overall design" (36%).

Assessment of the finalized student work

Final proposal of the students were assessed taking the integrated education approach influence into consideration as the output of the architectural studio. Moreover, the development of the students' awareness for designing in an urban setting stimulated by the characteristics of their sites was observed throughout the design process.

Several tendencies were noted among students' decisions. In some projects, the focus was on social, historical and physical aspects of the context, while in some, topography or the view gained priority in decisions about formation and orientation of the masses. Provision of natural light and ventilation shaped the architecture in some projects. Scale and forms of the existing building and environment provided hints and traces for the proposed buildings. In some cases, an architectural type and historical feature of Beyoğlu, 'the arcade' was adopted and integrated to the project in a re-interpreted form. Some students highlighted prefabrication, modularity and elements of structure as main elements, whereas other ones emphasized pedestrian movement as the dominant factor of their design attitude.

Within the scope of the study, student projects were analyzed in relationship with the determined criteria discussed in Phase I of integrated approach to studio work. Accordingly, four priorities were highlighted during the evaluation of student work:

Built environment

Due to the strong historical background of the location, the relationship with the existing built environment has been an important factor in design. The students were mostly inspired by the scale and form of the existing buildings, and they wanted to form a relationship between their design and the surrounding buildings (Figure 2).

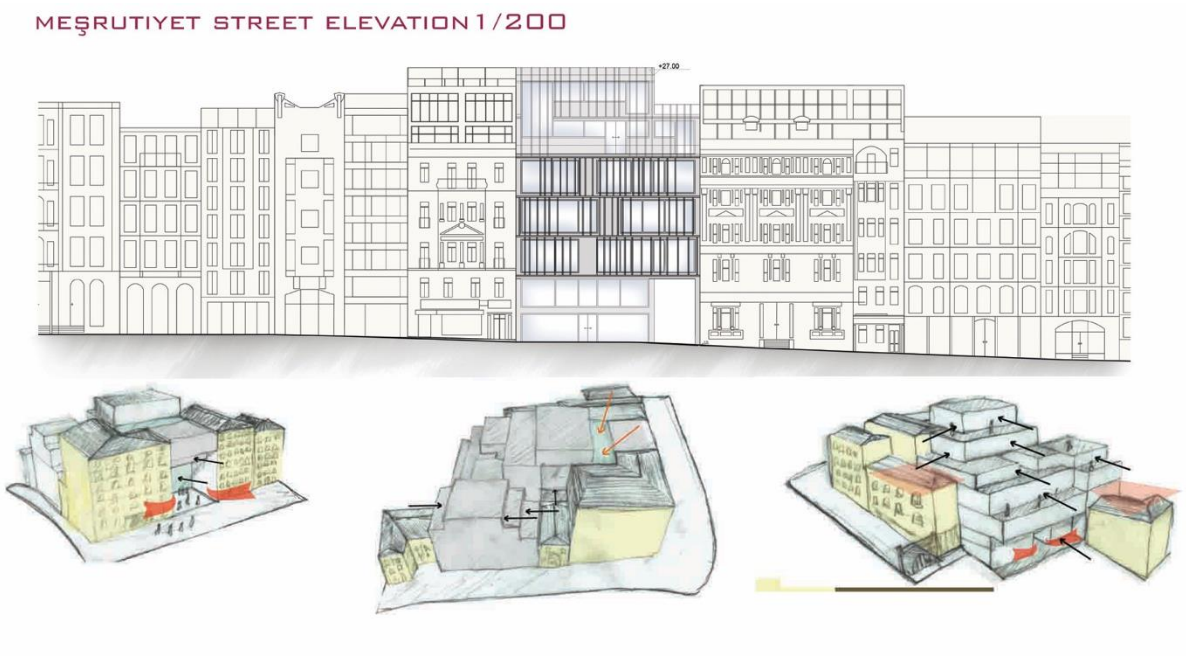

Figure 2. Sample student work referring to the relationship with built environment (source: authors).

The sites are located in a district where the efficient use of sea view could be an important contribution to design, so that the students tended to form the open spaces and openings on the façades according to vista points. Additionally, existing street patterns and pedestrian movement have been influencing factors in their design.

Social structure

The students' attitude about the social structure of the district outcropped through their decisions on the functional requirements. The building programs mostly formed in harmony with the existing social needs in the district, and in some cases, students wanted to integrate novel functions into their programs which they thought were beneficial in terms of cultural needs of the district (Figure 3).

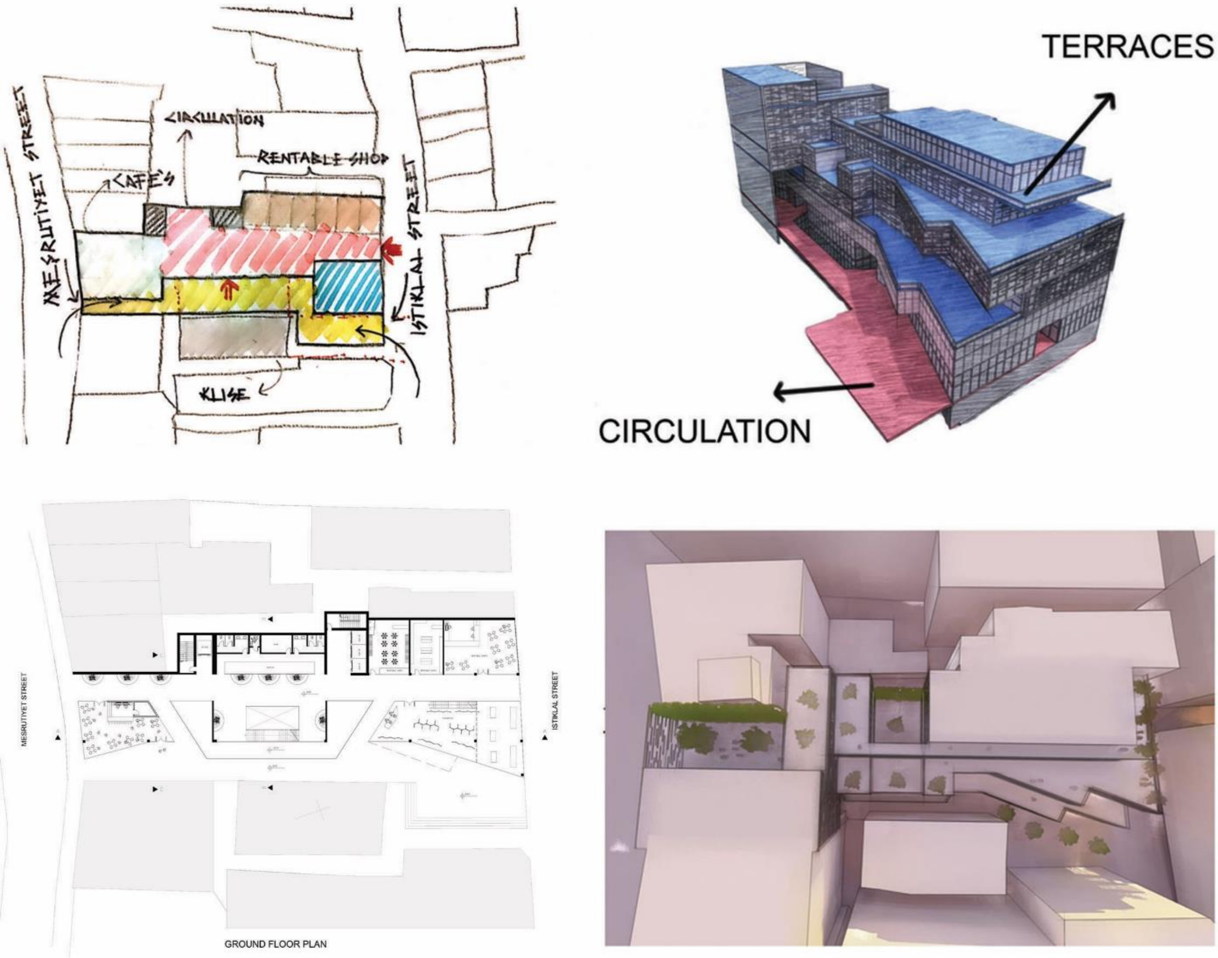

Figure 3. The students' proposal regarding social structure (source: authors)

The most commonly referred novel functions encountered in the building programs were culinary arts workshops and co-working spaces. Traces of these functions have already been started to show up around the site locations, but students wanted to tackle with the requirements of these functions more comprehensively within their spatial organizations.

Ecological sustainability

Ecological sustainability and energy efficiency have been prominent elements of design in the recent years. Their reflections are also visible in the student projects of this case study. The students have given importance to the use and control of daylight, mostly through the orientation of the building (Figure 4).

Figure 4. The students' proposal considering ecological sustainability (source: authors)

The relationship with the topography has also been important in terms of ecological sustainability, and many students tried to include green areas in their buildings in order to create a natural atmosphere within the dense built environment as a novel design attitude.

Structure and construction process

In addition to its crucial role in architecture, structure has been used as a design element by many students. Introduction of innovative structural as well as façade elements to the design was another observed motivation for the students. Additionally, the dense nature of the built environment and difficult conditions of construction around the sites guided some students to use prefabricated elements in their design. While some students made their design according to conventional methods, some others preferred new technologies materials and forms (See figure 5).

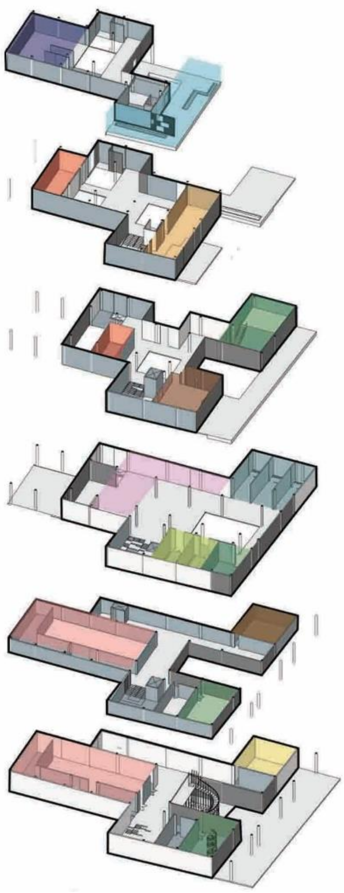

Figure 5. The students' proposal reflecting structure and construction process (source: authors)

Another tendency of design encountered in students' work was the use of modular systems. Modularity was available on the façade of the buildings, as well as on the layout. Grid plan, bringing together the structural elements and spatial organization in the layout is a representation of modular approach in design.

CONCLUDING REMARKS

This paper presents an implementation of integrated education approach into the architectural design studio. Studio instructors guided the students to deal with complexity in design using integrated design strategies. They tried to emphasize the complexity of urban context through the choice of project location and input by specialists as part of the integrated design approach. The level of complexity in design was high due to the simultaneity of situations as built environment, social structure, sustainability issue, and structure overlap onto each other at the same time.

During the design process, the students experienced multi-faceted and varying problems, so they developed their ability to interpret multiple factors and skills for complex problem solving. Their perception of complexity of the problem reflected on their proposals in various architectural means; functional, volumetric, topographic, structural, etc.

Students responded by producing programs of diverse functions. The themes ranged from entertainment to educational facilities; cultural to commercial functions. Additionally, as the outcome of the survey it was observed that each student emphasized different aspects of complexity in design. It was also observed that the students developed a sense of adaptive design approach as the reflection of continuous evolution of today's global city. The integrated design approach helped the students to cope with the challenges of different aspects of complexity in design.

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ANALOGOUS SYSTEMS AS A PEDAGOGICAL TOOL IN URBAN DESIGN

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INTRODUCTION

There is an evident question in academic pedagogical work: how can we teach urban planning and urban design in the contemporary moment when it is obvious that contemporary urban planning and urban design in general do not produce urban spaces where people feel at home? When we look at the majority of the global suburban and peri-urban environments, we need to admit that spaces turned into urbanized places are alien to humans.

In assuming this is a problem, we first need to find the cause which has produced the problem, as we believe that a known reason can lead to a solution of the problem. In the first part of the paper we attempt to define the problem as well as the cause of the problem by taking a glimpse at history, and in the second part we explain our proposal for a possible solution of the problem. The proposal has been practiced for 10 years now as a pedagogical tool within the belief that education is a basic step towards better solutions. It is based in the realms of science and art.

THE PROBLEM

Alienation from urban, suburban, and peri-urban spaces, as well as landscapes constrains the everyday life of people who inhabit or try to inhabit those spaces. Inhabitants cannot identify with places which do not consider all dynamics forming life. It is not enough for people to have houses and apartments to live in, and all the social security necessary. It is also not enough if a housing project involves the sustainability of resources as a core issue of the project, including nature and ecological approaches. Urban planning as a discipline, as well as urban design, has not been able to involve all dynamics into urban plans because it missed, paradoxically, at least one, space *per se.*

Urban planning

Urban planning became a scientific discipline in the last century, but if we look at it precisely as a scientific paradigm we find that since the first half of the 20th century it has developed into a compilation of other scientific disciplines like social sciences, economics, politics, geography, psychology, ecology etc. obviously with the aim to cover as many dynamics in space as possible.

Why then, as James Gleick[i] argues, have the models produced by economists, sociologists, psychologists, and urban planners – especially when they wanted to introduce strictness into the research of different systems changing in time – become caricatures of reality? Why have traditional urbanistic

analyses of urban sites, when studying and researching layers in space as demographic, economic, and ecologic layers, various uses, waters and floods, green systems, traffic, and many others – in order to get as much data as possible – and then via computer programs tried to formulate a strategy for the future development of a place, why doesn't all this effort lead to a realistic strategy?
The ultimate result is urban planning and urban design, which are not able to erase or even reduce the alienation from urban, suburban, and peri-urban spaces, and landscapes.

HYPOTHESIS

We will argue that urban planning as a discipline, as much as urban design, has failed to consider space *per se* as one of the dynamics constituting life. It seems as if urban planning has been dealing with space, but not seeing it.

Blind field

Henry Lefebvre[ii] stated that urban praxis is a blind field for an urban planner. The blindness is in the observation of urban spaces by the observer's eyes and concepts which were educated by theories and praxis of the industrialization. These theories and praxis have taught urbanists to think fragmentally and analytically. This has produced a reduced reality, therefore, the reality has not been seen.
Mental-visual perceiving of space has reductive power which reduces space *per se* into a homogenous and absolute system with a Cartesian 'common sense' which resolves space *per se* into *abstract* space that is a product of (mental) thought processes. It can be easily controlled by technocrats who consider such space as an available emptiness. They do not understand that space *per se* is not a product of a mental act. This is the reason why an *abstract* space, homogenous and hermetic, is self-destructive.[iii]

Responsibility of urban planning and urban design

We consider that urban planning as a discipline, along with urban design, must take a big part of the responsibility for the alienation from space because it failed, by utilizing a mental-visual perception of space, to realize that we have lost recognition of space *per se* over time. As such, space is not seen and therefore it is not a subject of consideration in urban planning. Urban planning involves thinking people and society, opportunities and strategies, economics, politics, nature, energy, material which is designed, housing, and the uses of public places, etc. All of these features are in space, but they are not the space itself. Space became a blind field of perception, and has resulted in missing dynamics. This is the paradox in which urban planning has found itself.
The lost recognition of space, and consequently the ignorance of its inherent characteristics might be one of the reasons that people do not feel at home in contemporary urban spaces.

When and how did this happen?

At this point it is necessary to make a comparison of industrialized contemporary space with space which Henry Lefebvre[iv] calls *absolute* space recognized in ancient Greece. If we take a look at an example of the pre-Hellenistic period like Epidaurus theatre (4th century B.C., 13,000 to 14,000 spectators), Dodona theatre (3rd cent. B.C., 15,000 to 17,000 spectators), and others we can see that the scene of the theatre is not just the landscape itself. The whole theatre with its auditorium embraces space. There is no doubt that space was then recognized as a divine entity where gods from Olympus settled down and protected people. Even more, the characteristics of space were considered to be features of divine creatures to whom temples were raised as a proof that humans had recognized space and its protectors.

But in Greek cosmogony there is an event where one of the Titans, Cronos, castrates his father Uranus. Cronos – Time castrated Uranus – Space. It seems that the consequences of this event did not hit the Greek world before the Hellenistic expansion. Was the Hellenistic expansion that point in history where the recognition of space got lost? In general, we can say that the history of man became a constant battle for land. Land became an object with strategic, political, and economic values. The divine space had been finally lost during the Enlightenment. Nature and landscape became an object of research and admiration on one side, and a profitable value on the globalized market on the other.

Modernism

The universal idea of modernism was an idea about social change, about an ideal society, freedom, and democracy which has already been dreamt about in theories and drawings by utopian socialists responding to the disastrous living conditions of working class in the 19th century. Modernism has produced innovative urban models for new towns and cities. The *Charte d'Athène* defined (only) four urban functions, separated from each other: work, housing, recreation, and traffic. Modernistic urban models anticipate living in airy greenery and sunlight to make conditions for healthy living in freedom for each individual, and that answer serious urban problems of the 2nd half of the 19th century and problems in the beginning of the 20th century.

We need to point out that all modern urban models consider the topography of certain sites talking about the characteristics of sites and landscapes. But deeper research of the models proves that in general they all treat space as an object. Space as an object can be redesigned by any technique to serve the idea. One of the early critics of modern urban planning was Eliel Saarinen. He was followed by many theoreticians and architects later in the 2nd half of the 20th century, e.g. the already mentioned Henry Lefebvre, Jane Jacobs, Kevin Lynch, and Christopher Alexander, to name just a few. They all criticized the two-dimensionality of urban planning as a process in which the complexity of space was ignored.

SCIENCE ABOUT SPACE

It seems curious enough that modern urban planning did not take into account other scientific paradigms like mathematics and physics, and their understanding about space developed in the same time. While in the 19th century scientific knowledge about nature of space was still mostly based on Euclidian geometry, Nikolaj Ivanovič Lobačevski, Janos Bolyai, and Bernhard Riemann found non-Euclidian geometry at the same time. Modern urban planning did not grasp the new knowledge about space, though in the early 20th century Albert Einstein disproved that space is an object or made of particles. He proved that space is not made of particles, and that particles influence space, and that space influences particles. We propose using the analogy of Einstein's ideas in that urban space is not made of architecture, but architecture influences space as space influences architecture. Moreover, that architecture should be created in such a way that the influence of space is not ignored. As Edmund Bacon said, "Architectural form is the point of contact between mass and space."[v]

In the 2nd half of the 20th century, knowledge about space was further developed. Should it not be necessary that urban planning and urban design take into account the current knowledge about space?

Contemporary mathematicians have proven that abstractions of reality are misleading when we want to understand the complexity of the world. According to chaos theory, space is one of the complex seemingly chaotic systems. Analogously, urban space is therefore one of the complex, seemingly chaotic systems. Some of characteristics of such systems are as follows:

- Non-periodic systems are not predictable,

- Any simulation of a problem makes the finest non-perfections which quickly grow in a dynamic process, and so a simulation cannot lead to real final solutions,
- Simple linear systems do not necessarily have simple dynamic characteristics.
- Simple systems can behave complexly, complex systems can behave simply, but the laws of complexity are universal,
  In the 1970's Mitchell Feigenbaum[vi] discussed universality in different complex systems. He found out that different non-linear systems behave equally,
- Complex, seemingly chaotic systems have many changeable qualities and a stable one. This one persists while all the others are changing in time,
- They possess self-similarity on different scales. Benoît Mandelbrot[vii] came across it while researching diagrams of prices on the market and the flows of rivers. He found similarities not only on small scales, but also on different scales. Mandelbrot penetratingly observed about art – that accomplished art has no scale, but it includes important elements on all scales.

We want to discuss urban space in this context.

IS URBAN PLANNING PURE SCIENCE, OR IS IT ALSO AN ART?

If urban planning is a science, than it should shift its paradigm in accordance with the contemporary knowledge about complex systems – like it was developed by mathematicians and proved by physics.
But then, is urban planning pure science or is it also an art?
Is it both, or is it an art which needs to be based on scientific knowledge about space? A pure scientific approach to urban planning when different analyses and simulations try to solve an urban problem have proved that it is not able to produce a creative solution even if we introduce the latest ideas of contemporary science into it. However, if we look back to the history of art we see that science was always fundamentally influencing art by establishing an understanding of the world, and at the same time art was upgrading this understanding by intuition, imagination, and inspiration, touching the ground of eternity which science can hardly reach. Martin Heidegger[viii] argued that art is being in accord with dwelling man, place, and truth. Could there be a more beautiful and exact definition of the role of urban planning and urban design if we consider place also as space *per se*?

THE PROPOSAL PRACTISED AS A PEDAGOGICAL TOOL

The question we can now pose is how to include scientific theory about space in the pedagogical work with students of architecture, urban design, urban planning, and landscape architecture. Despite the fact that all these disciplines involve sciences and technologies, they are all arts in their core issue. Teaching at the Department of landscape architecture, where students do not have mathematics as a subject and philosophy is optional, we have introduced an examination of urban spaces through the awareness that space is seemingly a chaotic system and that there might exist some analogous systems on a smaller scale that can in their characteristics behave similarly to an analyzed space. Because of the small scale, the latter can be observed as in a laboratory.
Observation and research of an analogous system of a smaller scale where we can find similar changing qualities as in the analyzed space introduces a more than 3D understanding of a space. With this tool students are able to understand space as a system in motion, a changeable system with one stable characteristic. This is usually a huge step for students who are used to 2D and 3D design. By analogous systems we try to find characteristics that are universal on all scales. Such analogies help students grasp

more than three dimensions of an urban space. Consequently, they are able to create new urban spaces with an awareness of the complexity of given spaces. As a result, they are able to think beyond the 2D plan and the 3D visualization.

Here we represent some of students' work using the tool of analogous systems. These examples deal with sub-urban and peri-urban spaces of Ljubljana.

One case study is Ljubljana Stegne, a suburban industrial zone where we mainly find the lighting industry, offices, garages, a shopping mall, a gas station, and a few individual houses. The district is degraded by many fenced parking areas, spread all over the place. The forms of a public space are not present. There are no public parks in that district, but it borders on protected agricultural fields to which it has no connection.

Students understand the reason for the degradation. They used the game Jenga as a possible analogous system where they stated that the voids of the degraded district filled with parking lots were similar to the voids of Jenga. When the voids are too many, the Jenga becomes unstable and finally collapses.

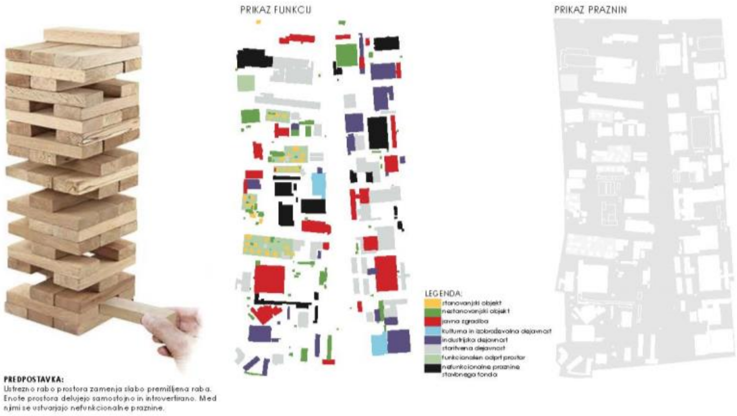

Figure 1. Ljubljana Stegne, Jenga as an analogous system[ix]

Figure 2. Ljubljana Stegne redesigned voids[x]

This thinking process resulted in the idea that the voids of the district need to be redesigned into public spaces which would stabilize the urban texture. Students proposed underground garages and turned parking lots into public parks all connected on the ground floor and the roof level with new skyscrapers. The case study Ljubljana North researched the borders between town districts. As an analogy, students observed the classical mechanism of a watch. A thesis was set: as a cycling wheel depends on a circulation of another wheel, so to a district's border depends on the border of a neighboring district. Just as the degradation of an urban or suburban space negatively influences a neighboring district, similarly an advancement of an urban or suburban border has a constructive impact across the districts' borders.

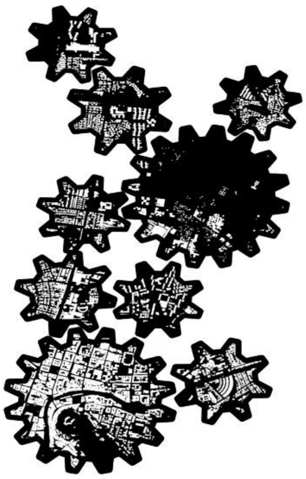

Figure 3. Ljubljana North, watch system as an analogous system[xi]

Figure 4. Ljubljana North, borders between town districts[xii]

The students tried to make a harmonious relationship between suburban texture and the landscape according to the thinking process through the analogy.
The case study Ljubljana suburbs was concerned with the reciprocal impact of the town's sub-urban and peri-urban districts, and the landscape surrounding the town. Students understood these two different complex systems through the analogy of overlapping rain-drops-circles in the water. Where two

different systems interfere, we found a potential node where we could harmonize the impact of urban texture with that of the landscape.

Figure 5. Ljubljana suburbs, overlapping rain-drops-circles as an analogous system[xiii]

Figure 6. Ljubljana suburbs, potential nodes harmonizing urban texture and landscape[xiv]

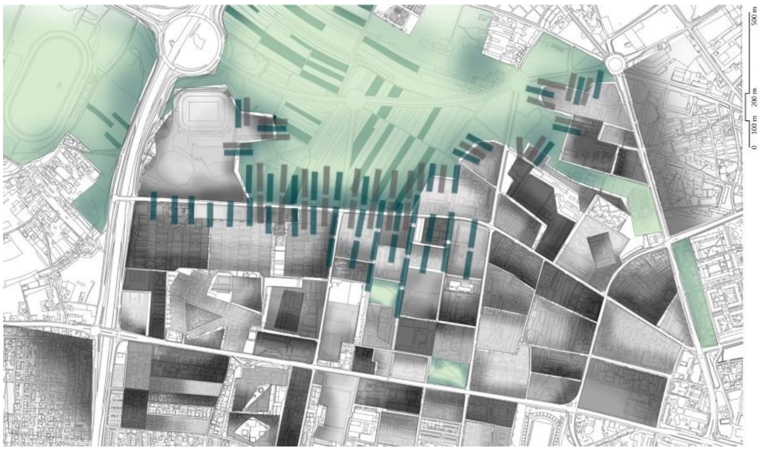

Figure 7. Ljubljana suburbs, a node harmonizing urban texture and landscape[xv]

Figure 8. Ljubljana suburb, designing a node[xvi]

The case study Ljubljana Center and River Sava explored the possibilities of how to connect the town center with the banks of the river Sava. It is a four to five km distance which could be walked in an hour, but is nowadays un-walkable due to physical, and also mental barriers along the paths. Students observed the behavior of a liquid soap mixed with water as an analogous system considering the reciprocal impacts of the town and the green system with the river.

Figure 8. Ljubljana Center and river Sava, liquid soap as an analogous system[xvii]

Figure 9. Ljubljana Center and river Sava, impact of the river making potential mixed-use nodes[xviii]

The observation of the system led to a thesis where the two impacts were understood as two systems colliding in several points in space. These points in the space were further understood as potential mixed-use urban nodes generating urban spaces. The nodes could be connected to each other by pedestrian paths, and thus connect the town center to the river. Students then designed a few different possible connections.

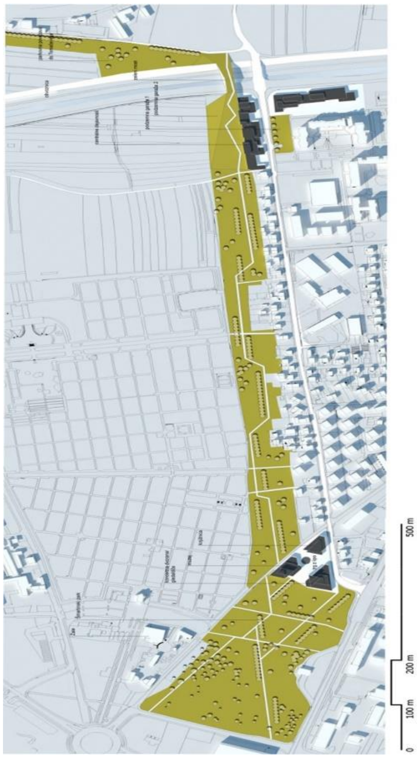

Figure 10. Ljubljana Center and the Sava River, two nodes on the path to the river[xix]

The case study Ljubljana - Medvode explored the relationship between Ljubljana and its satellite town Medvode. Both towns are connected through the Sava River valley. Students understood the tension between the towns as a complex system of a magnetic field.

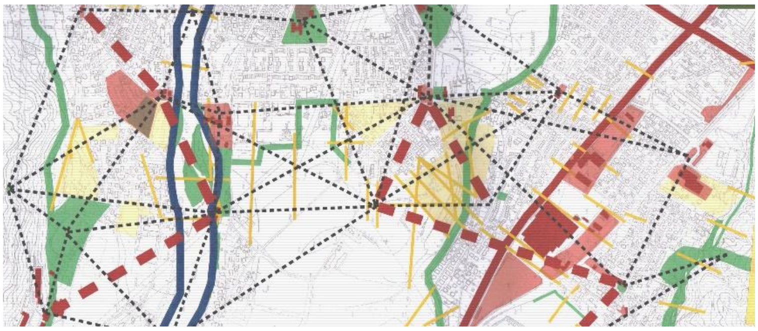

Figure 11. Ljubljana – Medvode, a magnetic field as an analogous system[xx]

At the same time they studied the sequences of sprawl already degrading the river valley. The question was how to make the sprawl more compact, and where green belts could be introduced to stop it. Students observed the behavior of sand particles under the impact of natural forces such as wind and other horizontal influences. This analogy was simulated by a lab experiment, and the process of the sand's movement was studied. The third analogy for this case study was taken from pedestrians' movements in a square, observing especially places where people stop and how groups were formed.

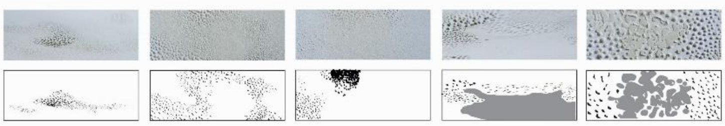

Figure 11. Ljubljana – Medvode, sand movement as an analogous system[xxi]

All these studies of analogous complex systems resulted in a redesign of the sprawl, in a design of the connections between both towns, and last but not least in architectural volumes which are the result of the understanding of the space.

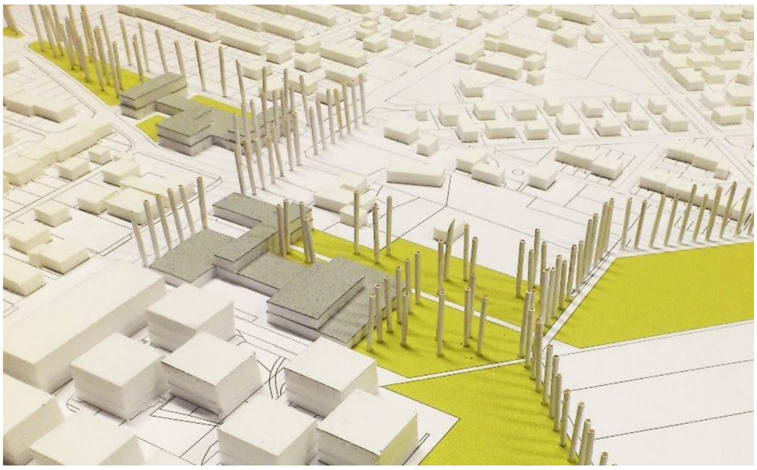

Figure 13. Ljubljana – Medvode, redesigning the sprawl[xxii]

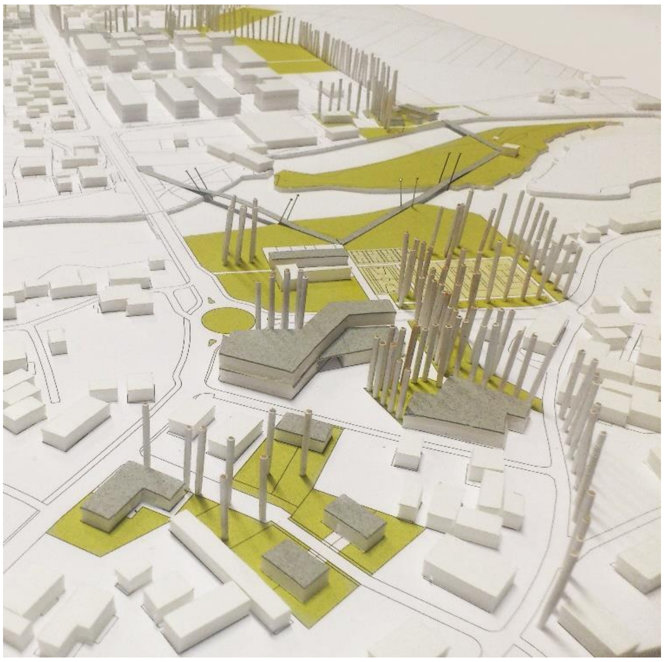

Figure 13. Ljubljana – Medvode, redesigning the sprawl [xxiii]

CONCLUDING REMARKS

Analogies of the complex systems are used as a pedagogical tool for a thinking process about space in specific urban, suburban, peri-urban places, and landscapes. A design then becomes its natural result. It needs to be said that this tool cannot be used for copying complex forms of other systems into the architecture or urban space. A formally complex design would be a result of the described thinking process.

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LIVE PROJECT: UNDERSTANDING THE DESIGN PROCESS FROM THE PROJECT BRIEF TO POST OCCUPANCY EVALUATION

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INTRODUCTION

According to Anderson and Priest[i], the founders of the 'live projects network' "a live project comprises the negotiation of a brief, timescale, budget and product between an educational organization and an external collaborator for their mutual benefit.' In this sense, it is argued here that a live project is a natural framework to introduce and explore the Royal Institute of British Architects (RIBA) working stages. Through this case study analysis, the relevance of delivering a live project, not only until the construction phase but rather extending it to the In Use and Post Occupancy Evaluation (POE) phase, will be highlighted. The students therefore gained a full overview of the design process, which helped them to reflect critically on their own interventions.
Live projects often sit outside of the architectural curriculum[ii], however, David Gloster[iii] suggests that we should be 'questioning where the margins of academic work reside – and who actually draws them.' Part of this project was integrated within the architectural curriculum in the second semester of the course and part of this project was developed during the summer period. This option raised some of the common challenges of a live project in architecture, namely the assessment process, the individual and group outcomes and students' engagement.[iv] Following David Gloster's advice, '(…) no approach to architecture education is considered by the RIBA as outside of the margins providing that the school justifies its approach in a credible academic position statement and mapping document (RIBA 2011:22) and demonstrates, through students' work, an honoring of intentions.'[v] Therefore, the following sections will demonstrate through which methods this live project was delivered and possible changes and improvements will be discussed based on reflections and evaluations by the students, the client and the professional partners.
The live project was delivered to second year students in the BA (Hons) Architecture program at Birmingham School of Architecture and Design at Birmingham City University in the academic year 2018/19. The students were asked to design an external structure for an outdoor area in a Montessori Kindergarten. They had the option of either designing a tree house, a new play house, a shelter for the forest school or an amphitheatre. All projects were to be located in the extended garden of the nursery on adjacent sites. After the initial design stage ended in February 2019 with a presentation of all projects to the client (the nursery managers), two selected projects were then built in June 2019, during the school's events week with a group of students. A few weeks after the hand-over of the completed

projects, some of the students as well as the tutors went back to the nursery to conduct a Post Occupancy Evaluation (POE) of the projects.

In order to experience the design and construction phases, this live project was composed in eight stages, directly related to the RIBA Plan of Work, which “recognises the stages that a building project goes through and promotes the importance of recording and disseminating information about completed projects.”[vi] The project therefore required the students to integrate structural and technological solutions into their design proposals.

A CASE STUDY

From Design to Post Occupancy Evaluation

As the presented live project consisted of play structures for a Montessori Kindergarten, much consideration was given to the topic of ‘Designing for Children’ and the Montessori pedagogy in particular. As Mark Dudek explains the Montessori ethic by paraphrasing Maria Montessori: “for a child ‘the hand is an extension of the brain’. They communicate and extend their understanding through the heightened senses of touch, smell and hearing, as well as through more immediate visual stimuli. This helps them to develop self-directed behaviour that does not have to be constantly helped along by an adult carer. The environment becomes the teacher in its own right.”[vii] A detailed analysis of the site as well as the needs of the children therefore played a key role in the selection of the play structures that were later built.

The design of the project formed part of the design module in Year 2 and was conducted in pairs. The aim of the brief was to draw on three topical issues that were related to the brief.

Firstly, the relationship between the space and pedagogy had to be considered and how the design could enhance learning by creating stimulating and engaging structures that would enhance the playful experience and promote different kinds of activities. As Mark Dudek notes: “children need spaces that help them explore and extend their abilities, whether they are satisfying their boisterous need to run, jump and climb or are involved in more creative activities such as painting and model-making.”[viii]

Secondly, the ability to adapt to different scales and proportions was challenged through the topic of ‘Designing for Children’. Although the proportions of the spaces had to be adapted for children, the ability for adults to enter the space to observe and aid had also to be considered, especially in the context of outdoor play structures: “Playing outside is key to developing young children’s bodies and minds, and, according to children themselves, it is what they like best at nursery.”[ix]

And thirdly, the consideration of the Montessori pedagogy, which promotes interaction with the environment to further the human development as “the architecture (…) plays a crucial role in maintaining our sense of wonder and curiosity long after childhood.”[x] Especially this task of planning for activities proved to be a challenge for the students as the functions of spaces are often set when approaching a brief.

Methodology

This project was delivered using the RIBA stages 0 through 7. These are the stages set out by the RIBA Plan of Work 2013, which is the UK model for the building design and construction process.

Due to the nature of the nursery site and the relationship with children, at some stages of the project, namely stage 0, stage 1 and stage 7, not the full cohort of students could engage in the Strategic Definition (Stage 0), Preparation and Brief (Stage 1) and the In Use phase (Stage 7). Therefore, these stages were not assessed but informed the design process for all students as well as adding value and methodology to the project.

Stage 0 and Stage 1

At the beginning of the project, a group of 15 students were asked to conduct Semi-Structured Interviews (SSI) with staff, Focus Group Discussions (FGD) with children and Behavioural Mapping (BM) of the children playing in the garden space. This helped the understanding of the pattern of young children's play learning through different activities. Learning by playing is a big part of the Montessori concept, whereby the theory is that the child will learn intuitively in a well suited learning environment and thus further their cognitive, social and emotional skills. The children were further asked what kind of structures they could imagine for the nursery garden.
Since we were not allowed to record the children neither through audio nor video, the students produced a graphic recording of the SSI of the children's contributions and collected their illustrations of the future garden interventions.

Figure 1. FGD: The dream garden: contribution from one of the children

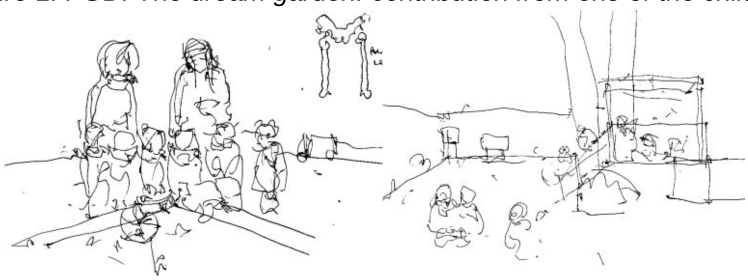

Figure 2. BM: Mapping the behaviour and movement of children

All students then had to produce a site survey and analysis based on their findings in the nursery garden and consequently had to select which of the four project proposals they wanted to design. The envisioned remodelling of a tree house, using an existing structure, a new play house, a shelter for the existing forest school or an amphitheatre was given by the tutors in conjunction with the requirements of the nursery and the conditions of the site.

Stage 2

After analysing the site, students, working in pairs, developed their conceptual designs for their chosen play structure. Weekly tutorials with tutors gave them guidance throughout the process. After a nearly month long design phase, the students presented their projects to the tutors and the nursery managers. The digital presentations included plans and sections as well as a rough estimate of materials and costs. Models of the play structures further helped to visualise their ideas.
The tutors and the client conducted the subsequent selection of ten projects. Relevant assessment criteria of this short-listing process considered the creativity of the projects and their appropriateness, the functionality and buildability of the projects as well as their cost efficiency.

Stage 3 and Stage 4

Considering the budget available to deliver this project, costs had to be reduced, therefore only two of the short-listed projects were selected to be built, a tree house and an amphitheatre. During the meeting with our professional partners, a local contractor and an architectural practice the two projects were evaluated in terms of their buildability, materials and structure. The students involved in the design of these two projects as well as a group of volunteers subsequently reworked the plans to add detail structural plans, revising materials and taking into account the comments of the local contractor. Following the risk assessment and the schedule of work, the materials were ordered.

Stage 5 and Stage 6

The construction of the amphitheatre and the tree house was conducted within one week. The two projects were thereby built at the same time on their adjacent sites by the groups of students along with their volunteers and the tutors. The main part of the amphitheatre thereby consisted of digging a big hole for the logs to safely be anchored in the ground. The group of the students building the tree house had to dismantle the old structure of the tree house before being able to refurbish it with a new timber façade, new stairs, a bench and a chalkboard inside the tree house and a slide on one end to have a circular path for the children to explore the tree house. After the week of construction, the site was cleared and the garden was reopened for the children to play.

Figure 3. Building the Amphitheatre

Figure 4. Building the Tree House

Stage 7

In order to understand the impact of their designs, the tutors as well as some of the students went back to the kindergarten one month after the handover to perform a POE of the two projects. Two observation- participation sessions with two different age groups were carried out and SSI with four members of staff were performed. No photography was taken during these sessions.

From mid- July, the children had been using the space again, inhabiting and furnishing the treehouse and using the outside structures as an integral part of their daily routine. Especially the newly created crawl space underneath the tree house proved to be a favourite among the children, where they could play house, zoo, and prison. The amphitheatre on the other hand was used in the first instance as an extension of the balancing beams nearby, being integrated in the daily morning exercise routine. In general, staff were very enthusiastic about the projects, integrating learning and teaching activities in the new spaces. The tree house, for instance, was newly integrated in the morning exercise through it's now circular pathway through it, where children were asked to step into the tree house and come down on the slide.

Through integrating this In Use Stage (Stage 7) into the overall project evaluation, students realised that their designs were being used for additional purposes and appropriated in non-expected ways. For example, the crawl space being high enough for some children to stand and sit, was used more as tiny house rather than a crawl space.

Evaluation and assessment

The assessed part: Stage 1 and Stage 2

Besides the project being conducted as a live project, which meant that construction, material and cost were considered in the design phase, the most challenging part of the project for the students proved to be the designing of activities, as "play patterns also change across a few hours. In an ideal world, children require a whole range of different kinds of spaces to cater for the evolving requirements to play and rest over what may be a long day in daycare or at nursery. If their play is to be consistently interesting, a supportive and flexible range of spaces needs to be designed with particular activities in mind."[xi] Sometimes the range and variety of too many options of activities seemed to hinder the buildability and functionality of the projects.

However, the topic of 'Designing for Children' demonstrated the multifaceted aspect of the project brief, as Michael Laris also points out: "When working on the design of playground equipment, many contrasting needs come into play. The safe functioning of the equipment is particularly important, yet the equipment must also be challenging to the user. It must also fulfill the demand of a manufactured industrial product. Being attractive, robust and affordable, and most importantly, it must appeal to the user in a deeper, more intangible way than most adult products. It must excite the child's imagination and create a sense of magic."[xii] Running this brief as a live project and group work improved the student's engagement. Particularly the ability to present their designs to a real client raised their motivation and enthusiasm. Some of the students mentioned that working in pairs was pushing them to work harder and insure that they were contributing towards the final solution.

The non- assessed part: Stage 0 and Stages 3 to 7

Due to the fact that this part was non-assessed as well as being timed during the events week, the first week of the summer break, the participation of students was very low. The students' whose projects were chosen to be built were motivated to construct their designs, other students unfortunately had to be motivated to participate. Although this part of the project was an extra scholarly activity the students participating benefited enormously from the experience, being able to face the challenges of building a project and getting feedback from clients and professionals.

Student's Feedback

In order to have feedback from students and integrate this on future learning and teaching activities, by the end of the project, during summer break, the students were asked to participate in an online questionnaire reflecting on their views on this project. The questionnaire was anonymous and was responded by 25% of the full cohort.

The majority of the students reacted positively to this project and found it useful to work on a live project, challenging the brief and getting feedback from clients and users. However, the tight time scale for the design stage of the project (1 month) and the difficulties establishing a clear budget from the start were also mentioned by the students as points to be developed for further live projects.

Positive feedback was given to the integration of the RIBA Plan of Work and all its stages. Although only a group of students participated on all stages, particularly the non-assessed stages (Stage 3 through Stage 7), the students felt that they got a basic understanding of the RIBA Plan of Work through this project and its stages.

The students involved in the construction process mentioned that they learned 'that the construction is not a smooth process and that there might be issues that have to be overcome.'[xiii] Learning by doing and problem solving were two strategies presented during the construction period. By the end of the live project, the POE, the last stage in the RIBA Plan of Work, highlighted the imagination of the children through the different ways of their use of some of the spaces. The method of conducting this live project through the RIBA Plan of Work Stages was thereby evident to the students and demonstrated a valuable learning outcome.

Regarding the student's suggestions for further live projects, some interesting points were raised and further suggestions given, e.g. provision of a live project toolkit, integration of the full project in the curriculum and no extensions into the summer study break, ensuring that all projects can be built and that all students can take part in the building process.

Client's Feedback

The client (the nursery managers as well as the nursery practitioners) were overall very enthusiastic about this project and positively surprised about the final outcome. As they had not cooperated with architectural services before or indeed had any contact with the profession previously, they were especially impressed by the students' creativity and detailed designs. They further positively mentioned the commitment and professionalism of the students. By the end of the project the client was very pleased with the final structures and the benefits to their outside play areas.

Partner's Feedback

The partners' input was also very helpful in this process, especially during Stages 3 and 4, providing guidance and a link between academia and professional practice. A collaboration earlier on in the project would have been beneficial for the students to integrate the advice given into their initial designs. The architectural practice involved was very pleased and was promoting the live project as part of their engagement with academia.

FINAL REMARKS

Similarly to other live projects in architecture, this project was developed 'in the borderlands between architectural education and built environment practice,'[xiv] establishing a link between academia and practice. Due to time constrains, the most critical point of this project was its integration in the curriculum and the assessed and non-assessed phases. Since the first phase was delivered under enormous time constraints, not all RIBA stages could be given the same emphasis, for example, students were not able to design their own brief.[xv] However, asking students to do a more extensive site analysis by using different research techniques, e.g. semi-structured interviews, focus group discussions and observation- participation revealed to be good practice to interrogate the client and the users about their needs and preferences.

This project can be divided into two different periods. The first one was integrated into the curriculum, from RIBA Stage 0 to Stage 2. The second one, from RIBA Stage 3 to Stage 7 delivered as complementary curriculum activities. The student engagement was 100% during the first period and the 'real client' dimension contributed to this attendance. During the second period, the student's engagement dropped dramatically due to it being a non-assessed activity during summer.

While delivering a type of 'Design and Build'[xvi] project, the scale of the project is important to make it feasible and to allow students to experience all its phases. The beauty in small scale project lies on the iteration between the design, the space and the user and allows a full comprehension and apprehension of the design process. In this sense, the chosen scale was appropriate to deliver this type of project.

For future live projects aiming to address the RIBA Plan of Work and covering design Stages from 0 to 7, it would be beneficial to integrate all stages into the curriculum. In order to ensure a good organization and transition between different stages, the project could be similarly divided into different periods, for example, running the first period at the end of the first term and the second period at the end of the last term.

CONCLUSION

This live project enhanced students' engagement and revealed to be beneficial for all partners at different levels. Students could understand the different stages of the design process, work in pairs, deal with a real client, respond to a real budget and site and experience the construction process. The initial site analysis (SSI, BM and FGD) helped to inform the students' designs and enhanced the importance of the user and the client when delivering an architectural project. The POE revealed to be a strong learning tool where students were able to reflect on the impact of their designs and develop their critical thinking. For the client (the nursery), the work developed by the students not only helped them to understand the role of the architect but enhanced their outdoor garden space by two play structures that considered and aided their Montessori pedagogy. The sponsors were pleased to support this project, develop their social responsibility and be involved with the future generation of architects. Especially the topic of 'Designing for Children' proved to be a valuable learning experience for the students, as they not only had to face the challenge of designing in a smaller scale but also to design for different activities. The POE stage was therefore useful, as it showed that even envisioned spaces can take on different functions and can be used in different ways, as was proven by the crawl space underneath the tree house, which was later used by the children as a 'house'. The small scale of the projects was further helpful to allow the play structures to be designed with a small budget in a tight time frame.

Mapping this process of development to the RIBA Plan of Work demonstrated to the students that taking on a project is a process that is running through different stages. Experiencing these stages, made this project even more applicable to real-life situations and challenges. As RIBA is set to release a new Plan of Work in 2020, it would be beneficial to further live projects to take this onboard and give the project enough time to incorporate (and possibly assess) all stages. The new RIBA Plan of Work 2020 will also incorporate more emphasise on ethical and sustainable issues. These issues could be incorporated into the project and possibly assed within different modules of the year, linking the live project to an interdisciplinary curriculum.

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DESIGN/SCIENCE FICTIONS: WORLDBUILDING AS LANDSCAPE PRACTICE

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Landscape Architecture and other contemporary design practices deal simultaneously with the process of compiling and data for decision making and compellingly presenting that content to a client or user group. Typically, this information is presented for projects in the near future when there are no significant changes to environmental conditions. The immediacy of most design project timelines omits the need to include complicated environmental projections as part of the decision-making process. However, there are instances in professional practice the require justifications for design decisions.

Mapping and diagrams are limited and require the audience to be capable of processing and synthesizing the information to understand the design process, and its impact. Renderings provide more insight into a design will look like when complete. As static images, they lack immersive qualities that explain the effects of change- designed and otherwise- on people who occupy the designed site or region.

Historical and contemporary image productions reflect broader historical, political, and social trends. In the case of landscape, image production is grounded in making static images starting with perspective drawing and painting. As an example, the Red Books by Humphry Repton documented his design proposal using narrative, plan drawings, and illustrative paintings.

Of the collection of the text and drawings, the illustrative paintings are the most compelling component. Painted flaps were used to fold over the image of the current conditions, allowing the client to see their property “before and after,” as if they were theatre props used to change the scene. Technically these were not animations, but they had the effect of engaging the audience in real-time as they turned the flaps.

Repton’s Red Books are as much speculation as they are designs. The before and after images are intended to compel the client into executing the work described in the book using illustrative plans and descriptive text. The intent used in making the overlaid images that allow the client to “see” the designs as they will appear after the trees have fully matured, taking on the illustrated size and silhouette. The implied tree growth alludes to a change in time that is not explicitly accounted for in the proposal. The illustrated mature state that would take decades to accomplish through plant management and maintenance.

In comparison, contemporary design decisions have more complicated trajectories. Most significantly, climate change has impacts on landscapes that will evolve over long periods that are not always evident in the present. Matthew C. Fitzpatrick and Robert R. Dunn introduced a method for comparing climate data projections for 540 cities in North America using maps to compare locations.[1] As an example, in sixty years, New York City and the surrounding region will feel more like contemporary Jonesboro, Arkansas.[2]

Using science to frame a landscape projection points to increased complexity when designing landscapes and also imagining them. Large amounts of discrete data can be challenging to process and organize to understand a problem. The economist and political scientist Herbert Simon described the problem of synthesizing information using three points called bounded rationality.[3] Simon describes bounded rationality as the constraints applied to the decision-making process of any person, using three central points. The first is that information is often limited and unreliable. The second is that people have limited capacities to absorb and synthesize information. The third is that there is only a limited amount of time to understand to make decisions based on the available information.

Repton curated the content in the Red books, providing only essential information to describe the design intent using aesthetics as the framework for design intent and goals. The overlaid images are essential because the synthesize the plan drawing and the narrative into images that can be easily understood. The climate analog maps only make things more complicated, requiring that the user visit the reference location and the future climate analog to perceive environmental differences. However, they are also experiencing social and spatial differences at the same time, making the process of perceiving the impacts of climate change more difficult.

The limitations of static images and physical travel make a case for other mediums that address the problem of how to convey information to an audience or user group. The ability to communicate content in a controlled and digestible manner is vital to help people make informed decisions. Science fiction writers used models that are similar to the one described by Herbert Simon to create frameworks for stories and is referred to as worldbuilding. Like bounded rationality, worldbuilding organizes what the audience knows so they may follow the story.

The science fiction writer N.K. Jemison uses a system of immersive levels to determine the level of specificity provided to the reader.[4] High immersion refers to information that is implied and rarely mentioned in the text. Moderate-level immersive content is information that is mentioned periodically throughout the book, enhancing or changing the direction of the narrative. Low-level immersion content consists of information that is continuously explained and makes up the meat of the story.

The models provided by Simon and Jemison for understanding how to organize information are also relevant to design practices. Where Simon outlines how large amounts of data can be prohibitive for effective decision making, Jemison describes frameworks that curate information to enhance comprehension. Applying both approaches is where storytelling in the form of science- or scientific fiction- becomes a beneficial model for design practices.

There processes in landscape architecture analogous decision-making and worldbuilding. Landscape architecture is a discipline that deals with time and change. Photo-renderings limits descriptions of problems that deal with time, obscuring complexities that the audience or user groups will eventually confront.

In contrast, the serial nature of television is an immersive format that allows the audience and user group to synthesize issues related to change through empathy. Referencing Simon and Jemison, narratives built in a serial form enable the designer to reveal complex problems using an intentional process. Layered descriptions of the world the characters- and by association, the audience- will occupy. The explanation of the constraints that frame Simon’s argument becomes the mechanisms that are used to create future scenarios according to Jemison’s worldbuilding process.

Repton used curated books with easily understood illustrations to entice an audience which was limited to a privileged few. Fitzpatrick and Dunn published work on a publicly open website, providing wide access but with limited interpretation. What would happen if media production became a design practice? How would they tell similar stories about places in the future? As the environment changes, the basis for design patronage needs to expand and be educated.

There are examples in contemporary television that are applicable. In the United States, the Weather Channel used augmented reality in conjunction with weather updates during Hurricane Florence. The short clips were a supplement the standard weather forecast using charts and radar. The network also had reporters stationed in Charleston, South Carolina to describe the impact of the hurricane as it made landfall. The augmented content illustrated the dangers of flooding. The level of information immersion was low, relying upon information provided in the forecasts. As the weather reporter in the studio discussed the importance of evacuating low-lying lands, the model was used to illustrate water levels. Showing the water level at incrementally higher levels allowed the reporter to describe specific dangers and impacts that the reporters in Charleston were unable to demonstrate accurately.[5]

In 2016 National Geographic Channel aired Mars, a series set in 2033 in which a crew of scientists establishes a base on Mars.[6] Unlike the Weather Channel's augmented reporting, Mars explicitly address the science of space travel. The series shifts between the future and the present, interviewing contemporary scientists to reveal the complexities of space travel and off-planet settlements as background for the fictional story. The high levels of information coming from scientists educate the audience while preparing them to them for the evolving storyline.

These are examples of how information can be organized to illustrate future scenarios, that connection to both the images produced by Repton and the map prepared by Fitzpatrick and Dunn. Both are speculative, illustrating potential futures that rely on scientific observation to create "realistic" scenarios. They also organize data in a manner that is easily understood by a general audience through narrative and image. These are also components of design, and this overlap is may be an opportunity to expand design practices and patronage.

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COLLABORATIVE AND EXPERIENTIAL LEARNING VIA "THE DAILY WORKSHOP SERIES (G.A.S.)"

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INTRODUCTION

Many researches focus on what they see as a gap between architectural education and the profession. It is very clear that the updating of new skill sets and the knowledge required due to the developments in several areas related to architecture is curial for the profession both in terms of production and in satisfying the urgent demands of the job market.[1] But is everything in this complex building package of equal interest for architectural education? What are the long-term and short-term skills and knowledge, what about the learning and experience? What is the balance that is best for student?

This paper explores collaborative and experiential learning via a series of workshops aiming to seek for a coherent methodology throughout the materialization of the design process by looking at and questioning the methods that govern the architectural design education. After critical examinations over the difficulties appeared in design education, it is proposed an alternative learning process developed within "The Daily Workshops Series (Günlük Atölyeler Serisi/g.a.s.arch)" which is a voluntary organization and a platform created by a variety of architects who are both educators and practitioners.

In the scope of this paper, specifics of the workshops in question and the examples of exercises done by design students from various architectural schools at different levels, would be underlined in order to understand the conception behind the development and execution of the workshops. Furthermore, the importance of having both educators and practicing architects engaged in these workshops with a great variety of participants would be discussed in terms of how that alters collaborative and experiential learning and the way teaching is done.

Difficulties in Design Education

Starting from the middle of the 20th century, designers have been aiming to discover and control design processes by systematic design methods.[2] It is believed that the design consists of two main processes of materiality: The first is the problematic that the designer produces according to his/her own background. The second process is the solution of this problematic. This idea was similar to post-positivist' approach, which regards the designer as a conscious processor.[3]

In architectural design education, following this idea, students learn how to design mainly in the context of their design studio practices called as 'project'. They mostly develop solutions to hypothetical problems or reach the goals at the end of the design tasks counted as design activities. At the first stage, they encounter with the design problems and tasks rather than dealing with the materialization of the design process itself. However, these discussions neglected the designers' personal constructions of reality and their reflective conversations throughout the design processes.[4]

Add to that, teaching activity of how to design has been a major challenge in the architectural design pedagogy for many years.[5] Especially architectural design assignments are prepared to challenge the students to achieve design solutions for different functions, behaviors, experiences etc. through dealing with over-constrained problems.[6] The tutors have so many expectations for the design projects of the students throughout the year and they want students to address these challenges. Because of the education system and the importance of the architectural design studio course in the curriculum, the motivation becomes - unfortunately – to get the excellent marks for the students. Therefore, the learning and teaching outcomes mostly do not meet the expectations for both sides.

Another fact that, the hierarchical system of orthodox pedagogies where the teacher is a giver/teller/sciential and student is a receiver/listener/as daft as a brush, reflects and creates the major problem of teaching/learning design dilemma. This opposite position of teacher and student bring the gap between education and practice, and the limitations in design education into existence.[7] Because of the hierarchy, the critiques/reviews, which are given by the tutors to students, are mostly understood as approval or rejection of the design. The jury is also seen as an imposition of authority onto students by evaluating merely final products instead of learning and designing processes.[8] This understanding could only provide a commodified system, in which students are seen as training candidates to serve for the maintenance of profession. The hierarchical structure and understanding rarely produce intended learning and teaching outcomes regarding the process-based focus of design education.[9]

Unravelling New Approaches in Design Education

These central challenges of the design process, teaching activity and hierarchical structure are all critical to design education and they are intrinsically linked also to content, method and ideology govern the architectural education and practice. Nevertheless, expectations to bring innovation into education rely on the question on identifying how students will take active and pro-active participation in the learning process.

As a new approach in design education, in the daily workshop series, we run all the workshops with the aim to question and seek for an alternative and participatory methodology for a way of learning, and also a way of teaching throughout the design process. The workshops are meant to generate a debate aimed at further improving the materiality of the design process. At the same time, this is a unique and much-needed platform for discussions among educators and students, professionals and researchers in architectural education.

THE DAILY WORKSHOP SERIES

The workshop culture as a principal focus of design education requires learning-by-doing based on the experience. The nature of the workshops plays a major role in the nature of the materiality of the experiences in designing activity. They form the initial ideas and conceptions about the nature of design thinking and phases of this activity.[10]

The workshops produced on daily basis exercises; the participants try to materialize an idea within a very short period of time. It is not easy to design and make this design understandable by counterparties in normal conditions. Trying to materialize an idea in one day instead of fourteen week -or extended period of time as in the studio, both challenges and motivates them better to think fast, imagine and produce more inventively. Here, it is not intended to produce finished self-selling items; on the contrary it is mattered that the self-describing materialized idea.

To materialize the idea; An "inferential" approach to design

The logical basis for the course of action in the workshops relies on the materialization of learning in design process and performative act of designing. In the daily workshop series, we enable participants to develop an understanding about the ingredients of design problems and task, even more so, begin to discover creative thinking, imagining and producing for materialization of learning in design process. In addition to hosting a number of different innovation and creativity, materialization of the design process also needs to have the similar type of understanding.[11]
This does not suggest the conventional way of understanding "design" as a way to represent or validate the "thinking process", but rather suggest a more dynamic approach that elaborates the process of design as a process of thinking, imagining and producing, and prompts to the materialization of learning. Such a methodological approach, to make in order to think, entails observation, improvisation and execution. And, it suggests to figure out how to discover alternative forms of idea generating the data for and through the design as illustrated in Figure 1.

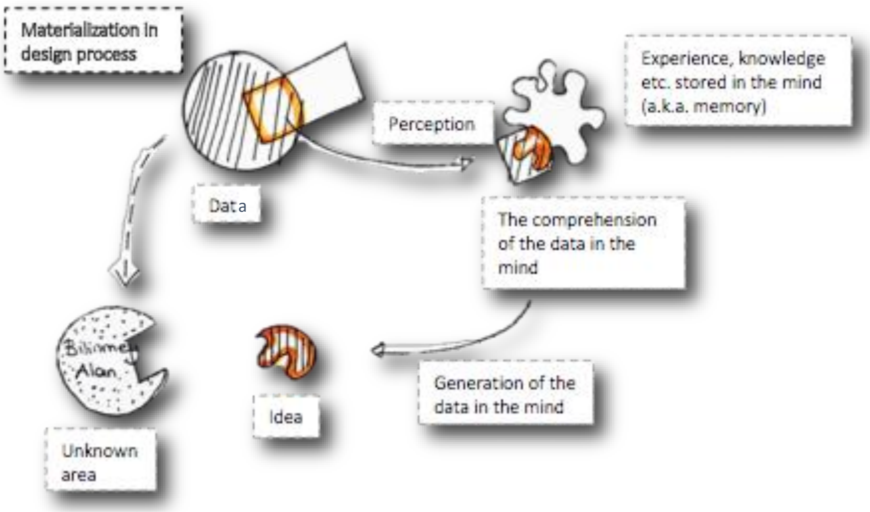

Figure 1. The diagram of the inferential data in design process.

We believe that creating novel ideas depends on how to deal with the data entered into the design process. Since a designer could use and benefit from the intelligence, thought and imagination at the same time[12]; he begins with an idea; within that idea prepares for, forms and generates to ideate. The ideation is the skill of grasp and being able to conceptualize what you design, in other words, materialization of idea.
A set of intended actions through the workshops prompt to extensive explorations of data; questioning the concepts, vocabulary and organization of design process in reverse positions; starting with the intermediary notions, and so on. We embrace this inferential data strategy in order to figure out how to discover alternative forms of idea generating the data through design process for the materialization of learning.

Tactics for Collaborative and Experiential Learning

To pursue our strategy, we define several tactics/priorities pertaining to the themes of our workshops and daily exercises within the workshops;

- to encourage students to think outside the box and of their comfort zone, to grasp the skills inside their personal capabilities,

- to create collaborative and beyond disciplinary experiences through research-based activities, and
- to reinforce experimentation towards a positive and candid environmental and social impact within professional area.

We believe that it is possible to intervene in the materialization of learning by revealing the contribution of these tactics which are; *experience the concepts*, *re- representation* and *alternative collaborations*. We use these three tactics for data generating to stimulate collaborative and experiential learning in design process (figure 2).

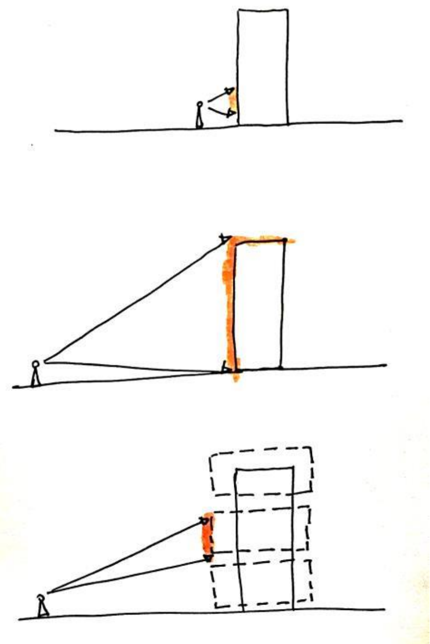

Figure 2. The diagram of generating data through grounding in tactics.

Experience of concepts may refer to the units of information that designers stress as important during the design process. These concepts are noticed as arising as sudden illuminations from subconscious and emerged in creative leaps. Alternatively, *re-representation;* could be seen as re-establishing of links between figural and conceptual arguments or echo of each other. They are aimed at the representation of some other thing embodying the idea of meaning. It matters that the re-representation is mostly materialized in learning phases as a search process. This kind of materialization is necessary for pursuing cognitive activity and developing a coherent network of ideas, but not for a satisfying outcome or finished product. This idea can contribute to open-ended and ambiguous representations leading to many possibilities of interpretations. Most importantly, *alternative collaborations* are like different conversations during the whole process. Communication of people and ideas serves as a primary vehicle for collaborative and experiential learning throughout the design process.

Development and Execution of "The Daily Workshop Series"

Development and execution of the daily workshop series are mostly Istanbul based, but have been performed all over the Turkey. So far, with this platform, we carried out a total of 32 workshops within a year and met with approximately 2400 people. Together we produced ideas in the field of architecture and design, participated in various competitions and received awards. We emphasized that design and production, education and practice should be team work, and so, we established various design teams by bringing students, educators and practitioners together.

Questioning and taking a critical position within a team may provide us to look at the ordinary from different angle and creative thinking, imagine and produce in result of the process of idea, ideate and ideation could be improved and developed. In the workshops, brainstorming, creative thinking, imagining and producing techniques, goal-oriented idea development in design, and intellectual visualization were examined extensively. We basically worked on how to activate and challenge creativity in design progress by asking lots of questions and doing small exercises/trials. We discussed with the participants how to develop creative thinking, imagining and producing skills through the concepts of fluency, flexibility, originality and elaboration which are essential for both education and practice.

Throughout the exercises/trials, we think, imagine and produce together with the participants from different schools and years of design education by putting aside the common stereotypes that govern the design activity, so that they could realize and discover alternative design making processes. Remaining of this section outlines the themes, contents and objectives of several exemplary exercises in detail we've done so far and provides examples of participants' works.

"The space' expressions" workshop

In general dictionary meaning, the architecture is the art of solving problems with the space. To question this very common stereotype, the issues of perception, analysis, interpretation and expression of the space examined from different perspectives within a critical approach. We focused on how to better describe the materialization of the space, in particular, we discussed the alternative ways of expression in the process of the production of space and expression through the produced space (figure 3). We emphasized the essence of the space, which has a very important role and effect in the materiality in architectural design process. We carried out the workshop with the aim to make participants think about and understand the meaning of our different senses and sensory qualities of space in our perception, interpretation and experience of them. We developed related exercises based on the themes of memory, experience and narrative.

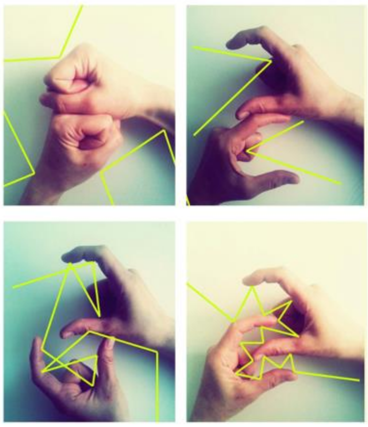

Figure 3. One of the exercises for expressing the status of the space with hand gestures. Istanbul Metropolitan Branch of Chamber of Architects, 29th June 2018, İstanbul, Turkey.

"The spaces of 'the section'" workshop

It has been argued that the contemporary meaning of the section is almost perfectly configured not to solve spatial problems, not least because the new generation of computer-based designers see issues such as concepts and meanings of the section as quality of visualization rather than spatialization. What alternatives are there? We questioned the concepts and meanings of the section in architectural design process by thinking, imagining and producing it in reverse positions through the themes of workshop. In order to figure out how to discover alternative forms of idea generating the data for and through the section, we discussed and talked about how the architectural design process starts with the section. We focused on how we can examine the data that is entered into the design through the cross-section and make it a part of the design process. We developed a collaborative exercise with these considerations. With the participants, we generated a narrative data to build a dream of life for the people who live already there by creating space fictions in the cross-sections (figure 4). Then we created an integrated cross-section to develop new ideas and perspectives on each other's design concepts, as well as narratives (figure 5).

Figure 4. Generating a narrative data during the workshop at "Good Design III-Izmir" event, organised by Izmir Metropalitan Municipality and Union of Universities in Izmir, 20th October 2018, Izmir, Turkey.

Figure 5. Final exhibition at "Good Design III-Izmir" event, organised by Izmir Metropalitan Municipality and Union of Universities in Izmir, 20th October 2018, Izmir, Turkey.

CONCLUDING REMARKS

The enormous diversity in architecture and design that we experience today in newspapers, magazines, TV and especially social media has helped take architectural education out of its ivory tower. Yet the pressure on institutions and educators to define the position of architectural education in relation to content, method and ideology has not and will not disappear for a while.[13] Probably, the struggle to accept this diversity with grace could be only solve by opening the issue of architectural education to discussion on different medias and establishing an appropriate relationship to the complex world by understanding the alternative approaches. As the strengths and weaknesses of the architectural education become more apparent, a new and more sober maturity may change the way of teaching and learning architecture.

Taking all into consideration, there are many limitations created by commodified design realm reflected in design education and by the gap between academy and profession. However, these limitations bring out some potentials by challenging both profession and academy for emerging new responses and alternative approaches. Designers are expected to become more skilled in social and cultural dimensions, more adaptable, flexible and versatile in their professional fields; and these expectations lead a continuous learning as a foundation of design education. This continuous learning approach could direct our future studies. We should focus on process and experience as well as product and knowledge; should listen as well as tell.

The daily workshop series could be seen as alternative expansions/trials prompts the experiential and collaborative learning in design process through performative act of designing. When viewed from this angle, these collaborative expansions alternate and evolve over the changing conditions of learning and teaching in return. We believe and also claim that the workshops are more productive in terms of teaching outcomes to focus on the materiality of learning throughout designing activity and to provide more rounded and nuanced models of the design process, and most importantly, to bring everyone into establishing a dialog on education, design and practice.

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MODELLING A FUTURE PRACTICE

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INTRODUCTION

The nature of architectural practice is undergoing rapid change and evolution. The increasing adoption of digital workflows within the design and construction industries, including digital fabrication, direct manufacturing, artificial intelligence and other emerging technologies presents both significant challenges and opportunities for the practice of architecture.

This paper will explore the implications of the adoption of new technologies on the practice of architecture. This discussion will be grounded in recent research into the impact of the adoption of digital fabrication processes within the profession in Australia. We will attempt to demonstrate a gap in knowledge around how technological shifts in the procurement of architecture might shift the model of practice. We will argue for the importance of architectural education in shaping the future of the profession and demonstrate how these possible futures have been modelled through the teaching program at RMIT University.

EMERGING TECHNOLOGY AND PRACTICE

Over the last 40 years an enormous amount of research has been undertaken, both in the academy and practice, into the development of the technologies associated with digital design and production in architecture. An early pioneer investigating the implication of the adoption of digital tools in architectural and design practice, Christopher Alexander sought to establish an algorithmic approach to design. Alexander used set theory to analyse design problems and prepare diagrams that bridged the gap between architectural and software representation.[1] This work was influential in design disciplines and also computer science and is credited with pioneering approaches to object-oriented programming.[2] Contemporary investigations into the application of digital tools in design and architectural practice are wide ranging. These applications include the use of communication tools such as social media for the development of audiences for design practitioners, or remote collaboration tools such as cloud-based storage and video conferencing to enable practices to access and engage with projects world-wide with greater ease. Other practitioners, such as Liam Young are using VR and other tools to develop new forms of practice that blur the distinction between film and architecture.[3] Practitioners such as Roland Snooks, Alisa Andrasek and Marc Fornes are using algorithmic tools to explore novel tectonics that would be impractical or prohibitively time consuming to develop in non-digital manners. Other practices, such as Gramazio Kohler, Achim Menges and others are utilising digital fabrication to variously expedite fabrication, implement novel tectonics and/or deploy mass customisation of building components or systems at zero marginal cost.

Emerging technologies are ubiquitous in architectural schools, and increasingly so in practice. 3D printing and other approaches to rapid prototyping are now commonplace. More and more firms are engaging in the direct manufacture of building components and experimenting with AI and other emerging information technologies.

Practice Futures: Digital Fabrication and Future Practice was a research project commissioned by the Architects Registration Board of Victoria (Australia). The project set out to investigate the challenges and opportunities that arise out of the increasing adoption of digital tools within the design and construction industries - Specifically focusing on professional practice in the architecture discipline in Australia. One of the major findings of this document was that was very little work has been undertaken world-wide into the implications of this shift on the legal, economic, ethical or other non-design domains of architectural practice.

A survey of the published literature on the impact of digital fabrication technologies on architectural practice indicates an overwhelming focus on the potential for optimisation of existing workflows. In their 2006 article ‘Control and Collaboration: digital fabrication strategies in academia and practice’ Richard Garber and Wassim Jabi explore in detail a series of digital processes that deliver complex geometry for construction. The article touches briefly on the potential for these technologies to deliver cost savings[4] and to change the role of the architect in the process of construction[5] (page 135). However, the implications of these issues are downplayed in favour of an analysis of technical and material systems[6].

The National Center for Competence in Research (NCCR) on Digital Fabrication at ETH in Zurich has established a Socio-Economic Working Group (SEWG) to examine the broader implications of digitalisation in the construction sector. While it is nascent, its work to date has principally focused on the impact of technological change on the construction industry, rather than the design sector. While the automation of the construction industry will have an obvious impact on who builds buildings and how they are built, the impact on the procurement of buildings has been largely overlooked. The adoption of direct manufacturing suggests a dramatic collapse of the construction value chain.[7] Rather than producing representations, the architect finds themselves providing direct instruction (i.e. code) for production. This shift would result in an unprecedented level of control for the designer over the built outcome, but at the same time signal a dramatic increase in responsibility and risk associated with design work.[8] In recent years, the profession has focused on risk mitigation through the deferral of responsibility to the client, consultants and contractors. The acknowledgement and acceptance of risk fundamentally changes the business model of architecture.

The advent of Artificial Intelligence (AI) and machine learning systems has resulted in disruptive change to several economic sectors. To date, the professional services sector, including architectural services, have remained largely unaffected by this technology, however it is inevitable that as AI systems become exponentially more sophisticated it will encroach into the traditional role of the designer.[9] Since 2017, a number of articles have been published describing the potential impact of AI on the sector. Many of these articles focus on the potential for AI systems to support or replace labour that is currently being carried out in architectural offices. “ Architects should see artificial intelligence as an opportunity—a tool to augment practice, replacing mundane tasks…”[10] A key issue in this is the viability of future employment in the sector.[11] While this is an important issue for the profession, what it fails to recognise is the potential for emerging technologies, such as AI, to expand the role of the architect and to open up new frontiers for the practice of architecture.

To adapt to technological change the model through which architectural practice is carried out will have to adapt and evolve. However, what is less clear is what this model might be. There are a number of major technological shifts that are disrupting the procurement of design and construction. As such it

is impossible to describe a single approach that would allow architects to be across all emerging technologies and markets. What this suggests is that the future of architectural practice might be a far more diverse understanding of what constitutes architectural services.
If this the future of architectural professional practice, how do we develop a model that describes these kinds of diverse approaches, and more importantly how do we teach it to the next generation of practitioners what it means to be an architect?

MODELLING PRACTICE THROUGH TEACHING

The Master of Architecture Program at RMIT University includes three units of professional practice across a two-year program. The third unit in this suite offers a unique framework in the context of architectural teaching in Australia. Professional practice three is focused on how technological innovations, digital frameworks, changing markets might affect the nature of architectural practice in the future. Students are challenged to operate in an entrepreneurial fashion to speculate on possible futures for architectural practice, with a focus on evolving the business model of architecture.
One of the underlying speculating in the development of this course is an observed similarity between the processes of research through design (that is iterative processes of speculative proposition and evaluation) and business planning (also involving speculative proposition and evaluation). The 'modelling' of speculative propositions is the key mechanism for evaluation in both context.
In the Professional Practice 3 course at RMIT, students are encouraged to 'design' through the medium of business planning. Equipping students with knowledge of business terminology, standard reporting tools and formats and how to apply this knowledge in developing a model for a sustainable design-oriented business.
Working in a stutorial (studio type tutorial) mode, students self-organise into groups of three and undertake a series of case studies, identifying design practices in Australia and internationally that are innovating in their use of digital tools, separately in the areas of communication and collaboration, processes used in designing, and finally within fabrication or procurement of built outcomes. In each of the first three weeks of the course, students present within their tutorial groups a short written and verbal report, identifying their selected innovative practice's background and market, the core identified innovation as compared to a traditional practice baseline and a speculation regarding how this innovation is monetised.
These practice innovation case studies form a collective body of research which students draw upon in identifying their own innovation, or application of an observed innovation, upon which they incrementally model a business proposal over the subsequent weeks, in consultation with their tutor(s). At the conclusion of the course, students present their completed business proposals verbally and as a formal business plan, including the following information:

- A description of the proposed service, showing an example to the service that are offered.
- A description of the value of the service offered; convince the audience that the service that you are offering is both innovative (that is different to other products/services on the market) and valuable for them.
- Description of the pricing structure of the service. How is it changed for it? By unit, hourly rate, as a percentage of total cost or another metric? How does the pricing scale, with different levels of service?
- Description of the market for the service. Who is going to buy it, and how you have identified them.

- Articulation of a marketing strategy. What steps are you going to undertake to communicate the value of your service to your identified market.
- Identify your 'start-up' cost, what is the total cost to bring your product or services to the market.
- Identify a unitised cost for delivering one 'Unit' (design for one house, one widget etc.), the proposed sale value of each unit and therefore profit per unit.
- Gross up how many units are required to repay any start-up costs and achieve identified profit targets for year 1, year 5 and year 10 targets.
- Identify any risks (financial and litigation) related to your proposed innovation and outline steps for mitigating them

The combination of the Innovation Case studies and the Business Plan assessable tasks encourage students to research and engage with innovations underway within architectural practice that will affect their own careers as they enter the profession, but also crucial apply this knowledge through the design of their own business model proposals.

FUTURE PRACTICE MODELS

Over the last several semesters a number of themes have emerged in the types of innovations identified and the business models presented. These themes include the use of computational tools (including machine learning) as a mechanism for evaluating large data sets in identifying new project opportunities or client relationships, the use of digital fabrication of building components and/or systems, application of augmented reality as a tool for optimising the construction process and applications of emerging systems for intellectual property management (including Blockchain technology) to capitalise on latent IP with architectural practice as a secondary income source.

Machine learning

Applications of Neural Networks and Machine Learning systems within architectural practice have been explored in several different ways. These computational systems offer novel techniques for the modelling and analysis of complex or non-linear information.[12] In one of the more interesting examples of this approach students Laura Venier, Stephan George and Giovanni Gunawan proposed the use of a machine learning system for evaluation of allowable planning envelopes for individual sites within Melbourne, tested against existing building envelopes and historical sales data derived from commercially available sources. This evaluation was proposed as a methodology to identify individual or aggregate sites with very high potential for future development.

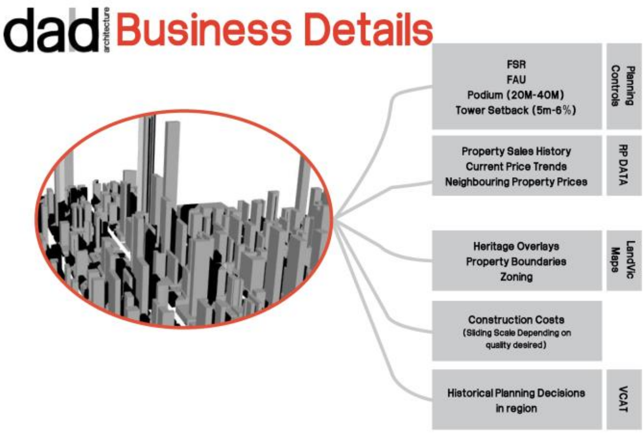


Figure 1. DADI by Laura Venier, Stephan George and Giovanni Gunawan

The business model in this case offered developer clients a report of selected areas within the city for a nominal fee. The fee for this service was not proposed as a profit centre for the business, rather as a 'loss-leader' pricing strategy, where this particular service is sold below its cost to produce cost to stimulate sales of more profitable services. In this case the development evaluation reports served as a mechanism for establishing relationships with prospective development clients, with an aim towards subsequent engagement for the architectural services on projects identified as high potential for future development. This strategy back-ended profit the profit centre for the business model in more conventional design services. Interestingly, since this proposal was presented approximately two years ago, several businesses have emerged in Melbourne offering similar or related services to those described above.

Digital fabrication

Another thematic has been the expansion of architectural practice into fabrication through the application of digital or advanced fabrication. An example of this approach is James Pazi, Alexander Christos and Thurston Empson's, proposal for XYZ. This proposal identified a niche for the resolution and development of complex geometry components and prototypes in advance of large scale production by others. Rather than a conventional practice this practice seeks to sub-construct to a larger practice providing a specialised fee for service in the design development of building components or assemblies and the preparation of files for direct manufacture.

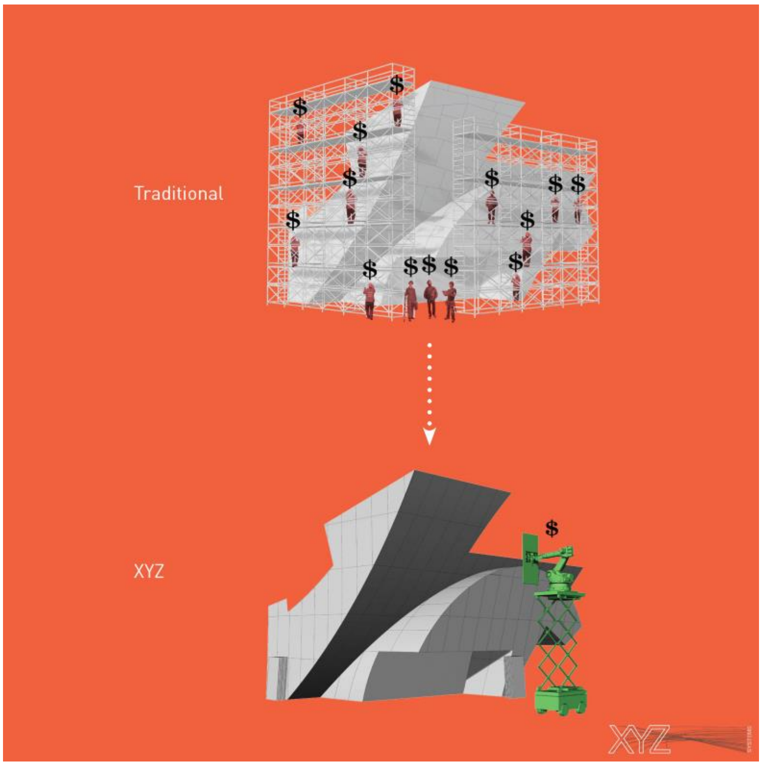


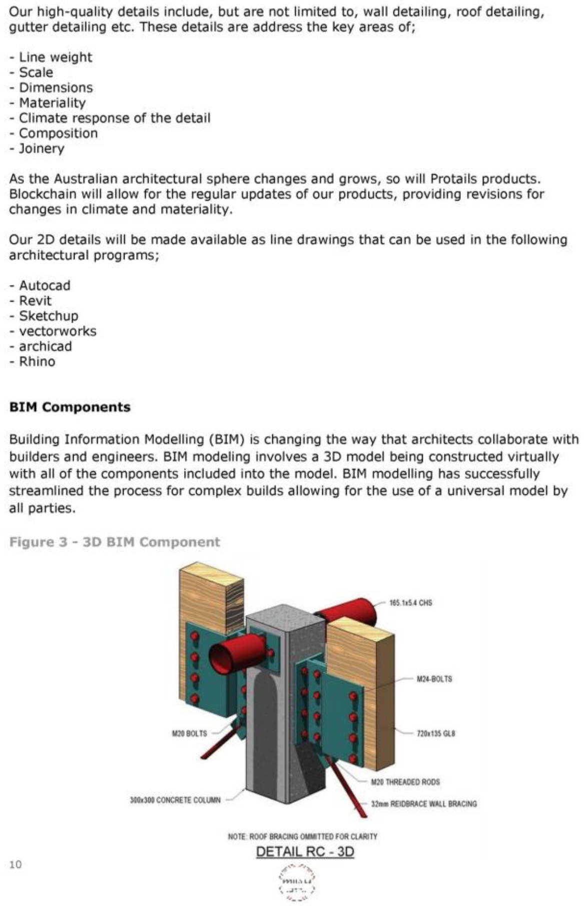
Figure 2. XYZ by James Pazzi, Alexander Christos and Thurston Empson

The proposition in this case rests in the identification of a market opportunity in that current architectural documentation typically describes design intent, with subsequent documentation for fabrication (shop-drawings) prepared by sub-contractors to the principal contractor. Where digital fabrication is being used this process is less effective as the digital model, rather than drawings, is often used directly in the manufacturing process. In these cases, the digital model needs to be optimised for fabrication during the design process. Many architectural practices do not currently have the specialist knowledge for embedding fabrication processes and information within their digital models, opening a space for the services proposed by this business proposition. However, over time as these skills become more wide-spread, the market niche occupied by the proposed business would shrink.

Intellectual property/blockchain

Several projects have also investigated applications of Blockchain technology, including Simon Sawyer, Chris Crawford and Yuanbo Zhang's proposal, 'Protails' which involves the expansion of a conventional architectural practice, to monetize the practices back catalogue of construction details. While standard construction details are widely available and published, in publications such as Detail magazine and others, there are very few publicly available construction details based on Australian construction methodologies, which are significantly different to European or American approaches.

In this proposal students proposed to make available a catalogue of standard construction details developed and used by their own practice for use by other architectural practices. via micro payments, enabled through application of Blockchain to manage licencing. Specifically, Blockchain allows for highly secure licencing at significantly lower cost than traditional centralised licencing, due to its distributed nature. This lower licensing management cost, enables extremely low cost per transaction (in the range of 5-10c per application), which aims to increase volume over individual return per sales unit. In this case, students proposed that this service was an adjunct to a convention architectural practice, that delivers value form a key piece of practice intellectual property, that conventionally lies undercapitalised.



Our high-quality details include, but are not limited to, wall detailing, roof detailing, gutter detailing etc. These details are address the key areas of;

- Line weight
- Scale
- Dimensions
- Materiality
- Climate response of the detail
- Composition
- Joinery

As the Australian architectural sphere changes and grows, so will Protails products. Blockchain will allow for the regular updates of our products, providing revisions for changes in climate and materiality.

Our 2D details will be made available as line drawings that can be used in the following architectural programs;

- Autocad
- Revit
- Sketchup
- vectorworks
- archicad
- Rhino

BIM Components

Building Information Modelling (BIM) is changing the way that architects collaborate with builders and engineers. BIM modeling involves a 3D model being constructed virtually with all of the components included into the model. BIM modelling has successfully streamlined the process for complex builds allowing for the use of a universal model by all parties.

Figure 3 - 3D BIM Component

10

Figure 3. Protails by Simon Sawyer, Chris Crawford and Yuanbo Zhang

Augmented Reality

A further theme that has emerged has been the adoption and integration of Virtual Reality and/ or Augmented Reality in changing the way that designers communicate design intent to clients, and/contractors. An example of this is Michael Lopes-Vieira, Montgomery Balding and Eleanor Morgan's proposal 'Design & Construct', in which they proposed the elimination of 2d project documentation, via the application of Augmented Reality representation of a detailed 3d model for use by construction trades on site.

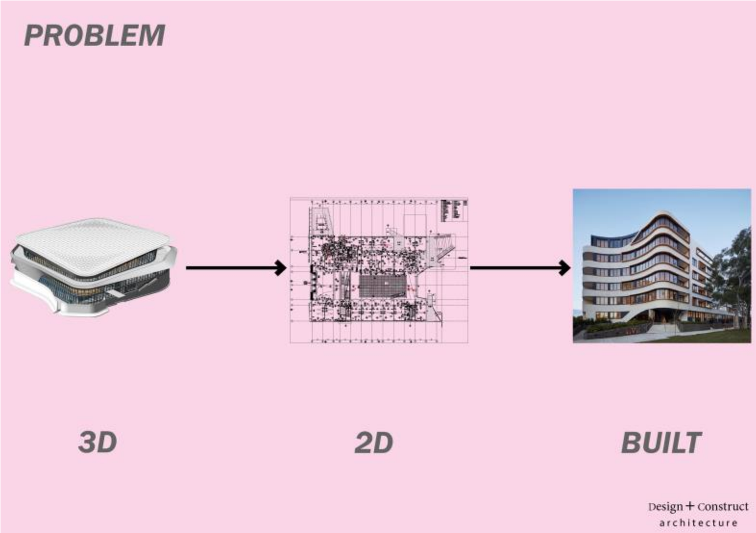


Figure 4. Design + Construct by Michael Lopes -Vieira, Montgomery Balding and Eleanor Morgan

The core observation in this proposal is that current workflows in architectural design, develop complex and information rich digital 3d models, which are then represented in 2d for the purposes of contract scope definition and for use by construction trades. This process loses significant information from the 3d model which leads to errors on site and is also extremely time consuming for designers to produce. This proposal identified a specific sub-set of the developer client market, who are integrated developer/builders, who would appreciate the value of the application of AR on site to expedite construction on site and reduce errors. The identification of this market niche allows the proposed business to market their service based on this advantage, rather than any efficiencies in the design process, allowing the business model to retain these improved efficiencies (and therefore profit) for use in other areas of the business or to shareholders.

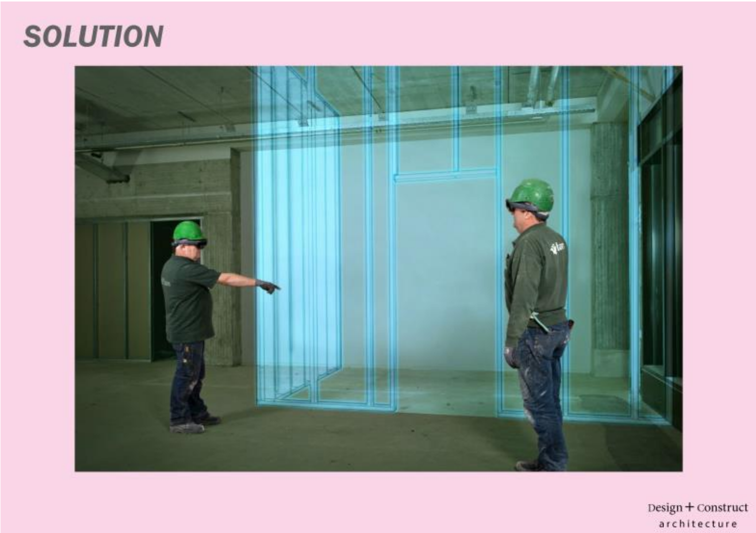


Figure 5. Design + Construct by Michael Lopes -Vieira, Montgomery Balding and Eleanor Morgan

As the course continues to run the potential impact of new and emerging technologies upon architectural practice are actively investigated. These investigations are necessarily speculative and often raise more questions than they answer, however they equip students with a basic knowledge of financial terminology and standard forms, and engages them in thinking about how they can play a role in shaping architectural practice as they enter the profession.

CONCLUSION

The rapid emergence of new technologies will inevitably impact the procurement of design and construction. Disruptive change driven by technology has the potential to fundamentally change the paradigm through which architectural practice is understood. While there is an important role for architectural research and pedagogy to play in developing technological systems for design and construction applications, it is equally critical to develop an understanding of how these changes will shift the model of architectural practice, and potentially open new frontiers for the discipline.

In this space, it is vital for universities and professional bodies to develop an open understanding of what might constitute practice in the future. The pedagogical agenda articulated in this paper illustrates an approach by which post graduate teaching programs might provide a mechanism through which students are actively engaged in hypothesising potential futures for the practice environment into which they are entering.

Ultimate this provides a framework for experimentation and innovation in architectural practice research, in which ideas can be seeded through vertically integrated teaching and expanded through speculation to provide a series of propositional models for future practice.

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ARCHEATABLE: FOOD AND PASTRY ART AS A VEHICLE FOR THE TEACHING OF DIGITAL DESIGN AND FABRICATION LESSONS IN ARCHITECTURE

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INTRODUCTION

More than ever, architecture shows diffuse borders in academia and industry. Today, it is a profession that is constantly and rapidly reinventing itself and connecting with other disciplines to expand its boundaries. The speed of the incorporation of new technologies, like digital design and fabrication, means an uncertain but stimulating field of experimentation in teaching, research and practice.

Academia cannot ignore such substantial changes and must incorporate adaptive strategies in the curriculum that allows it not only to be in line with the industry but also to train future thinkers capable of transforming both architecture and other tangential disciplines.

Students must be trained to respond with creativity in permanently changing scenarios and proposing new models of thought and business opportunities. This is an opportune moment for them to explore these interdisciplinary relationships, address collaborative projects and take risks.

The paper will present the educational process and results obtained in the course archEatable, A journey through architecture and Haute pâtisserie. It is an innovative teaching experience created by the author at the American University in Dubai in Fall 2018, focused on a relationship between Architecture and the world of Gourmet Pastry. It presents edible works of art designed by students, the collaborative experience with pastry chefs and a unique and non-conventional academic approach in the teaching of Digital Design and Fabrication techniques.

archEatable configures itself as a new discipline that questions some of the standards on how to educate future architects today.

What is archEatable?

archEatable is a professional elective course offered to juniors and seniors in the Bachelor of Architecture Program at the American University in Dubai. It was taught for the first time in the Fall semester of 2018 for a duration of 16 weeks.

archEatable explores the limits of education in architecture through a unique approach in the teaching of digital design and fabrication techniques. It has also meant an opportunity to collaborate with professionals from diverse disciplines with compatible design processes and to interact with students and faculty from other schools in the American University in Dubai.

archEatable focuses on a relationship between Architecture and the world of Gourmet Pastry, Haute patisserie. Twelve students were asked to design unique edible works of art, supported by the use of specific cutting-edge software and machinery. The course incorporates novel 3D-printed prototyping, silicone moulds and laser cutters to create geometric cakes.

Given its originality and complexity, archEatable seeks to research, experiment and risk. The course has had required out-of-class learning activities such as the silicone moulds manufacture session at Originbase Fabrication Lab in Al Quoz, Dubai, and recurrent meetings at the International Centre for Culinary Arts, ICCA, Dubai.

To promote closer relations between schools, the course also took onboard students of the Mohammed Bin Rashid School of Communication with the mentorship of Professor Roozbeh Ali Kafi. The students filmed and documented all the different phases of this journey.

To conclude the semester, the results were presented at a special event open to academics, students, designers and the general public, held on December 19th in Cosentino Showroom at Dubai Design District (d3). This venue is the cradle of design in the region, and is representative of Dubai's reputation as a city of innovation. This is reflected in the city's appointment as a "Unesco Creative City of Design", the first Middle Eastern city with this designation.[1]

archEatable exposed students to innovation by using the latest technology, making them more prepared for a professional world. For the instructor, it created a course that embraces the future of education and configures itself as a new discipline in academia.

Precedents and modes of learning

Among others, a significant mode of learning precedent is the Solar Decathlon Competition, where the students design a project to be built with professional standards. Solar Decathlon is a broader project in scale, housing prototype, with a duration of two years. Due to its magnitude, the work is carried out in teams and jointly with specialists from other disciplines commonly linked to architecture.

archEatable does not formalize learning in ways similar to other disciplines. Now that digital fabrication is changing architectural practise and teaching, this course proposes to go one step further; which is actually, to transform other fields such as Haute Pâtisserie with a remarkable impact.

INITIAL CONTEXTUALIZATION: PASTRY ART AND DIGITAL FABRICATION

The baking and pastry arts industry is a specialization within the category of food preparation and service. As in many industries, it helps to have prior experience in the field to become a successful pastry artist. As architects without specific training in pastry, we faced the challenge of ensuring that the final cakes were faithful to the design and met the standards of health conditions, taste and textures.

In digital fabrication, machines receive geometric information from computers to elaborate on physical elements by subtractive or additive operations. At this starting point, it was necessary to provide students with the training required to process the digital cake designs to be adequately created, later transferred for fabrication with such machinery. In our case, we began with a more specific inquiry to see which of these techniques are currently applied in the world of pastry. Secondly, we proposed the necessary adaptations to make the designs compatible with the machinery and resources available at the university. In parallel, students investigated the most inspiring chefs and designers who are working with innovate processes and advanced digital design and manufacturing tools. The task was carried out and covered the sections described below.

Machinery and new technology applications

Students were asked to search on specific pastry machinery, 3D printers, food 3D printers, laser cutters, CNC and others. We studied references like the Japanese team Open Meals[2] that aims to use replicating technology to usher in a new era of experiencing food using their revolutionary Pixel Food Printer. This vision of the future of replicated food extends until the year 2100, explained in the project future100years.[3]

Another study was the 3d printed drinks developed by Benjamin Greimel in his PRINT A DRINK project; it is the world's first 3D printing technology for drinkable liquids. The technology merges methods from robotics, life sciences and design to explore an entirely new field of 3D-printing.[4]

Software

Students explored tools for standard 2D-3D software, structural and natural forces simulators and plugins for parametric design. Among the findings, a valuable reference was the work done by the artist John Edmark[5], using Rhinoceros 3D and Phyton programming language. Rhino is a 3D modeller that is used to create, edit, analyze, document, render, animate and translate NURBS curves, surfaces and solids, point clouds and polygonal meshes. There is no limit of complexity, grade or size, apart from whoever owns the hardware.[6] Rhino 3D is one of the most advanced software in digital design, and it was the primary tool used in the classroom, along with the digital design phase. Students studied how Edmark implemented the use of Rhino 3D programming language through Phyton: a widely-used, interpreted, object-oriented, and high-level language with dynamic semantics, used for general-purpose programming.[7]

Innovative Chefs

Pastry & culinary art are currently experiencing one of its sweetest moments. Thanks to the impact and instant diffusion that social media allows, gastronomy is now one of the most popular subjects. Dinara Kasko (Ukraine, 1988), is a graduate architect and has become one of the key figures of contemporary pastry art. In the case of the archEatable, Kasko was the inspirational starting point of the course. She creates highly artistic, edible cakes using 3D printers and laser cutter machines.

In the article *Creativity and Innovation Patterns of Haute Cuisine Chefs*, Jose Albors, P. García-Segovia, Javier Martínez-Monzó and Jose Luis Hervas-Oliver, surveyed different reference chefs on, among other topics, their sources of innovation and creativity. The results revealed that the most relevant sources for change were the restaurant staff as well as the cooperation with other colleagues. The collaboration with institutions such as universities or external experts or ideas sourced from competitors was second place, with a smaller frequency and intensity.[8]

archEatable sought to highlight the benefits of collaborations between specialists from distant disciplines, and the results showed that synergy multiplies thanks to those differences. Chefs who stand out and have become a reference are precisely those who have opted to cross culinary arts with disciplines such as chemistry, biology, psychology, mathematics and nutrition. A significant example is Ferran Adrià (Barcelona 1962), who managed to incorporate molecular gastronomy into his courses.[9]

Food & Senses: Foodpairing & Performance

One of the course proposals was to investigate the relationship between food and senses. One of the findings of this stage was "Foodpairing", a scientific method to identify which foods & drinks go well together.[10] The sensory experience culminates with the construction of the tasting event. It is a building of intensifying atmospheres such as those carried out in the restaurant Sublimotion in Ibiza, by chef Paco Roncero (Madrid, 1969). Sublimotion is the world's first gastronomic show: a fusion of Haute gastronomy and technological vanguard developed over two years by a team of professionals from different sectors.[11]

This initial phase of contextualization was crucial for entering the culture of contemporary gastronomy along with the most significant and stimulating techniques in terms of digital design and manufacturing, the latter widely known from the architectural field.

COURSE PRODUCTION SEQUENCE

Cake concepts: Four levels of complexity

In architecture, the concept is also known as the generative idea or the design scheme, the essence of architectural design.[12]

At the initial stage of the cake design, the pedagogical approach was to establish four design proposals with increasing complexity to expose students to exponential challenges and critical design problems.

Table 1 shows the level required for each proposal in terms of concept, geometric complexity, abstraction and overall difficulty. The level scale is about ideation maturity, quality of work, deep understanding and risk. The level was set as low, medium, high or extreme.

Table 1. Requirements and difficulty of each design proposal

LEVEL	Low	Medium	High	Extreme

PROPOSAL	CONCEPT	GEOMETRIC COMPLEXITY	ABSTRACTION	OVERALL DIFFICULTY
1	High	Low	High	Low / Medium
2	High	Medium	Medium	Medium
3	High	High	Low / Medium	Medium / High
4	Extreme	Extreme	Extreme	Extreme

For Proposal 1, the geometry is relatively simple but the concept, abstraction or minimalism achieved has to be reliable. It consists of making a mature reinterpretation of contemporary architecture or art masterpiece. On the next level, in Proposal 2, the use of digital tools reaches a medium level of complexity; however, with a high level of synthesis that makes the difficult seem easy. The outcome is not geometrically too complicated, but it should be a never seen shape in the field of pastry art. With a remarkable complexity rise in Proposal 3, the geometry, digital tools and manufacturing process suggested must be wholly original and disruptive in the field of pastry art. Finally, the ultimate stage is Proposal 4, where the idea is considered extreme in its difficulty in all aspects, however an achievable challenge that pushes forward the expectations of the course.

Examples of the students' concepts for each proposal are described below. See in Figure 2.

Proposal 1: The building Elbphilharmonie Hamburg in Germany inspires the cake.

Proposal 2. Neuroscience inspires the cake.

Proposal 3. The dandelion flower inspires the cake.

Proposal 4. The idea of fractals inspires the cake.

Students were encouraged to make better, well-justified decisions about the function and aesthetic value of the proposals, avoiding falling into formal whims.

Digital design: Project evolution and geometry metamorphosis

From concept to final form includes a process where the design evolves. Inspired by the first phase, the concept forms the soul and contributes to the formation of the "cake".[13]

Some of the features debated and improved throughout the cake's digital design phase were: strength of concept translated into form, message and relationship with pastry art, general aesthetic, suitable size for the cake or the portions, formal balance between the parties and composition, ingredients and machinery accessibility, market adaptability, cost and final cake feasibility.

Note that the "plate", final presentation and tasting ritual were also thought of as integral parts of the cake, and that the way of approaching, discovering and tasting the cake became a user-object performative interaction. The complete process provided substantial changes in the concepts and the initial proposals, finally reaching a higher level of design maturity. Trials, shape transformations and concluding designs were modelled in Rhinoceros 3D and Grasshopper. Final images were generated within Rhinoceros 3D using V-Ray rendering engine. Figure 1.

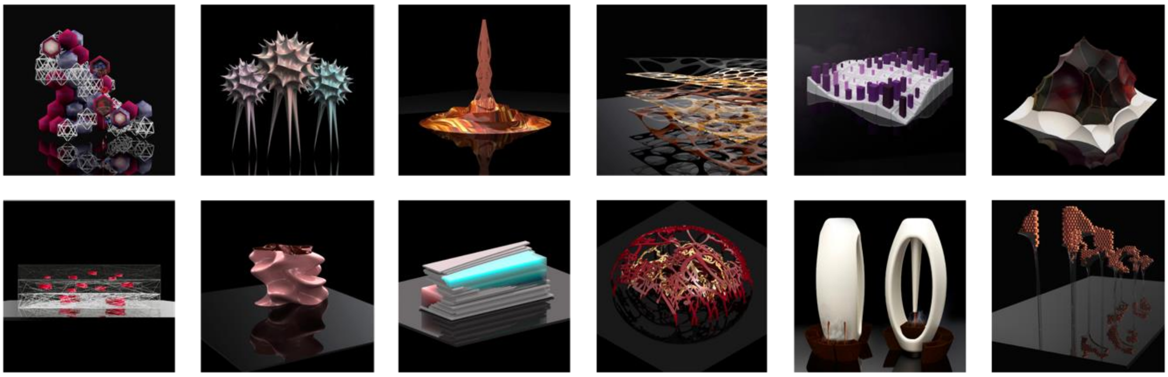

Figure 1. Student's work: Final digital designs

Digital fabrication

For the development of this phase, students worked with different manufacturing techniques that best suited their configuration. The selected methodology was rapid prototyping, using 3D printing for the majority of projects and a laser cutter for a few ones. Rapid prototyping employs a diverse group of techniques that are utilized to quickly and efficiently fabricate a 3D scale model of a physical assembly or part.

The use of 3d printing was not targeted to obtain the final piece, but to quickly get the replica of the cake that would allow obtaining the subsequent silicone mould in order to find possible design flaws for correction before proceeding with the next project phase. These rapid prototyping techniques allowed students to work very fast, at low cost and to obtain full-scale physical models for testing. Figure 2.

Mould making

As if it were a unique architectural work, custom-made formworks had to be prepared to pour the silicone that configures the mould to be used in the final cake making. This phase consisted of using the 3d prototype manufactured previously to make a container or formwork where the pieces are housed, and the food-grade silicone is poured. Later, it should cure at room temperature for 24 hours before demolding. Figure 2.

Cake making

archEatable had several external components seeking to promote academic research and interdisciplinarity at both professional and university level. First, students had a consultation with professional pastry chefs at their off-campus facilities. However, it was not possible to count on the chefs to find the suitable ingredients; there was also some uncertainty about the making of the cakes by the students. Only 33% of the cakes were satisfactorily completed and edible. The remaining 66% were not completed correctly, either because they were executed faithfully to the design but not edible 17%, because they turned out totally or partially failed 25%, or they were not made 25%.

Table 2. Final achievement index of the cakes

Complete cake: Faithful to design and edible	4/12 (33%)
Incomplete cake: Faithful to design but inedible	2/12 (17%)
Totally or partially failed cake	3/12 (25%)
Unrealized cake	3/12 (25%)

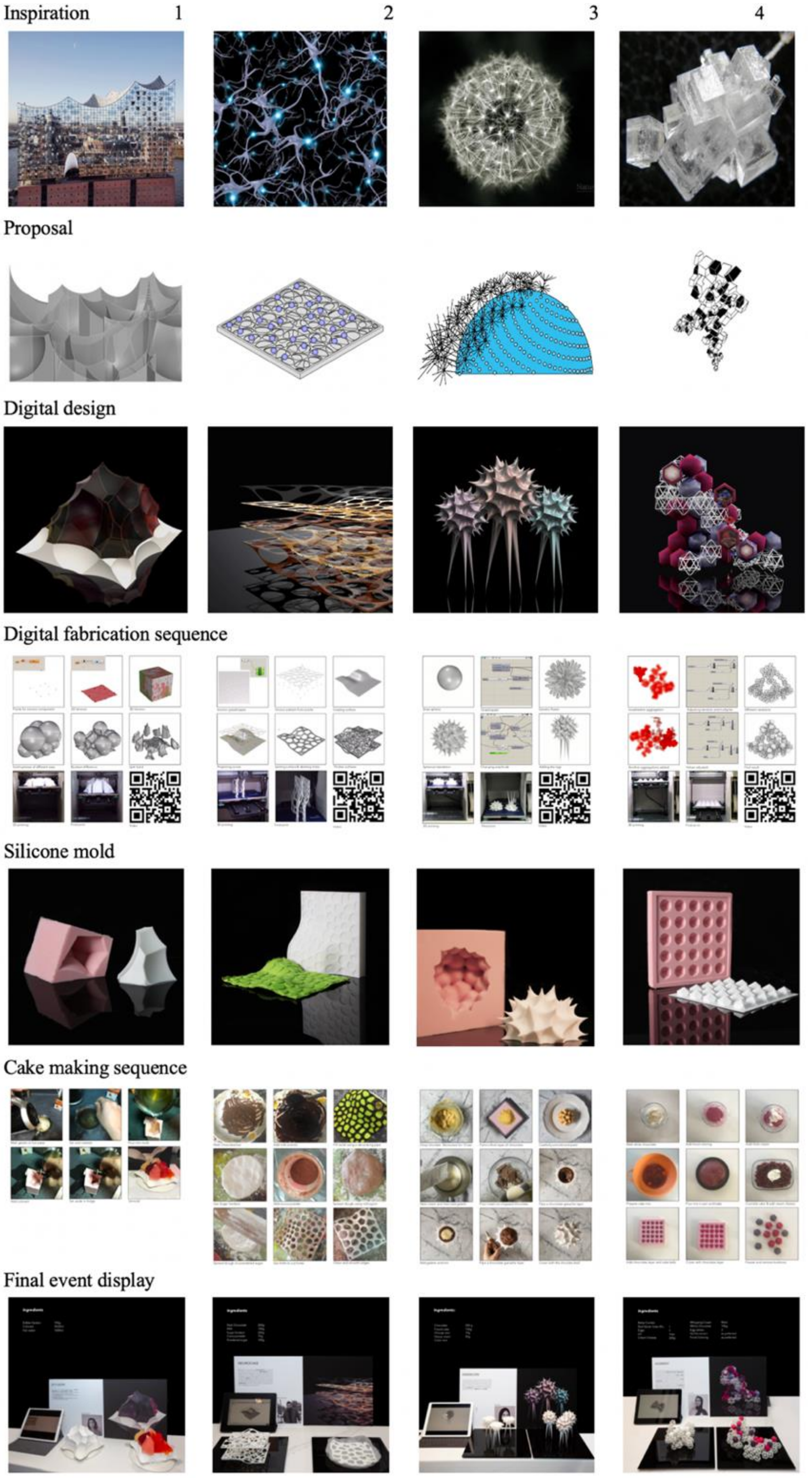

Figure 2. Student's work: Sequence of course production

What is unique about how students learn in this process

What is unique about this teaching project is that students are heading to design and manufacture a consumable product from beginning to end. The entire journey happens in a very short period and in a necessarily collaborative environment where pastry chefs, professionals unrelated to architecture, have

a crucial role in the outcome. archEatable illuminates the often-hidden creative process where much of the learning takes place. Students are involved in all stages and face constant difficulties. They learn to be more precise, to visualize future problems caused by the current design, and when it happens, to solve them and propose alternatives. archEatable refines their ability to be mindful, active and self-directed learners.
From the academic point of view, each stage is an opportunity, and at the same time a requirement, to substantially improve the student´s work. Professor and students learn about the power of collaborative synergy with pastry chefs, creating a project that is by no means possible without this cross-knowledge. Together with the professor, the work is co-evaluated by these external experts and adapted to their disciplines' specific needs. As a result, they make a final product that responds to a multidisciplinary perspective.

COURSE EVALUATION

Several individual surveys of the students were carried out. The professor also made his evaluation of the teaching experience that allows him to evaluate the results, find deficiencies and propose changes to improve future editions.

Students' interviews

From the topics asked in the questionnaire, the testimonies were the following:
Student 1: *"This course opens the spectrum we usually think about when we talk about architecture. It is also a way to widen our perspectives on how to connect what we have learnt in architecture with our daily life."*
Student 2: *"archEatable pushed the limits of our creativity as we did not only think of how the outcome would look like but also of how it would be produced, presented and served. The emphasis on the process was very prominent in the course which we learned the most from."*

Instructional report

Students highlighted positive aspects of the instructor such as relating the course to other disciplines, relating the course to what is happening today, and motivating students. They also pointed out deficiencies and areas in need of improvement such as clarity in how they would be evaluated.

Teaching self-assessment: limiting factors

The following table describes the main limiting factors, and therefore priority improvements, to emphasize in future editions.

Table 3. Limiting factors in the different phases of the course

Digital design	**Digital fabrication**	**Mould making**	**Cake making**
○ Mastery of the digital design software used ○ Geometric complexity to become a piece of pastry art	○ Non 3d printable geometries ○ Unsatisfactory 3D printings ○ 3D printers limited features and capabilities	○ Supply market availability for food-grade silicones ○ Access to suitable machinery and facilities for the mould making	○ Mastery of pastry techniques and ingredients ○ Knowledge and market access to the most suitable ingredients

		○ Inadequate unmolding or broken pieces	○ Access to appropriate machinery and facilities for the cake making ○ Supervision from pastry professionals ○ Non-self-standing ○ Non-edible outcomes

CONCLUSION

Choosing a discipline such as pastry art and evaluating the results of this first edition of archEatable has shown how necessary it is to move away from the "core" of a discipline. To speak of the "core" of architecture is imprecise, for although it is a discipline that has been redefining itself since its existence, at the moment, it does not present theoretical and practical clarity.

A condition that identifies architecture and design is its permanent innovative character. The collaborative will of the course has revealed the status of some design areas in the context of the United Arab Emirates. Dubai has become the first city in the Middle East to be appointed as a "Unesco Creative City of Design". Paradoxically, it has been challenging to find pastry professionals with a clear innovative profile and a desire to go beyond the implanted nature and unique vision of local business and short-term economic remuneration.

Nowadays, digital design and fabrication tools make the interaction between disciplines very flexible. Thanks to them on the one hand, archEatable is a pioneering teaching experience in architecture, and on the other hand, consolidates a differential and qualitative leap hardly attainable by traditional methods in other fields such as Haute patisserie.

The table 3. Limiting factors in the different phases of the course helps in recognizing the proposed improvements for future course editions. The objective is to increase performance in each stage so that the final results of higher quality are achieved, since 66% of the cakes were not completed correctly in some aspect. Future course editions and research will focus on the improvements that might expand the boundaries of both disciplines: architecture and pastry art.

Finally, the impact of this course in the academic, curricular and artistic field deserves to be highlighted. The instructor was awarded the Provost's Award for Innovation in Teaching 2019 at the American University in Dubai. He was also invited to participate in the 1000 vases Art Dubai International Fair 2019 exhibition[14], with a new design inspired by thematic and teaching methodology developed during the course.

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Education, Design and Practice – Understanding skills in a Complex World

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TEN YEARS OF BUILDING TECHNOLOGY AT CITY TECH: REFLECTIONS ON THE EVOLUTION OF FIRST YEAR BUILDING TECHNOLOGY COURSES IN AN OPEN ENROLLMENT CANDIDATE BARCH PROGRAM

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INTRODUCTION

Educating architects of the 21st century requires reflection on the historical roots of pedagogy, analysis and integration of the application of best practices from the scholarship of teaching and learning, and creative development of new strategies that balance hard and soft skills development with critical thinking and creative problem-solving. A BARCH candidate program at New York City College of Technology (City Tech), an open enrollment CUNY college in Brooklyn, offers a testing ground for innovative pedagogy that can achieve this balance while pursuing its mission to increase access to the discipline by an underrepresented population. Emerging from a historically vocational culture, the building technology curriculum at City Tech is a case study in the goal for balance between job readiness and critical knowledge and skills development. Formally referred to as construction documents courses, the building technology courses are becoming dynamic laboratories for investigation that seek to integrate with the design curriculum. They incorporate history and theory to place discussion of structure, materials, tectonics, and performance into context. This paper reviews the experimentation and development of first-year building technology courses over a ten-year period at City Tech. Case studies of prominent buildings ranging from the Empire State Building to the Yale Center for British Art are presented as vehicles to provide a place-based laboratory and a historical/theoretical context for learning. Emphasis on three-dimensional explorations of structure and assemblies developed through hand drafting and digital modeling will be reviewed for their learning efficacy. Finally, improvement techniques for reading technical texts will be presented. These strategies are shown to be particularly useful for a diverse and often underprepared student cohort.

REFLECTION ON THE HISTORICAL ROOTS OF PEDAGOGY

Architectural education has inherent challenges stemming from the breadth of this discipline that seeks balance between science and art. The wide range of skills required to successfully practice outlined by Vitruvius in the ancient world are carried into the 21st century by registration and accreditation boards.[1] Schools of architecture, encouraged by the National Architectural Accrediting Board (NAAB) to continuously improve, must periodically reexamine their pedagogy and curriculum to make adjustments that improve the facilitation of students' intellectual and personal growth and prepare them for a successful career in architecture or allied fields that continue to evolve with new approaches and technologies. This reexamination of pedagogy must recognize and respond to age-old challenges inherent in training and educating students of architecture precisely due to the breadth of the discipline, the role of young graduates in practice, and the preparation and skills required to advance in the profession for a successful life-long career.

The first formation of formal architectural education provides insight into the persistent emphasis on the hard skills in architectural education. Early programs such as the Mechanics Institute in New York served as training grounds to provide draftsmen to the emerging architectural profession of the 19th century in the United States, following an approach to pedagogy that today would be described as vocational.[2] The founding presentation of the first collegiate program at MIT in 1865 documents an approach to pedagogy that seeks educational efficiency and emphasis on hard skills at the sacrifice of exploration of the ideas of architecture, establishing an approach devoid of theory that is still characteristic of vocationally oriented programs.[3] Theory and the poetic exploration of architecture are left to the elite who have the luxury to explore these aspects of the discipline. This separation of the practical and theoretical continues in many programs to this day in the chasm separating building science/technology and design education.

This same founding document for MIT's program, however, has an important distinction in its approach to teaching technical aspects of architecture. The founding director William Ware outlines an approach that emphasizes learning by doing that is rooted in rigorous investigation of the materials and methods of construction following the scientific method, with observation and experimentation critical tools for learning.[4] This direct and intimate interaction with the material reality of architecture is consistent with a contemporary experiential, place-based and inquiry-based learning approach that uses the built environment as a learning laboratory, moving critical activities outside the classroom. In this 19th presentation of architectural education we can see the kernels of balanced approaches to educating job ready students that are engaged and prepared to adapt and change with the discipline.

TECHNICAL AND GENERAL EDUCATION IN ARCHITECTURE CURRICULA

The technical courses of many curricula around the country have persistent pedagogical roots in the vocational foundations of American architectural education, currently with a significant emphasis on digital tools for documentation. This emphasis is based on the view that documentation skills provide the smoothest and most time efficient pathway to entry level employment in the industry.[5] Vocational education still has relevance in the 21st century as demonstrated in countries like Germany, but it has limitations that become evident in the middle and late career of graduates of vocational programs. Studies indicate that degrees rooted in a general education core prepare graduates for greater career longevity through their adaptability to changing workplace and professional conditions.[6] Indeed employers in the 21st century emphasize in surveys the importance of critical thinking,[7] learning skills, and soft skills in the contemporary workplace.[8] Education scholarship increasingly supports inquiry and research as a critical approach to undergraduate pedagogy.[9] In the context of architecture baccalaureate degree programs with a general education mandate, technology courses can be reconceived to move beyond a pure focus on documentation skills to become dynamic studio-based laboratories for nurturing technical knowledge, critical thinking, and creative problem-solving skills. These courses also can be designed to break down the silo culture common in higher education by layering technological investigations with historical, theoretical, and aesthetic perspectives.

The architecture program at City Tech provides a case study of the transition of a vocationally oriented program to a general studies baccalaureate degree program as well as an emerging undergraduate professional degree program.[10] In 2009 the faculty of the department decided to reconsider its curriculum and to begin a process of realignment and integration of courses using NAAB's education requirements as the guide. In a major curriculum change, two documentation courses and two materials and methods courses were combined with a digital documentation course to form two new technical studios, Building Technology I and II. The fundamental goal of the combination was to be able to link lecture-based material and drawing exercises. Beyond this goal, these new courses allowed a significant shift from classroom based "knowledge acquisition" to courses where the technical knowledge is placed in historical and theoretical context, critical thinking skills are developed, and place-based inquiry is integrated.

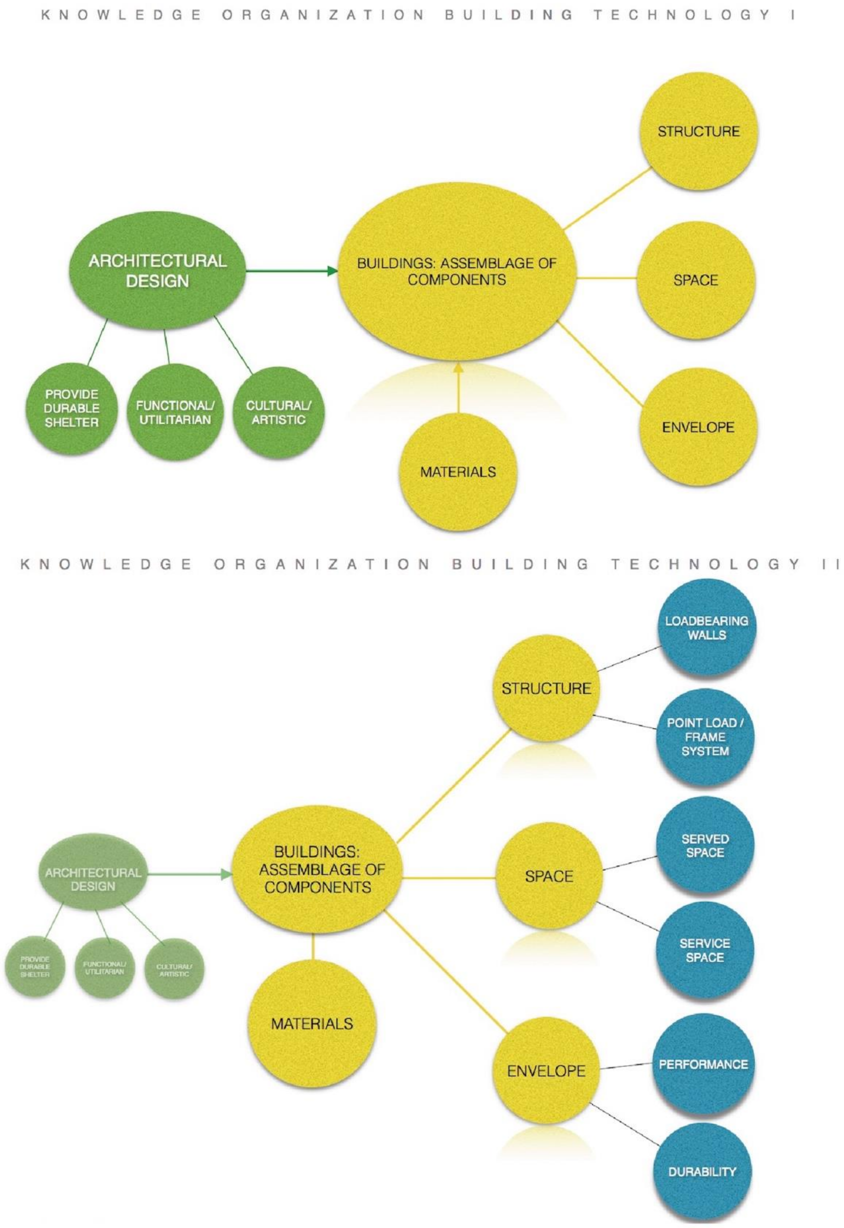

Figure 1. Knowledge organization: course content for two sequential courses diagramed as concept maps showing broad categories for the first course and then finer grain topics building on this knowledge foundation in the subsequent course.

ANALYSIS AND INTEGRATION OF BEST PRACTICES FROM THE SCHOLARSHIP OF TEACHING AND LEARNING

The scholarship of teaching and learning is an important reference for the development of these new courses; in particular, three principles of teaching and learning are particularly relevant: prior knowledge, student motivation, and knowledge organization.[11] At the starting point of a first-year course, faculty need to be cognizant of the students' prior knowledge as effective learning is significantly impacted by the nature and extent of what students' know when they enter into the program. Further, students' motivation is important to how they learn, impacting the "direction, intensity, persistence, and quality of the learning behaviors in which students engage."[12] Also critical is the consideration of how students organize knowledge. Experience is critical to the associations and connections students make between bodies of knowledge; lack of experience in the discipline hampers effective mental organization of the new material presented.[13] Each of these principles are addressed in the new courses. Prior knowledge is surveyed through the initial class discussions and a combination of reading and drawing assessments. Knowledge organization is made explicit through the integration of concept maps of the course content on the syllabus as well as scaffolded strategies for active reading note-taking through concept maps and graphic organizers. Student motivation is built through an emphasis on classroom engagement through active learning strategies as well as out of classroom exploration of the built environment focused on local iconic architectural works.

Scholarship on deep and meaningful learning guides addition pedagogical strategies for the new courses. The retired lecture-based courses focused primarily on *retention* of information, while the new courses adopt strategies developed to foster the ability to *transfer* information.[14] In his research on learning, Richard Mayer links meaningful learning to constructivist learning, where students "engage in active cognitive processing, such as paying attention to relevant incoming information, mentally organizing incoming information into a coherent representation, and mentally integrating incoming information with existing knowledge."[15] Meaningful learning leading to problem-solving skills and critical thinking are central goals driving the development of these courses.

EXPERIMENTING WITH METHODS FOR MEANINGFUL LEARNING

A Case Study Approach:

Prior to the launch of the new courses, an experimental learning community was formed in 2011 that combined the first semester drawing and materials courses. A case study strategy was adopted using the Empire State Building as the subject for investigation, chosen for its unique iconic position in New York City architectural heritage. It was also selected based on the information available to support student investigation, including the Lewis Hines photo documentation of the construction of the building. These construction photographs along with drawings made available at the Avery Library's Drawings and Archives Department allowed the students to reconstruct the layers of the building, learning about steel, stone and brick masonry, concrete, metal and glass, construction sequence, and the tectonics of the great 1930's tower. The investigation combined use of hand sketches, AutoCAD, SketchUp, and Revit modeling. The student studies embody learning through research and inquiry, with the process of investigation taking precedent over the product. A third-party review by a lead engineer from Thornton Tomasetti validated the level of engagement and investigation as well as the rigor of this process.

This experimental course demonstrated the potential for the use of a number of strategies in the curriculum. First, using case study buildings of significant historic or design value facilitate the learning behaviors promoted in the literature, including inquiry through careful observation as a key to constructing knowledge, and analysis as a key to the development of critical thinking skills. This was facilitated by site visits where students could use high resolution cameras and sketchbooks as tools for careful observation to initiate their analytical investigation. The case study also demonstrated the value of using buildings that have significant documentation to be used not for mere reproduction but for a rigorous investigation of structure, envelope, materials, and tectonics. Finally, the first-hand experience of seminal architecture through place-based learning is both a tool for increasing motivation and engagement as well as establishing experiential knowledge foundations that can be built upon as the students mature.

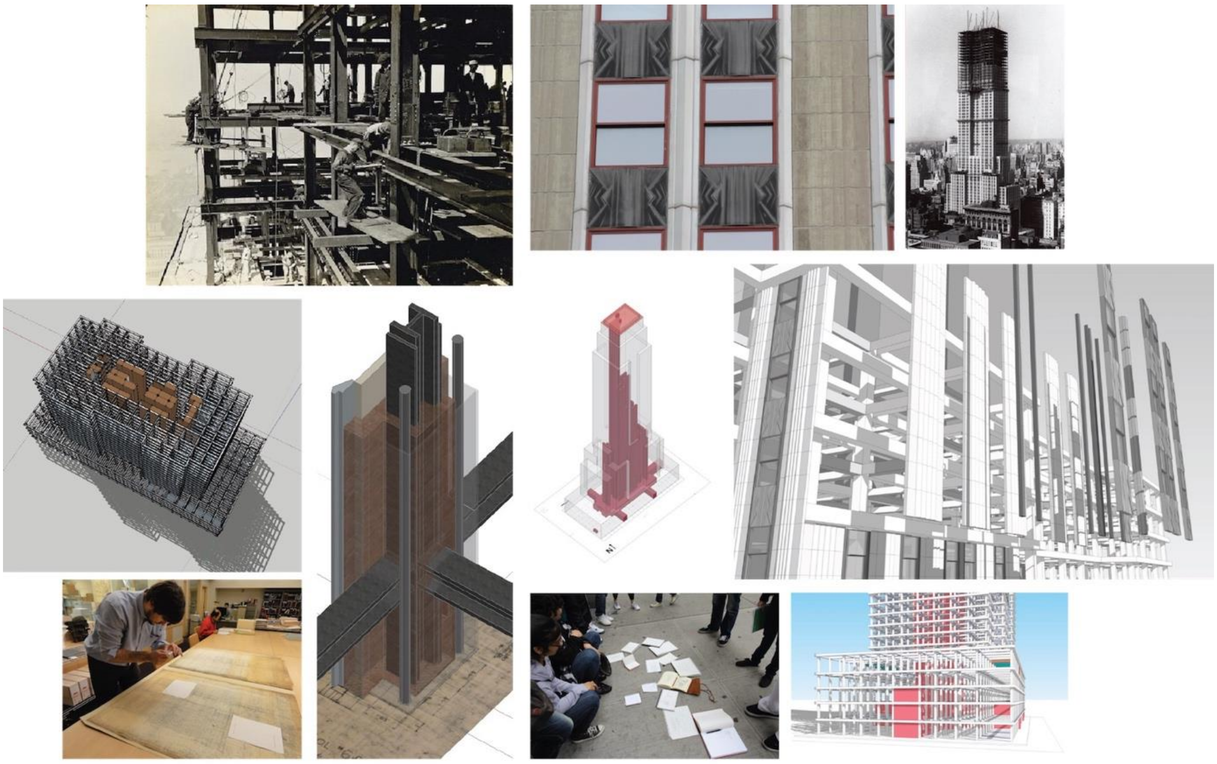

Figure 2. Empire State Building: experimental case study with inquiry as focus, 2011.

Drawing Exercises:

In the following year, drawing assignments were developed for the launch of these new courses to test their impact on student knowledge development and critical thinking skills. They also were designed to address gaps in prior knowledge and skills including a rigorous understanding of geometry, mechanical drawing, scale, and orthographic projection.[16] In the old drawing course that followed a rote vocational model, students reproduced a series of two-dimensional drawings provided in their handouts. In the new courses, students developed base skills in mechanical drawing but here used two-dimensional drawings as a basis for three-dimensional investigation of the volumetric nature of the building elements and their spatial relationship to each other. This approach was applied in both of the new first-year technical studios. For the latter course, the Yale Art Gallery was selected as the initial case study building. Here another critical pedagogical strategy was introduced: the careful linkage of reading assignments and drawing investigations. The course maintained the existing text book, Allen and Iano's *Fundamentals of Building Construction*[17], but with the addition of Ching's *Building Construction Illustrated*[18] to support the three-dimensional visualization central to the new drawing investigations. The syllabus was crafted to lead the students through the course materials following the sequence of construction, from foundation to envelope, with each stage investigated with variable parameters to require problem-solving application of the knowledge gained through the reading materials and class discussions.

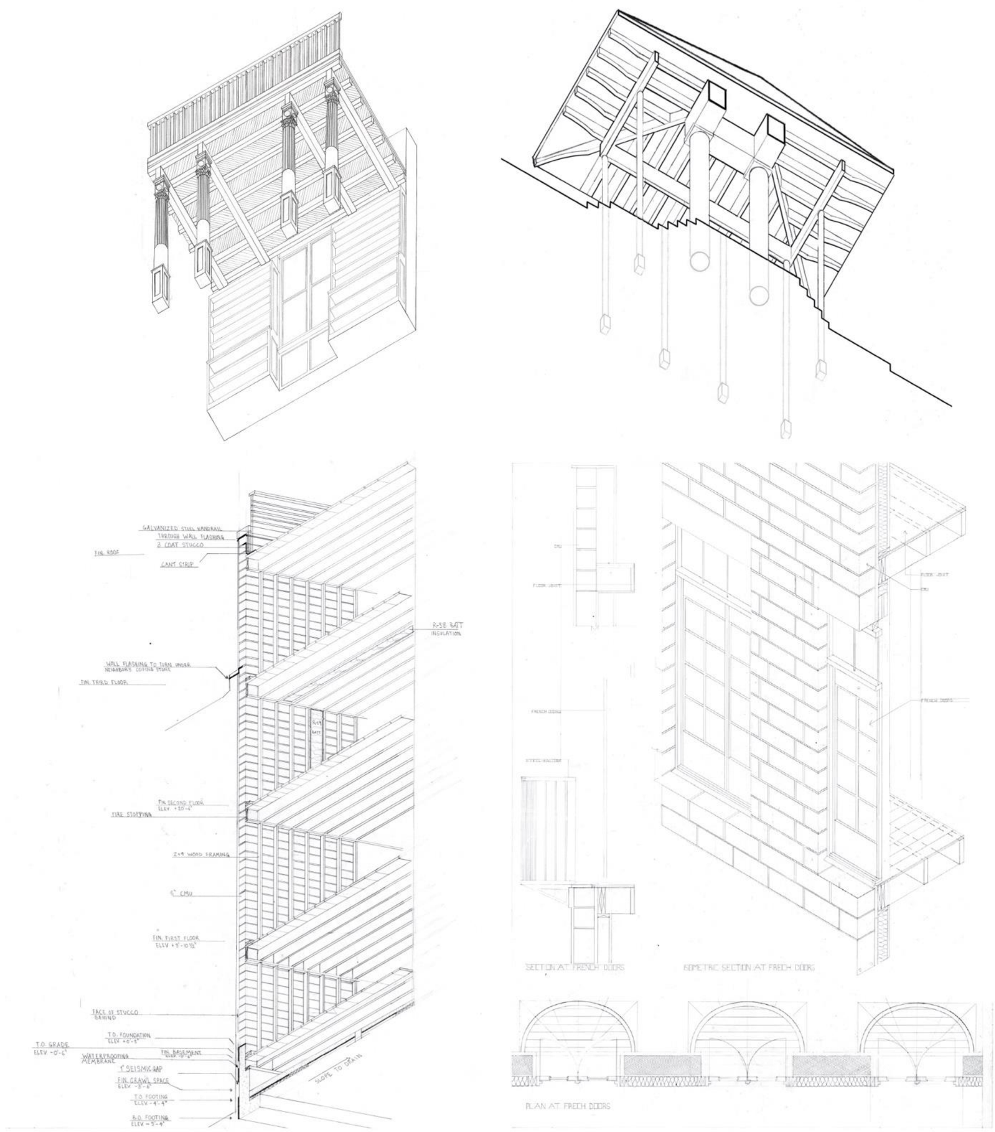

Figure 3. First semester student work after course redesign: three-dimensional studies of structure, envelope and tectonics, 2012-2016.

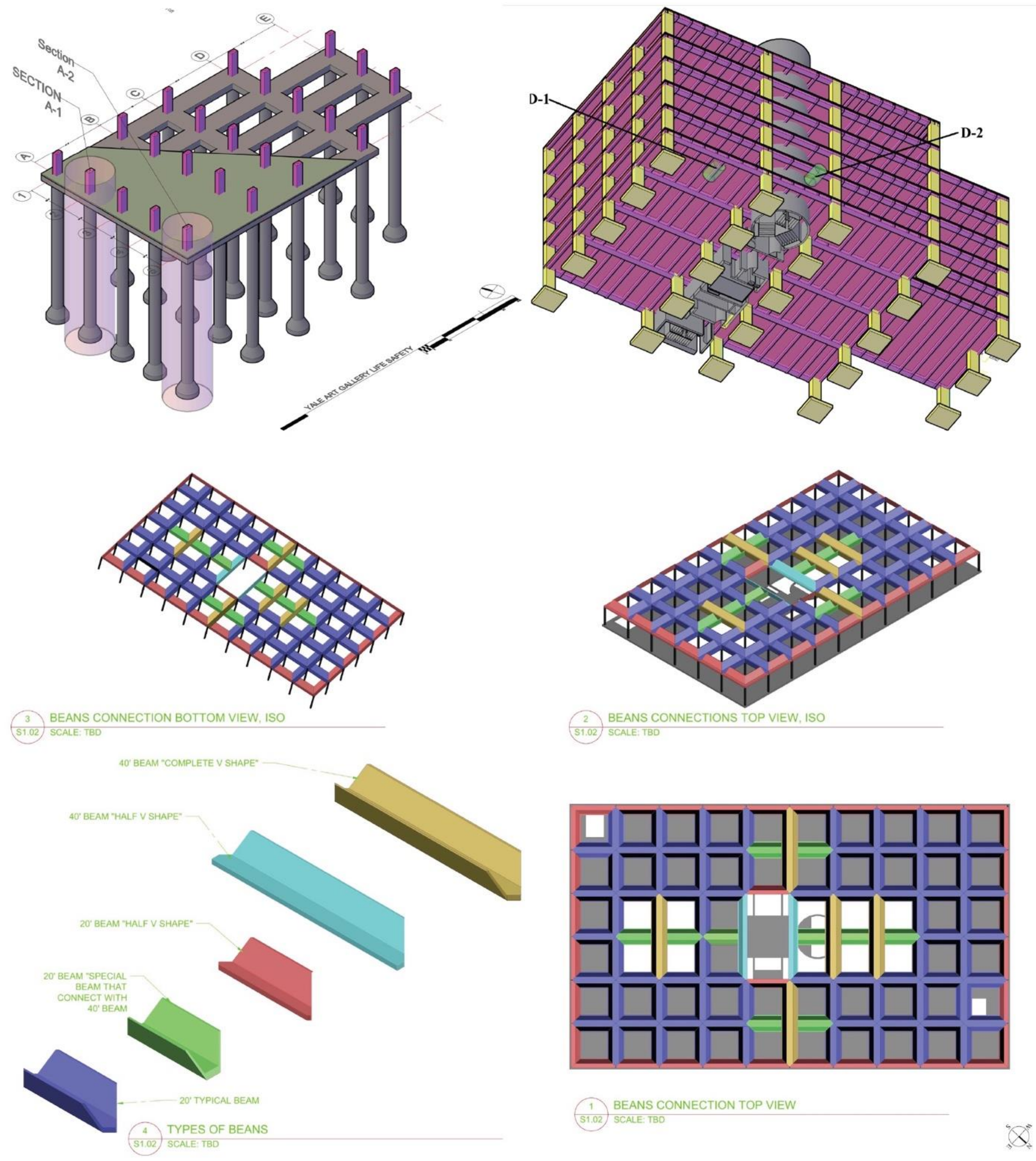

Figure 4. Second semester student explorations of caisson foundations & one-way slab system using Yale Art Gallery as the basis for application of technical concepts in course readings, 2012 (above) Student team analysis of the Yale Center for British Art roof precast concrete beam system and types, 2014 (below).

With digital tools introduced in the second semester, the assignments leverage the three-dimensional capability of these tools to study elements such as the concrete structural system or the window wall at high resolution. For example, the structure assignment asks the students to apply a selected system to the case study building, using the rules of thumb described in *Building Construction Illustrated* for the depth and spacing of elements following the case study's structural spans and geometric configuration. In this way, the student's work is moving beyond document reproduction and is constructing knowledge through application and problem-solving. Some of the critical elements of the Yale Art Gallery, such as the drum stair and window wall, were faithfully studied three-dimensionally to gain insight into Louis Kahn's elegant tectonic resolution of structure and form. In time both the Yale Art Gallery and the Yale Center for British Art were central case study buildings for this course. Each semester, a combined trip took students from all sections to New Haven for the day for the first-hand site investigation. For most of the students, this was a special day dedicated to the enjoyment and appreciation of the significance of architecture as a discipline, a quality particularly apparent through the mid-century modern works concentrated in New Haven.

Figure 5. Experiential + place-based learning: exploring first-hand the tectonics of elegant design solutions, Yale Art Gallery, 2013.

One method of assessing meaningful learning is looking for evidence of higher order thinking following a model like Bloom's Taxonomy[19]. The Yale Center for British Art has served well to engage students to reach higher levels of learning as the building's remarkable subtleties make learning through inquiry using observation as a primary tool a challenge. For example, the relationship and size of columns that look relatively consistent in fact change from one location to another. The students soon realize that a first level observation is not enough and a higher order investigation is required. Student attempts to accurately model the structural frame became an exercise in constant discovery. Similarly, students took the initiative to study the roof structure once they observed the complexity of the precast beams required for the varying structural conditions. Further, the observable problems of condensation on the exterior of the exposed structure led some students to achieve the highest levels of Bloom's Taxonomy, where they sought to create a new exterior envelope to creatively solve the problem.

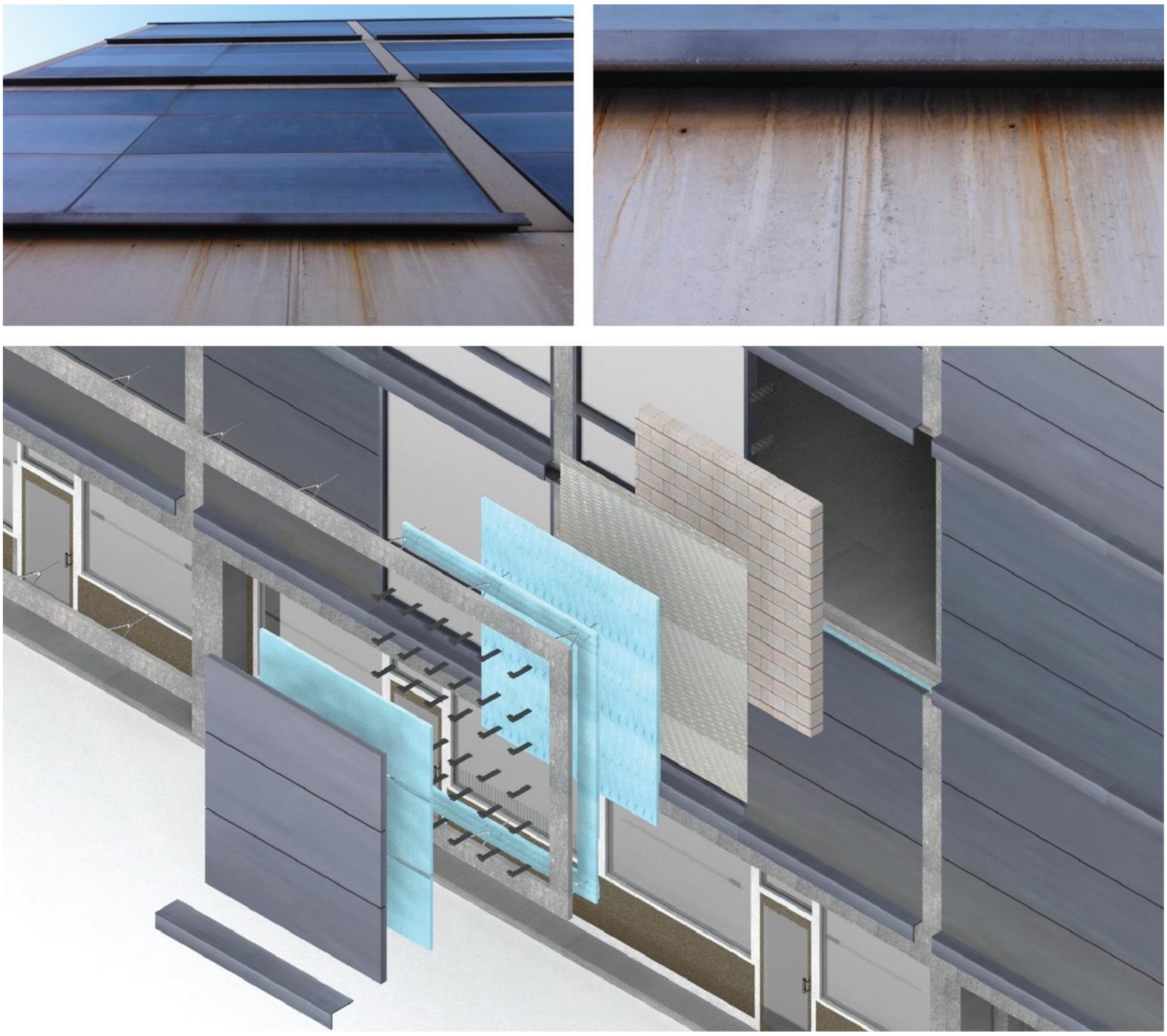

Figure 6. Inquiry and research: student photographs of observations of condensation stains emitted from behind exterior metal panels and drip profile. (above) Research and creative problem solving: student proposal to solve condensation due to cold bridging in exterior, (below) 2014.

CHALLENGES OF TEXT-BASED LEARNING IN TECHNICAL COURSES

While the drawing assignments show strong evidence of higher levels of student achievement, the critical companion of increasing technical knowledge and skills through reading is a continued challenge. A reading assessment conducted in spring 2012 raised the flag that our first-year students struggle with reading technical texts effectively. This has sparked the participation of the building technology courses in the college wide READ program, which seeks to improve disciplinary literacy and reading effectiveness. Each semester we implement strategies for improving reading effectiveness and measure progress through pre- and post-assessments. This strategy includes faculty training on improvement strategies and resources. This effort is showing signs of success with the assessment results improving, providing evidence of the effectiveness of the adopted strategies.

One important strategy is an emphasis on seminars seeking a higher level of *active student engagement* in lieu of lectures. In the seminars students and faculty sit together to work through selections of the required readings to model strategies for increasing comprehension, reading effectiveness and critical analysis of the information. This is achieved in part through concept mapping as a group that illustrates the hierarchy of the concepts as well as the relationships and connections between the concepts. This strategy shifts the classroom efforts to building tools and skills that allow students to improve their independent work with the text outside of class time. Another key strategy implemented is a shift from weekly quizzes to submission of reading notes. Each student must submit their scanned, handwritten notes and sketches from each reading assignment and site visit. They are required to utilize both text and sketches for their notetaking along with summary concept maps that demonstrate an understanding of the hierarchy of the concepts. Another strategy for increasing reading engagement are “walking seminar” discussions that take students out of the classroom and use direct experience of the built environment to make the concepts in the text tangible and tactile. As mentioned above, the text and drawing assignments are used in tandem to offer students the opportunity to deepen their knowledge of the text-based concepts through application. Starting this past semester, students are also required to post a summary and reflection of each reading on the shared course site prior to the “walking seminar” discussion.

While these strategies are showing signs of success in actual reading effectiveness, the greater challenge of motivation remains a factor in student performance. Some students naturally show signs of greater dedication to their drawing investigations than their reading, reflecting how they value the course work. Analysis of student grades reveals that while the drawing scores hold steady across the semester, the reading scores drop off at the end of the semester when students are overwhelmed by all the work across the curriculum and they choose to place a higher priority on drawing assignments. This assessment of motivation requires yet again another creative solution.

CONCLUSION / KEY FINDINGS

The continued refinement of these courses seeks an increasingly well-informed balance between the forces that drive job-readiness, including the tools of documentation, with the facilitation of critical thinking and creative problem-solving that foster a life-long learning ethos in the students. The evolution of these courses continues to this day, but the most important pedagogical innovations developed over the decade of experimentation continue to serve as the basis for teaching and learning. The key findings of this examination of a decade of course development are:

1. Emphasis on material and system investigation through three-dimensional drawings allows

students to understand volume and relationships more clearly.

2. Linking assignments and reading material allows exploration, application, and practice, providing the increased opportunity for meaningful learning.
3. Assessing students' prior knowledge and continuously adjusting strategies and assignments accordingly provides foundational knowledge and skills for more effective learning.
4. Using New York City as a laboratory for teaching and learning, bringing students into first-hand contact with seminal architecture accomplishes the following:
    a. Provides the students with an increasing foundation of experience of architecture to improve knowledge organization across all courses in the degree program.
    b. Motivates the students towards engagement and dedication to learning.
    c. Facilitates meaningful learning using inquiry and observation through place-based, experiential learning.
    d. Utilizes active strategies for teaching and learning that accommodates a variety of learning styles.
5. Text-based learning is a critical tool for building the skills employers require as well as facilitating life-long learning for each graduate. Faculty attention and support of student reading effectiveness is critical to the success of the students.

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[1] Vitruvius tells us that the architect should be a person "of letters, a skillful draughtsman, a mathematician, familiar with scientific inquires, a diligent student of philosophy, acquainted with music; not ignorant of medicine, learned in the responses of jurisconsults, familiar with astronomy and astronomical calculations." Vitruvius, *On Architecture,* trans. Frank Granger, (Cambridge: Harvard University Press, 1995), 9. In comparison, NCARB's Educational Standard includes the categories of General Education, History and Theory and Human Behavior, Building Practices, Design, Professional Practice, and Optional Studies, while NAAB requires evidence of student learning in the categories of Critical Thinking and Representation, Building Practices, Technical Skills and Knowledge, Integrated Architectural Solutions, and Professional Practice. From Vitruvius to NAAB, the individual seeking the professional title of architect needs to be a well-rounded practitioner with a broad education.

[2] George Barnett Johnston, "Drafting Manuals and Manual Training: Rouillion and Ramsey's Architectural Details," *Journal of Architectural Education* 58, (4):43, doi: 10.1162/1046488054026732.

[3] William Ware, "An Outline of a Course of Architectural Instruction," (paper presented at the Society of the Arts of the Massachusetts Institute of Technology, Dec 21, 1865), https://libraries.mit.edu/archives/mithistory/pdf/architecture.pdf.

[4] Ibid. 14.

[5] "Do your homework: The most required skills to work at the top 50 architecture firms," Archinect News, July 18, 2014, https://archinect.com/news/article/104482643/do-your-homework-the-most-required-skills-to-work-at-the-top-50-architecture-firms.

[6] Eric Hanushek, Guido Schwerdt, Ludger Woessmann, and Lei Zhang, "General education, vocational education, and labor-market outcomes over the lifecycle," *Journal of Human Resources* 52, no. 1 (2017): 48-87.

[7] Marlene Scardamalia and Carl Bereiter, "Knowledge Building: Theory, Pedagogy, and Technology," in *Cambridge Handbook of the Learning Sciences,* ed. K. Sawyer (New York: Cambridge University Press, 2006), 97-118.

[8] "New Survey: Demand For 'Uniquely Human Skills' Increases Even as Technology and Automation Replace Some Jobs," Cision PR Newswire, January 16, 2019, https://www.prnewswire.com/news-releases/new-survey-demand-for-uniquely-human-skills-increases-even-as-technology-and-automation-replace-some-jobs-300779214.html.

[9] Mick Healey and Alan Jenkins, *Developing undergraduate research and inquiry* (York: Higher Education Academy, 2009).
[10] See NAAB's website for confirmation of the program as a BARCH Candidate Program here: https://www.naab.org/school-view/?record_id=27444
[11] Susan A. Ambrose, Michael W. Bridges, Michele DiPietro, Marsha C. Lovett, and Marie K. Norman, *How Learning Works, 7 Research-Based Principles for Smart Teaching (*San Francisco: Jossey-Bass, 2010).
[12] Ibid. 10-90.
[13] Ibid. 10-90.
[14] Richard E. Mayor, "Rote Versus Meaningful Learning," *Theory Into Practice* 41, no. 4 (2002): 226-32.
[15] Ibid. 227.
[16] This gap has increased with the demise of vocational courses in middle school and high school education in the United States as noted by Eric Hanusheck et. al., "General education, vocational education" p.49.
[17] Edward Allen and Joseph Iano, *Fundamentals of Building Construction: Materials and Methods* (New Jersey: John Wiley & Sons, 2019).
[18] Francis Ching, *Building Construction Illustrated* (New Jersey: John Wiley & Sons, 2014).
[19] Here a modified version of this taxonomy is taken from Susan Ambrose et al, *How Learning Works*, p.246.

FIGURES

1. Knowledge Organization Concept Maps by Professor Jason Montgomery, 2015.
2. Compilation of Student Research and Site Investigation of the Empire State Building, Professor Jason Montgomery, 2019.
3. Three-dimensional structure, envelope, and tectonic studies: Nison Bakayev, Shandel Jessamy, 2012, Charles Walker, 2013, Mirna Ayoub, 2016.
4. Foundation Study: Devindra Persuad & Luiza De Souza, Concrete Frame Study: Charles Happel, 2012, Yale Center for British Art roof system analysis by Latifah Ford, Juan Rodriguez, Jose Nuriega, Donna Enty, Deny Lopez, 2014.
5. Student Photograph of Site Discussion at Yale Art Gallery drum stair, 2013.
6. Student photographs of Exterior staining, Yale Center for British Art, 2014. Proposal for solving condensation issues in exterior metal panel: Carlos Jacome, 2014.

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