INTEGRATION OF DIGITAL TOOLS AND FABRICATION METHODS FOR LEARNING CAAD

Innovative pedagogy methods applied in a design college in Abu Dhabi

MARCO SOSA AND LINA AHMAD
ZAYED UNIVERSITY, Abu Dhabi, United Arab Emirates
marco.sosa@zu.ac.ae | lina.ahmad@zu.ac.ae

Abstract. The interior design curriculum at the College of Arts & Creative Enterprises (CACE), Zayed University in Abu Dhabi, offers two CAAD courses; the first is concurrent with first-year Interior Design studio; the second is a year later. The objectives of the first is equip students with the tools needed to represent and communicate their designs, while the second looks in-depth into the process of documentations. This paper will focus on presenting our pedagogical approach in the first CAAD course, as well as tracing students implementation, knowledge utilization and how it is carried over into their main interior design studio. It will also shed light into CAAD influence on expanding student technical and material knowledge through direct space survey and documentation. The paper aims at presenting and reflecting upon a dynamic devised adaptable pedagogical method that identifies two student categories; those who learn how to 'practice design' (majority), and those who unfold the realm of 'being a designer' (minority). It is the latter few that continue their path, emerge into various international settings, and have a major influence on their local communities.

1. Introduction

The two researchers are architects acting in their capcaity as Assistant Professors of Interior Design at Zayed University, a Federal University in Abu Dhabi. Our students' come from a unique demographic, they are all Arab females and local Emirati with a unique background that is rich with culture and tradition, situated amidst a global and international setting, yet still in an isolated protected sheltered environment. Zayed University was founded in 1998 as an all-women's university based on the American liberal arts college system. It houses five colleges and over 8,000 students attending classes on two main campuses, one in Abu Dhabi and the other Dubai. The University became co-educational in 2008 with the introduction of the men's program, but undergraduate education remains gender segregated and 80%

of the students are female. Zayed University is accredited by the Middle States Commission on Higher Education. In addition, the College of arts and Creative Enterprises holds substantial equivalence accreditation from the National Association of Schools of Art and Design. The Interior Design program is one of the four majors offered by the college. Our students join the program with limited exposure and very basic acquired design skills, yet with extensive ambition and yearning for learning. They spend their first three semesters fulfilling university and language requirements, and join their selected major on semester four, very often with a misinformed understanding on the difference between design and decoration. As educators, we find ourselves having to address simultaneously two main tasks: to instil, in our students, design thinking process, and to equip them with basic knowledge and representation tools and skill sets to be competent designers. We offer two CAAD courses; the first (CAD 1) offered concurrently with their first interior design studio and the second (CAD II) a year later. The first aims at equipping students with the tools needed to represent and communicate their designs, while the second is more an in-depth look into the process of documentation.

2. CAD I

This course aims at providing interior design students with sufficient skills to be intermediate users of CAD 2D in relation to interior design and space planning of both residential and commercial spaces. Upon successful completion of this course, students are normally able to understand which digital CAD/BIM technology is applicable to which target audience and demonstrate proficiency in the use of industry standard vector-based CAD software and associated hardware technologies. The normal learning process applied consists of presentations and discussions about contemporary digital design techniques and implementations in the Interior Design practice, lectures and hands-on training in the use of the software packages. The primary software used is Autodesk's AutoCAD Architecture (ACA). Traditionally, the course was taught through a series of exercises encouraging learning by repetition. We have been experimenting with an alternative way that builds on the student's needs and encourages exploration and search for the 'right' answer. Basic CAD commands are introduced over a few consecutive classes. Students are then given an assignment that requires more knowledge than they had been given to successfully execute. Students are left to experiment and discover based on their needs and project requirement. This, straight away, separates students into two categories; those who inquire about the process to find information and those who 'demand' to be given the answer.

3. The new approach - extended

"A new digital revolution is coming, this time in fabrication, it draws on the same insights that led to the earlier digitizations of communication and computation, but now what is being programmed is the physical world rather than the virtual one. Widespread access to these technologies will challenge traditional models of business, aid and education." (Gershenfeld, 2012).

We believe that teaching is directly connected to self-learning and experimenting, especially when teaching design. Whereas there is a set formula to learn technical skills, software, history, facts and figures, design involves intuitive learning. This is achieved through inquisitive and active experimentation, especially in investigating how materials 'form' spaces and how people occupy spaces and their effect on their environment. These experimentations are carried out using digital or physical models, using digital or artificial light or actual daylight. These findings must then be recorded meaningfully using video, photography, sketches and drawings for them to be successfully represented as 'atmospheres' in design proposals. The system follows learning by making, doing, discovering and experimenting. We believe that these factors should be applied to skill learning class such as CAD for interior designers. We believe that learning such a valuable technical skill should be integrated into the student's journey developing as a designer. "A prototype is both a question and an answer. An agent provocateur. A dry run. A rehearsal. A preview. And, at its best, a revelation." (Burry & Burry, 2016).

During the summer 2014, Zayed University, received two digital fabrication machines; laser cutter and 3D printer per campus. Although we recognize that the two machines and the adjacent wood workshop are not enough to put the students on the forefront of the 'maker' movement, it allowed us to explore the possibility of integrating these machines into the studio environment and CAAD labs, test students recipients, and utilize the teaching tool as a mean to produce meaningful research. Therefore we engaged in a process of linking deliverables in a studio/lab project to larger body of ongoing research, allowing for more experimental and progressive project studio design briefs. This approach gives the opportunity to students to have meaningful deliverables that are not simply generated as skill or design exercises but are research contributions, while adhering to the required learning outcomes set in the syllabus. Our interior design students excel at following instructions, and learning technical skills such as: drawing, painting and CAAD skills. However, they quite often find difficulty in transferring the learnt technical knowledge to utilize it in their studio design proposals and scheme representations.

4. Case study I

On June 2014, the United Arab Emirates inaugurated its first architectural pavilion at the 14th Venice International Architecture Biennale. The pavilion's title was; "Lest We Forget; Structures of Memories" with Dr. Michele Bambling, as curator. The exhibition chartered the impact of modernist architecture in the UAE and provided a timeline of the history of architecture in the UAE for the past 100 years. Part of the problem encountered at the time, was the lack of available and accessible information, this is partly due to the rapid development of the nation. Some of the material had to be generated and the curatorial team was keen to involve higher education institutions. One of exhibits required the production of architectural facades of modernist buildings. This was a coordinated effort between professor Deborah Bentley from Abu Dhabi University and us. A method was adopted to record a series of modernist building facades in Abu Dhabi. Students were introduced to two main prototyping technologies; subtractive and additive (computer controlled laser cutting and 3D printing). At this stage, majority of the students either lack or have very basic understanding of 3D modeling techniques. With the help of this technology, and through rigorous outline of production and implementation steps, students produce detailed elevation façade drawings and sectional physical models of assigned buildings. The exercise has a series of outcomes; teach students the basic skills for drafting in 2D using CAAD, Teach the students how to use CAAD to generate three-dimensional structures using digital manufacturing technology. Through the drawing and physical model production, we teach the Interior Design students how to analyze the façade and help them understand how these facades are composed in a series of layers making transitional spaces between private/home and public/street. In addition, the models show the simplicity of the designs adopted by architects of the period to be economical with materials (due to shortage of locally source materials) and adapt to cultural and climate needs in the region. The chosen buildings were built between 1975 and 1990, which define the 'growing' period and nation forming of the UAE. A period often referred to as "settling the nomad" (Elsheshtawy, 2011). The purpose of the study was to create awareness in the built environment in the UAE and engage in a conversation about a possible approach to architectural sustainability by keeping and the maintaining of existing build environment. (Sosa & Ahmad, 2015). This exercise was a form of preservation as well as drawing the public attention to the time specific tectonic intricacy; usually hidden under layers of accumulated poor maintenance. The method we followed was a sequence of activities; photograph the facades of the buildings on site. Assign a scale to the elevation photograph using the building façade components and the street elements. Use CAAD to draw the facades generated by the elevation

photographs to produce a two-dimensional elevation drawing of the building's façade. Use the DWG file to rationalize the make up of the façade and produce a sectional model of the pattern. Students analyze the construction sequence of the building by breaking it into sections. Usually these elevations are repeated modules that elegantly form a façade. The students then rationalize the construction of a module of the façade using subtractive digital fabrication technology using the laser cutter machine.
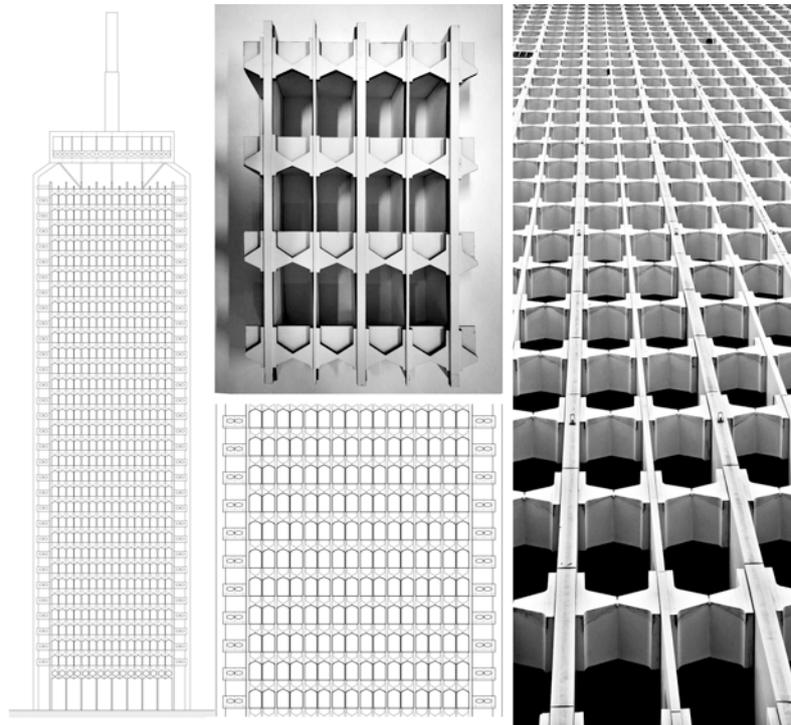
Figure 1. Rashid Tower, Dubai, CAAD drawing & model generated in class. © Lina Ahmad.

5. Learning outcomes

The students learnt how to use different media (photographs and video) to survey and generate two-dimensional architectural line drawings from them. In the process, they learn how to use the specific CAAD software and hardware available. The students then use critical thinking through devising a strategy to make the three-dimensional physical representation. They are required to think of materials composition, cutting sections and assembling process, as well as keep an eye on the overall aesthetics of the piece. They understand that machines are not magical pieces of hardware that produce beautiful objects for them, but rather sophisticated equipment that needs

specific kind of data to output defined results. They learn how to use digital fabrication hardware and its possible applications to other projects. We had three objectives to the approach; 1) Test the initial response of students with zero design experience and no previous exposure to technology. 2) Initiate first steps towards the model of "learning by doing" while simultaneously integrate basic parts of current technology; thus challenging the traditional modes of how knowledge is taught and acquired. 3) Experimenting with the notion of learning outside the classroom boundary, where work progress is the main driver and lead initiator for steps to follow and knowledge to acquire; forming a piece of a larger research body. The results of the class were very successful, especially as the skills were transferred to the students work in the studio. One of the triumphs of the class was to successfully add another dimension to what students usually perceive as a tedious but crucial technical class, such as CAD. By introducing a studio aspect into it, students fulfilled all the necessary skills and learning outcomes and simultaneously produced and participated in a larger research body.

6. Case study II

On Spring 2015, The Porcelanosa Group launched the 1st Architecture & Interior design award in the UAE. Students were asked to design a bathroom within the constrains of a particular space size and limited materials available from the Porcelanosa material catalog. The competition was integrated into the syllabus of the design studio class curriculum. The timing of the exercise was specifically relevant because the participating student cohort was the first one to have gone through the Modern heritage building façade project. This was the first opportunity by which we tested the improvised pedagogy approach through assessing the process by which students utilized the learnt skills not only to represent their designs via CAAD drafting, but also via three-dimensional physical models representation for concept exploration and final design proposals presentations. The design competitions we incorporate into the syllabus, tend to be contests opened by government institutions, private companies and other organisations. The course integrated design competitions allow the students to experience the competitive conditions that will be encountering in the industry. These studio-integrated opportunities have so far been very successful, as they provided opportunities and experiences outside the studio classroom environment. This is of particular significance to our students as they are all female and mainly local Emiratis with limited opportunities to experiencing these on their own because of regional cultural challenges.

The semester culminated with the students' successful application of the learnt CAAD skills in the previous term; not just as methods of representation but also as exploration and testing tools. During the previous CAAD project some students expanded their skills to start using 3D printers

through 3D modeling, while others aggregated laser-cut sections. In addition, this enabled them to reproduce complex objects, test their spatial 3D occupation, as well as push the boundaries with the laser cutting. The produced models were then carefully photographed resulting with a showcase of the atmospheric conditions of their spaces.

Figure 2. Visualization of bathroom space created through utilizing laser cutter and 3D printer technology in Interior Design Studio. ©Asma Al Mukhaini.

We kept an eye on the cohort who underwent the previous two presented case studies at their senior year, to evaluate their independent implementation. The summary of our observations is as follows; All of the 18 students used AutoCAD either to generate or as basis from where their orthographic drawings were generated. One student (A. J.) was inspired by the leftover laser cut elements. Aggregating and subtracting them, she ended up basing her interior space materiality and tectonics on the aesthetic achieved through her models. Two students (A. M. and R. K.) conducted their building site studies and analysis via CAD drawings and laser cut models. One student (K. S.) designed furniture components through laser cutting, which then informed her overall design. One student (S. O.) ventured into another Autodesk program - 3D max. Through self-taught activities that complimented course that she outsourced, she used the rendering method to communicate the materiality aspect of her environment. She also referred to laser cutting methods to design a bespoke piece of furniture that later informed her conceptual design. One student (T. W.) experimented with movable laser cut models to inform her project design. As a reflective outcome, 100% of the students' utilized CAAD software for drawings production and 33.33% of them demonstrated direct benefit from the introduced extended approach.

7. CAD II

The second CAD course takes a very different approach; whereby and due to the nature of the BIM (revit program), the outcome is geared to produce a documentation package of a space. BIM strength lies in the parametric modeling, analytical capabilities and its coordination capacities between different disciplines and design parties. Despite the encouraged industry integration, mimicking the complex procedures of actual projects in an office environment remains a challenge. This is partly due to the absence of engineering discipline in our university, but also is a direct result of students' inexperienced level. They very quickly get overwhelmed with the required hierarchal thinking process and frustrated with the alternate modeling approach through data; they perceive to dispute the familiar free hand scribbling approach. The method followed in the classroom utilized a number of BIM principles to develop and nurture students' skills and abilities; the design workflow and drawings order was reversed; generating the two-dimensional orthographic drawings from three-dimensional modelling. An emphasis was placed on understanding the difference between modelling and annotation components, and their behaviour across the different views. Parametric relation of information was highlighted and the power of data coordination was demonstrated by asking the students to produce a basic documentation package for a space using two software; AutoCAD and Revit. Throughout the term an emphasis was made on the 'tool'. When a different tool is used, the process as well as the outcome changes. In the technical class selected CAAD 'tools' are taught. In our interior design studio classroom, we do not dictate the software to use. Students are rather encouraged to explore different 'tools', understand the strength of each one and to experiment by mixing and integrating them. We stress on the importance of information relayed through the presented outcome rather than the method used to achieve it. Students are free to develop their preference, nurture their abilities and find the means to fulfill the expected requirements. Observed shortcomings; 1) Students are usually impatient and are expecting quick result, similar to those experienced in CAD I. 2) Students experience difficulty in fully understanding the Building Information Modeling methodology, and remain for quite sometime clinging to the generic automated representations offered by the program. 3) Students struggle with notion of 'family' in Revit. This obstructs and limits the elements they design with. They find themselves dependent on the available very generic families – found across the net, or on the very specific ones sources from suppliers and manufacturers. This has up-to-date availability prevented them from utilizing bespoke elements from their own design. 4) Majority of the students' work remain in the concept / schematic stage. This prevents them from experiencing the BIM strength at the detail and coordination stages.

CONCLUSION

"The transition from processes based on craftsmanship to more industrialised ways of building calls for new tectonic strategies and a rethinking of our conception of architecture." (Beim & Madsen, 2014). Not that long ago, fabrication was seen as a process that follows a 'product' design. Fabrication and design were clearly differentiated as two detached non-concurrent processes. Fabrication merely led to the final outcome. Today, it very much relates to the design process, to the designer intellect and to the end users' specific needs. It manifests itself as not only an integral part of a design process but also as means of learning and knowledge acquiring journey that extends itself beyond the traditional boundary of a classroom. Fabrication methodologies combined with the recent shift to computational tools, has enabled designers to realize and "Manage high orders of complexity, experimenting with new forms of iterative graphic space" (Ahmad *et al*, 2015). We seek individual self-empowerment, whereby students learn via doing and experimenting. We recognize that our current student's work does not fall within the category of 'cutting edge design', but this paper aims at presenting and reflecting upon a dynamic devised adaptable pedagogical method that produces two categories; those who learn how to 'practice design' (majority), and those who unfold the realm of 'being a designer' (minority). It is those later few that continue their path, merge in various international settings, and have a major impact on their local communities. As design instructors and researchers, these constant changes of the design studio briefs keep us in touch with the design industry's trends and needs, and keep our teaching relevant and our students at the forefront of expectations within the industry once they graduate.

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