

THE EFFECT OF DIGITAL EXPLORATION IN THE MIMETICS OF THE DESIGN PROCESS – A NEW CURRICULA?

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INTRODUCTION

The extent digital methods are becoming used in the design process is increasing exponentially. As students move through their studies they learn not only about architectural design but also how to navigate their design process, the methods to be used and when to use them. In this study we present the initial findings of a detailed study focusing on the effect of digital exploration in the design process of masters in architecture students. The study evaluates the use of CAD and BIM in the design stages and focuses on exploration of design projects undertaken in the studio setting for architecture students. For this study the term ‘digital, or digital methods’ will be considered to include both CAD and BIM in the design process.

The learning process is guided by the exploration and detection of a design idea in both form and function, with the virtual environment providing a dynamic environment.¹ This is further reflected in the constructivist theory where the learning processes use conceptual models, which are used to create incremental stages that become the platform to attain the next design iteration.² The use of CAD and BIM within the design process allows students to visually explore the architectural forms they are creating in greater depth when compared to analogue sketching and negates the issue of drawing skills when using digital methods.

AIM

The primary intention of this study was to understand the effect of CAD and BIM within the design process of Architecture students, in parallel with analogue methods. The full design processes of 16 students were analysed and assessed for all activities (CAD and analogue) used during a 9-month design project. From these 16 students the patterns of CAD activities, in parallel within analogue activities, were mapped to create design process timelines for each individual student, indicating ‘when’ CAD and analogue activities took place on a month-by-month basis, and during ‘what’ stages of the design process. Associated interviews with each student undertaken throughout the design process were assessed using Nvivo to identify theme of ‘when’ to consider such methods were used. The resulting individual design process timelines and thematic analysis were then collated and assessed to gain unique and novel insight into the effect of digital exploration within the architectural design process of master architecture students. Prior to this research, the review of existing literature indicated that no studies have been undertaken that mapped and analysed the design process through

the assessment of both analogue and digital methods, considering a more holistic analysis that considers when and why digital methods are used, during what stages of their design enquiry, in parallel with current analogue methods, and how students move between these methods throughout the design process. Furthermore, extant literature highlights a lack of guidance around how to teach digital methods effectively throughout the design process, limiting both an educator's and students' knowledge on how digital methods could be used across the design process. To address this gap in knowledge this study collected data from 16 architecture master students over a period of 9-month design project and undertaken to gain key insights relating to a more holistic understanding of the effect of CAD on the design process within architectural education.

METHODOLOGY

To address the aim of this study to understand the effect of digital methods on the design process of master's in architecture students, the previous chapter presented the collected data from the 9-month design project, including observation field notes, interview transcripts and design process artifacts such as sketchbooks, drawings, digital renders, physical and digital models. Through collation and analysis of these materials the researcher was able to reach an overall understanding of the data for each individual student and in doing so map the students design process timeline to highlight when digital and analogue methods were used during what stages of design process and from a thematic analysis of interviews, gain an understanding of why methods were used. A detailed cross-analysis of the timelines and thematic results and analyse of the sample as a whole was undertaken to gain a complete understanding of the data. To support this cross-analysis the findings are now explored through the 'lens' of 'when' digital and analogue methods are used, but also considering during 'what' stages of the design process these methods are used. The 'when' and the 'what' are explored through the analysis of the established timelines, while the themes of digital and analogue use established through the thematic analysis of the interviews. While lenses and methods (digital and analogue) are initially analysed individually, the data and findings are triangulated to complete the cross-analysis of the data and to gain holistic insight into the effect of digital on the design process, in parallel within analogue methods.

RE-ABSTRACTION AND RE-ALIGNMENT: THE NEW CONVENTION FOR DESIGN PROCESS

Recent academic papers that have continued the exploration and study of creativity in the architectural academic arena, "Improving Architecture Students' Design Skills: A Studio Experience."³; 'The Effect of Manual Sketching on Architectural Design Process In Digital Era,⁴ and Effect of Computer Learning on performance in early Architecture Education.⁵ The precursor to research into creativity and the creative process were the studies concluded by Finke, Ward and Smith⁶ who posited the hypothesis that 'the creative process is one of a multiple stranded series of processes that together evolve towards a combined phase of creative insight and discovery'. Intriguingly these multiple occurrences converge only having moved through a distinct phase termed 'pre-inventive' where the 'structures' of the artefact are brought together from mental representations of the prior creative occurrences.

Interestingly Cross and Dorst,⁷ concluded that the creative journey is also a series elements termed activities that also occur in succession and result in a 'novel event'. This novel event could be aligned with the notion of 'creative leap' or eureka moment, when the processes that have occurred prior to that moment allow an alignment or focus to the thought processes that enable the production of the 'artifact' or design solution. However, Cross⁸ and Dorst⁹ do not suggest that the processes or stages to

arrive at the artefact have to be part of a cognitive model in order to materialise. In fact, they concluded that such events can be random in nature, or 'non-routine' and the occurrence of the artefact is merely one activity that is different to all others due to the emergence of a 'considerable or unanticipated' happening. This study uses the hypothesis of Visser¹⁰ (2004) who proposes that design activity is comprised of a series of procedural stages that conclude in the production of what he calls the 'creative artefact'. The use of digital exploration can allow for enhanced reflection of their designs and the ability to create iterative steps that employ progressional advances of multiple layers that are fully implicit and part of the students learning journey.

ANALOGUE AND DIGITAL METHOD USED IN THE DESIGN PROCESS

The findings for 'when' CAD and analogue is used is brought together and the findings are initially assessed in terms of resulting subgroups '(DIGITAL)WN' (for when digital methods are used) before the same approach is taken for analogue methods. The subgroups depict reoccurring approaches that are shared by the overall student group in terms of 'when' digital methods and analogue are used in their design processes. Secondly, the findings from the cross-analysis of digital and analogue methods are brought together for the overall student group to explore levels of correlations. From this analysis a greater understanding of the phenomenon is achieved. The resulting timelines depicting 'when' digital and analogue methods and consider what stages of the design process is shown in Figure 1 for analogue exploration and Figure 2 for CAD/ BIM exploration in the design process.

FINDINGS: SWITCHING MODES OF EXPLORATION: HOW CAD AND ANALOGUE IS USED IN THE DESIGN PROCESS

This study examined 'when' digital and analogue methods are used where considered against the five key stages within the design process shared between established Design Process models of Maver,¹¹ Lawson,¹² Hillier,¹³ Oxman¹⁴ and Gelernter¹⁵.

These stages are:

1. Understanding
2. Definition
3. Synthesis
4. Analysis and Evaluation
5. Presentation

The study considered what activities were undertaken by each student within these design process stage and at what point in their design project (from month 1 to 9) the stages of the students' design process and presented similarities in the data based on the established design process timelines for each student. However, this study also examined overarching behaviour in the group and their approaches, and techniques which it is considered by the author to be of particular importance in understanding the connection between the design process, the act itself, and the learning that comes from this process.

From the analysis described 10 key findings have been established, these findings are depicted in Figure 3 'Use of Analogue for Similarities in 'when' Analogue is used for', Figure 4 'Use of CAD/ Digital for Design Stage – Correlation of Design stages and occurrence'.

These findings are as follows:

1. All students undertook analogue methods from month 1, with the majority (15 of the 16 students) using analogue for understanding.

2. All students within the sample engaged with digital methods at some point during the design process. With the majority (12 out of 16) of students engaging with digital methods by month 4 (midway) in the 9-month design process.
3. Students who adopted digital methods the earliest, did so to support their understanding stage of the design process, with understanding being the most preferred design process stage when digital methods were initially adopted.
4. Students who adopt digital methods initially towards the midpoint of the design process, in months 3 – 6, largely do so for definition and synthesis, reflecting the analogue design process stages that typically take place during this phase of the design process.
5. Students who adopt digital methods towards the end of the design process month 7+, did so largely for presentation, but in doing so, results indicate that to use digital methods for presentation, there is a need for some initial digital work (design stage) to take place.
6. The majority of students (13 out of 16) eventually used digital methods for presentation.
7. Students who adopted digital methods later in the design process (4FB, 6KJ, 16JO and 7GP) were found to be the most reluctant to use CAD due to skill level, and a feeling that digital methods would restrict their design. However, their adoption of digital methods appears to stem from an acknowledgment that they couldn't resolve or refine some design issues using analogue methods.
8. Beyond initial use, the majority of students (13 of the 16) in the study group all used digital methods sequentially for synthesis, analysis & evaluation, and presentation stages of the design process
9. All but one student progressed through monthly stages for both analogue and digital methods in a linear fashion. With the majority of students (13 of the 16) undertaking a linear process of understanding, definition, synthesis, analysis and evaluation, and presentation. Furthermore, 9 out of 16 of the sample were found to have a strong similarity to this common analogue process within their design stages, with digital stages either mirroring the analogue process or missing one stage.
10. When digital methods is adopted, the majority of the students (12 out of 16) adopted a similar digital sequence of stages, to their analogue sequence of stages, indicating that as students' progress through their design stages, once digital methods were adopted, they are applying both digital and analogue methods in parallel to address the objectives of the design stage they are in.

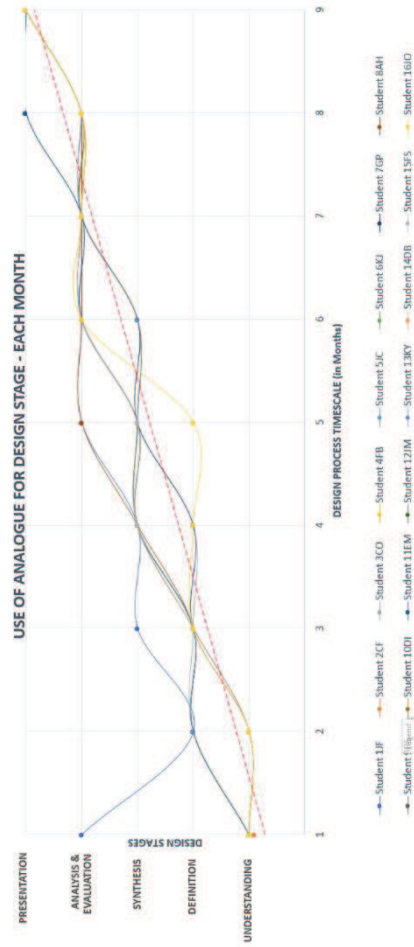


Figure. 1. Use of Analogue for Design Stage – Each Month

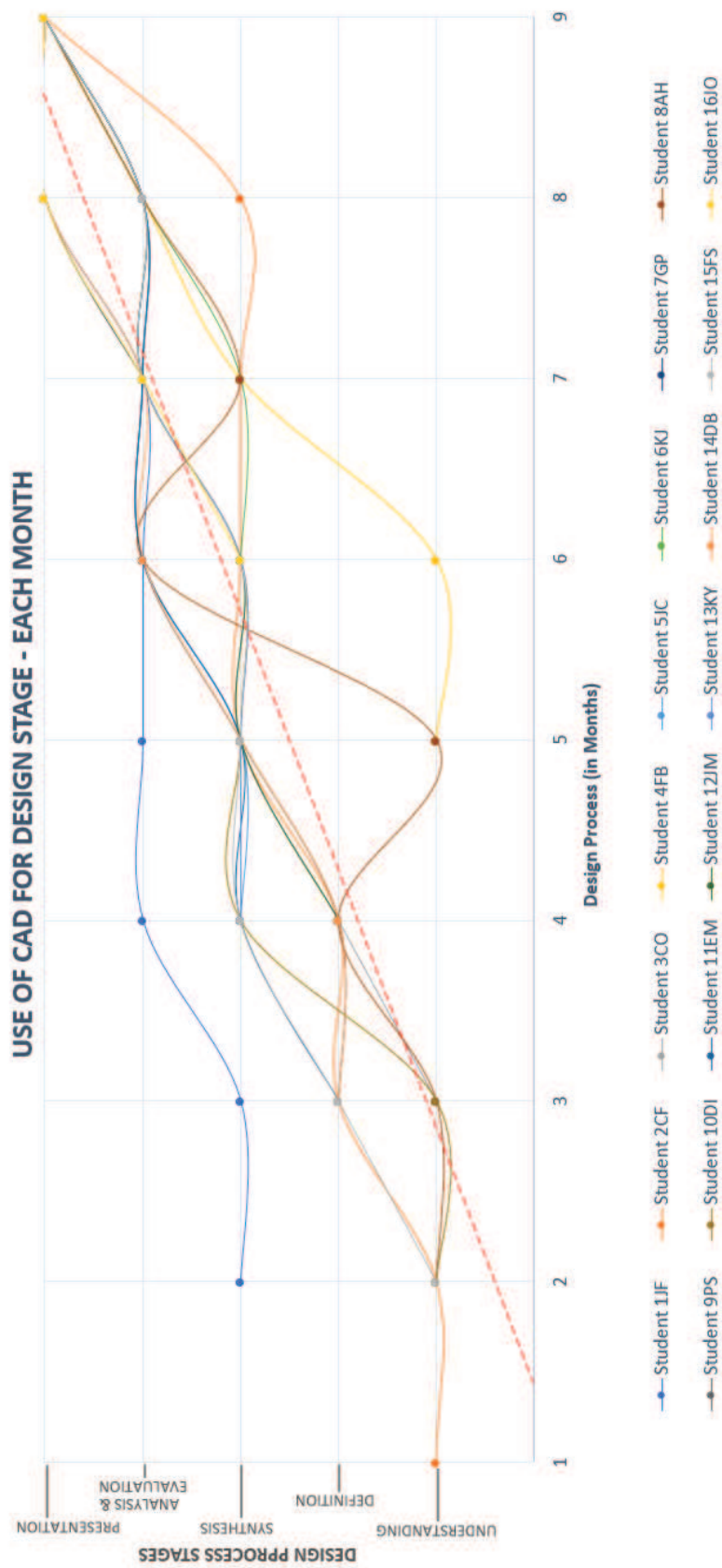


Figure.2. Use of CAD/ Digital for Design Stage – Each Month

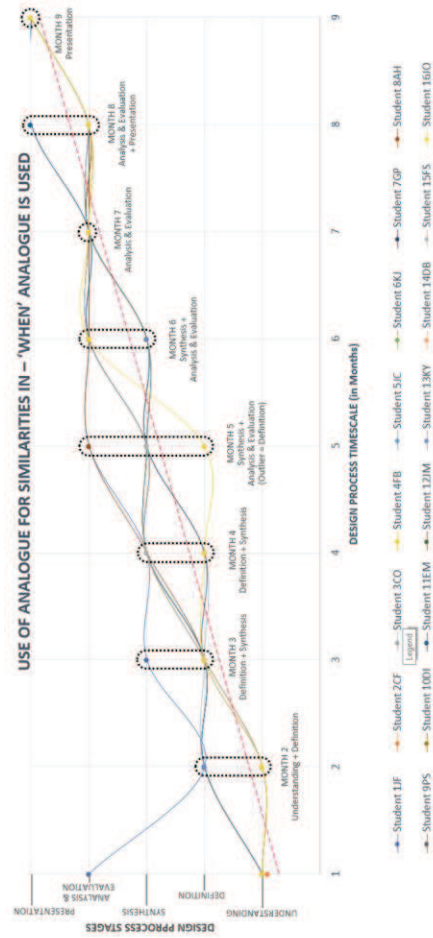


Figure.3. Use of Analogue for Similarities in 'when' Analogue is used

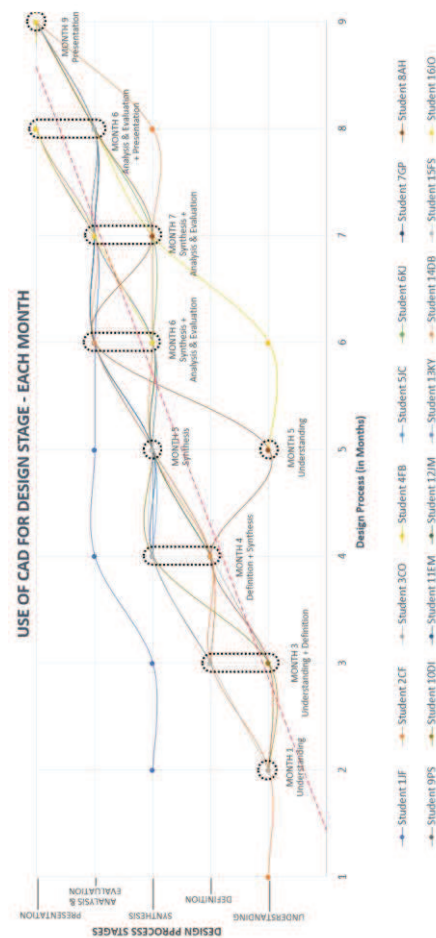


Figure.4. Use of CAD/ Digital for Design Stage – Correlation of Design stages and occurrence

OBSERVATIONS

While the previous sections have drawn findings more directly from the analysis presented, throughout the author has aimed to provide additional insight into these findings by highlighted related contextual observations. In considering the overall approach of digital and analogue methods across the 9-month study, through the undertaken observations this study considered the overarching behaviour in the group, and their approaches and techniques, and the outcomes of these decisions and behaviours on their design process. The resulting insights are considered by the author to be of particular importance in understanding the connection between ‘when’ and ‘why’ students used digital and analogue activities, during ‘what’ stage of the design process, act itself, and the learning that comes from this process and the outcome of these actions. From this analysis 12 key findings can be proposed.

OBSERVATIONS

1. During the study it was observed that all of the students used both analogue and CAD activities at some point in their design process, with the majority of students undertaking CAD and analogue processes in parallel for most of the design process.
2. The students studied would change activity type in order to remove their ‘designers block’. This would establish a ‘dialogue’ for the student to test or amend these design outcomes in order to

problem solve. To re-cast a design problem allowed the student to see the problem in a different way allowing resolution of the problem visually.

3. It was observed in the study that the retaining of analogue activities throughout the majority design process, once CAD was adopted, helped the students to retain an abstract understanding of their proposed scheme. This was most noticeable in students who retained the use of conceptual drawings and models to consider a design problem.

4. Students who predominately focused on CAD activities did not, in the main, produce abstract material and lacked the ‘conceptualising thought process’ required to problem solve, Zeisel (2006)m inhibiting their design process.

5. It was observed in the study that a combination of activities were used by students in their design process during the production period. This was to overcome any lack of intrinsic artistic ability, or CAD skills thereby lessening the learning difficulties faced by students beginning with less inherent talent for visualising their scheme using CAD.

6. Early use of CAD was evident in the findings of this study, as a positive influence on a student’s confidence in design.

7. Students within the study who were observed to efficiently use analogue and CAD activities once they had ‘cast’ their design, used increasing CAD activities to gain a more intricate understanding of their design proposal. The CAD model providing accurate visualisation in two-dimensions and three-dimensions in parallel, effectively becoming ‘talk back’, Oxman (2002).

8. The prompt for the student’s choosing CAD was the ability to visualise a design problem allowing for conceptual understanding and design resolution. The three-dimensional environment of CAD together with the rapid ability to amend a virtual model was recognised as a considerable benefit to clarifying a design solution accurately. The use of CAD for visualisation of their CAD was an incentive for students who struggled with a lack of artistic ability.

9. Students engaged with CAD activities to gain a more intricate understanding of their design proposal. The use of CAD would also reveal unexpected consequences, concepts or features of a design problem that would otherwise may not have been achievable by analogue methods.

10 Students commenced the use of CAD to allow for integrated and immersive opportunities in their design resolution, allowing them to ‘experience’ their design iteration rather than it be merely illustrated, providing a more efficient and informative approach for testing design solutions.

FINAL THOUGHTS: DIGITAL METHODS OF EXPLORATION IN THE ACADEMIC STUDIO

It is now understood in academia that the pace of technology is impacting on the differentiation between digital physicality and physical digitality. These previously separate domains are now becoming increasingly integrated and the clear lines between the two are now blurred. There is concern amongst many in architectural studios within academia that this integration will bring with them a new era of exploration within studio design, that of synchronic exploration of building form using both traditional and increasingly digital methods.

What was once a design process that stemmed from pen to paper to thought and back to pen, in an ordered and responsive learning and design journey. The students within today's architectural studio utilise the integrated and immersive approaches of Building Information Modelling (BIM) and digital exploration. The student still 'models' their building, its form and spatial expression, however via digital modelling, an immersive exploration can be experienced, when opting for a digitally created model. This digital model allows the embedded data and information about space, structure and materials to be synchronically manipulated in a blended and deeper learning journey. The digital models that are created during the design process allow for the synergy of both physical and digital

modelling with design exploration occurring seamlessly. This readily accessible and seamless environment allows for a greater accuracy and finer levels of manipulation to be achieved.

There is a new pedagogic classification occurring when using digital modelling in architectural teaching... that of depth of learning. When using the digital model, the cohort were able to explore more 'what ifs' in rapid succession which enriched the final learning journey and its pedagogic outcomes. Using the digital model the learning was deeper still; the connection with the model was far more immediate, seeing the model in a real world setting seemed to enhance communication between student to student or student to tutor dialogue. Both perception and interpretations of the models studied were richer in detail and created a new critique dynamic.

Modelling is a key tool in architectural studio teaching, using them allows higher order cognitive skills to be used by the cohort, such as spatial, planning and relationship of form. Using AR to explore the model(s) allows for a critical synthesis of these cognitive skills, where interactions with the model create immediate design iterations that move the student forward through their design journey.

NOTES

- ¹ Fabrizia Mantovani. "12 VR Learning: Potential and Challenges for the Use of 3D." *Towards cyberpsychology: mind, cognition, and society in the Internet age 2* (2001): 207.
- ² William Winn. "A conceptual basis for educational applications of virtual reality." Technical Publication R-93-9, Human Interface Technology Laboratory of the Washington Technology Center, Seattle: University of Washington (1993).
- ³ Salih Ceylan and Sema Soygenis. "Improving Architecture Students' Design Skills: A Studio Experience." *International Journal of Art & Design Education* (2022).
- ⁴ Augustinus Madyana Putra, Gagoek Hardiman, Agung Budi Sardjono, Evaristus Didik Madyatmadja, And Gerarda Orbita Ida Cahyandari. "The Effect Of Manual Sketching On Architectural Design Process In Digital Era." *Journal Of Theoretical and Applied Information Technology* 100, No. 2 (2022).
- ⁵ Joy Sen Vriddhi. "Effect of Computer Learning on performance in early Architecture Education." *Journal of Engineering Education Transformations* 35, no. 4 (2022).
- ⁶ Ronald A. Finke, Thomas B. Ward, and Steven M. Smith. *Creative cognition: Theory, research, and applications*. MIT press, 1996.
- ⁷ Kees Dorst. "The core of 'design thinking' and its application." *Design studies* 32, no. 6 (2011): 521-532.
- ⁸ Nigel Cross. "Designerly ways of knowing: Design discipline versus design science." *Design issues* 17, no. 3 (2001): 49-55.
- ⁹ Kees Dorst. "The core of 'design thinking' and its application." *Design studies* 32, no. 6 (2011): 521-532.
- ¹⁰ Willemien Visser. "Dynamic aspects of design cognition: Elements for a cognitive model of design." INRIA, Rapport de recherche n 2116 (2004).
- ¹¹ Thomas Watt Maver. "A theory of architectural design in which the role of the computer is identified." *Building Science* 4, no. 4 (1970): 199-207.
- ¹² Bryan Lawson. *How designers think*. Routledge, 2006.
- ¹³ Bill Hillier, and Adrian Leaman. "How is design possible?" *Journal of Architectural Research* (1974): 4-11.
- ¹⁴ Rivka Oxman. "Prior knowledge in design: a dynamic knowledge-based model of design and creativity." *Design studies* 11, no. 1 (1990): 17-28.
- ¹⁵ Mark Gelernter. "Reconciling lectures and studios." *Journal of Architectural Education* 41, no. 2 (1988): 46-52.

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