Digital Computation on Architectural Design Process in Universitas Multimedia Nusantara

Rizki Tridamayanti Siregar[1,*] Irma Desiyana[1]

[1] *Architecture Department, Faculty of Art and Design, Universitas Multimedia Nusantara, Tangerang, Indonesia*
[*]*Corresponding author. Email: rizki.siregar@lecturer.umn.ac.id*

ABSTRACT
In the digital era, BIM (Building Information Modelling) has enriched and transformed Architectural pedagogy, particularly in the architectural design studio. It has challenged students during design activity, either it helps or limits their design. We review students' achievements that employ BIM as part of the architectural design process. In this case, BIM parameters based on The International Union of Architects (UIA) revised edition 2017 include creative process, analyses and strategies for the design process, technical knowledge, and ability to communicate ideas such as drawing, modelling and documentation. This research focuses on the architectural design studio of the fourth semester of undergraduate study in Universitas Multimedia Nusantara (UMN). We use the correlational method to comprehend students' performance in the digital design process. First, we observed and followed students' design processes. Second, we collected final grade data from two applied BIM courses, Architecture Design 3 and Digital Computation 2. This research aims to assess the influence of BIM utilization on students' performance and achievement in the design process. The results will improve learning methods and their effectiveness in architectural design and digital computing.

Keywords: *Digital computation, BIM, Digital modelling, Pedagogical method, Architectural design.*

1. INTRODUCTION

The development of digital thinking and tools in architecture education is ineluctable. Thus, architectural education must be familiar with technologies development to exhibit practical and productive knowledge and skills in the workplace [1]. On the other hand, architectural education has become dependent on digital modelling applications for design decisions [2]. BIM (Building Information Modelling) software systems combine interfaces to suit all sectors' users [3]. The purpose of BIM in design activity is to quickly adapt to new inventions and alterations in technology, tools, methods, and social problems [3].

Furthermore, the architecture curriculum in Universitas Multimedia Nusantara (UMN) has started to elaborate and employ digital thinking in the compulsory course and the design studio in the second year. This research uses the fourth semester with Digital Communication-2 (AD 2) as a compulsory course that teaches BIM and Architectural Design-3 (AD 3) as the design studio that utilizes BIM. There are three objectives of this research:

- To assess the correlation between the Architecture Design-3 and the Digital Communication-2.
- To assess the influence of BIM utilization on students' performance and achievement in the design process.
- To assess the most significant parameter on BIM utilization on students' performance and achievement on the design process course.

2. THEORETICAL BACKGROUND

Architectural education has concentrated on the design studio to learn design and has been supported by other courses. The design studio is the main of architectural education with high levels of Student-Centered Learning pedagogies [4]. Learning in a design studio is inductive and problematic to improve students' visual design thinking [4]. Architectural education requires design ability in visual and spatial thinking, both 2D and 3D [2]. Observation, analysis, and 3D thinking are the keys to an understanding of scale, geometry, pattern, and design thinking [2]. The dominant characteristic is critique in formative,

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summative assessment, and feedback [4]. The design process has four sequential and cyclic stages: exploration, information-gathering, interpretation, and schematic design [4].

Digital thinking and application in architecture education have become challenges and opportunities. Architecture education promotes a holistic and interdisciplinary practical and theoretical reflection from various scientific areas [5]. BIM allows a different design process workflow definition that helps recognize constraints and design reasoning [3]. When the design studio has a character learning by doing, it becomes an excellent opportunity to improve students' digital and image elaboration skills [6]. Digital application is appropriately applied to the design process when students perceive and comprehend visual and spatial thinking, design principles, and other design forces [2]. The digital skills have been well integrated into the architecture curricula if students can slowly learn how to integrate digital skills in design tasks [5].

There are attempts to collaborate digital thinking into the architectural design process. A study has compared formal and informal teaching methods of digital thinking and architectural design process integration in design studios [7]. The formal method follows a rigid content and methodology; meanwhile, the informal method let students define and explore their learning strategy [7]. The study has revealed that understanding digital thinking increases students creative thinking [7]. The lack of understanding of digital thinking leads to difficulties applying in the design studio [7]. The design studio is a formal method that focuses on the design process and design thinking where it is possible to accommodate the informal method [7]. A mentor in the design studio became a facilitator of student learning rather than a transmitter of knowledge [7]. As a result, architectural curricula must integrate digital thinking and skills, ultimately in the design studio [1]. Students in the second year are encouraged to re-elaborate or remodel the initial design with various media [1]. The digital tools have helped students explore growth patterns, but they lacked generating unit designs and examining the human life cycle inside, outside, and between units [1].

3. METHODOLOGY

The International Union of Architects (UIA) Charter issued a global architectural education standard. This standard is one of the basic guidelines for the architectural education curriculum at Universitas Multimedia Nusantara (UMN) Tangerang.

Chapter 4 has three-part, 4.1 to 4.3, where UIA explains the parameters as a reference for curriculum development for architecture pedagogy (Figure 1). Chapter 4.1 about **Design** delineates the learning targets to encourage students to be able to think creatively, innovative, capable of thinking three-dimensionally, and can analyze and make critical judgments to formulate design strategies [8]. Chapter 4.2 about **Knowledge** describes the educational goals to encourage students to be aware of the links between architecture and other disciplines, master technical knowledge of construction detail, structure, materials, and understand technical documentation, design procedures from the design phase to the construction phase [8]. Chapter 4.3 about **Skills** explain the student's ability to collaborate in all design phases with all members of interdisciplinary teams [8]. Mastering to communicate design ideas through drawing, model making, speaking, or even numeracy and writing [8].

The parameters break into five parts, such as:

- Creativity, innovation,
- Analyses, critical judgment and formulate strategies for action,
- Technical knowledge of structure, materials, and construction,
- Design procedures and processes,
- Documentation and specifications in design realization and collaboration.

These five parameters of UIA, A-E, are used to measure learning achievement in two courses, Architecture Design-3 (AD 3) and Digital Communication-2 (DC 2). The final grade data from these courses were collected and compared. This research aims to assess the influence of BIM utilization on students' performance and achievement in the design process and to show the correlation between AD 3 and DC 2.

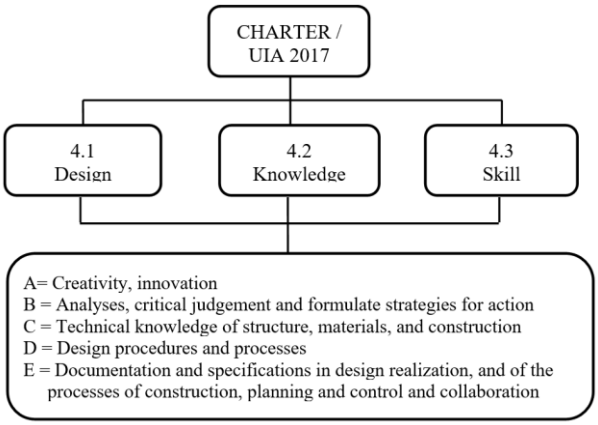

Figure 1 Outline of UIA charter for architectural education.

4. RESULTS AND DISCUSSION

Department of Architecture in Universitas Multimedia Nusantara (UMN) Tangerang applies

integration between each course. Architecture Design is the core of the curriculum, and the other courses support Architectural Design. DC 2 teaches BIM in the fourth semester, and it has integrated with AD 3 in the same semester.

4.1. Architecture Studio-3 2021

AD 3 uses urban scale issues and utilizes low-rise and wide-span building technology. Students criticize living space problems in urban and architectural contexts through the idea of form by outlining designs based on public functions, circulation, spatial planning and programs, issues, and design concepts (Figure 2). This studio also emphasizes cooperation and collaboration in exploring and solving problems in the core area of transit-oriented movement.

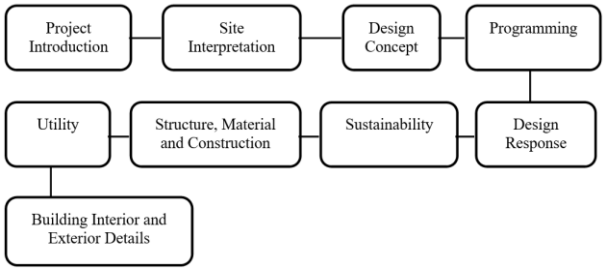

Figure 2 Architecture design-3 process.

The solutions are applied in public buildings and open public spaces as an interconnected area, especially the crowd node or transit center. Students can integrate various knowledge in the previous and current semesters into the design, such as structure and construction, architectural theory, building physics, parametric design, and others. Aspects of occupant comfort in buildings are a significant concern, so students need to understand the basics of sustainability and building physics, especially ventilation and natural lighting. In the end, students can design with different levels of complexity and function. The diagram below shows the stages of project implementation in AD 3.

The implementation UIA Charter in AD 3, such as:

- ***A (creativity)****:* The study case was a public transportation station challenging students to propose a unique building form that maximized the site potential and function. Students were encouraged to explore mass compositions and geometry possibly.
- ***B (analyses)****:* The students redesign the Duri Station circulation system as a Transit-Oriented Development (TOD). They collaborated to collect and analyze data and presented a better system.
- ***C (technical knowledge)****:* The design included multi-storey buildings with a maximum of four floors and used wide-span structures. The students proposed building concepts and systems, including structure, utility, material application, and construction detail.
- ***D (design procedures)****:* All this concept and knowledge translated into construction phases logic. Every project phase must be well presented from the design and operational stages.
- ***E (documentation)****:* In the end, students communicated the project through drawing concepts and details.

4.2. Digital Communication-2 2021

In DC 2, students used Autodesk Revit Architecture software to introduce the BIM (Building Information Modeling) system. Autodesk Revit Architecture assists students in digital modelling both physical and functional characteristics of a building facility. DC 2 provides an understanding of building information used by various parties or disciplines in a project, from the planning phase to the operational phase of the building. The diagram below depicts the stages of course implementation in DC 2 (Figure 3).

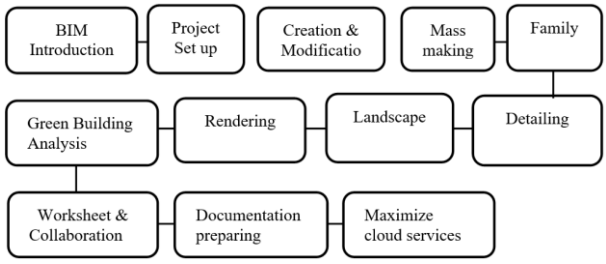

Figure 3 Digital communication-2 process.

The UIA Charter implementation in DC 2, including:

- ***A (creativity)****:* The students created and modified digital architectural, interior, landscape, and supporting elements of the objects.
- ***B (analyses)****:* The students experimented with the BIM system, working principle, and project setup. Revit architecture as a modelling tool and as an analyzing tool.
- ***C (technical knowledge)****:* The process included Revit family introduction, made digital models of utility objects, such as stairs, shafts, railings, and curtain walls, and another construction detail.
- ***D (design procedures)****:* Introduction to the principle schedules, scheduling quantities, and cost estimating.
- ***E (documentation)****:* The student-created templates and prepared sheets, rendering, worksheets and tried collaboration tools; they also used Autodesk

A360 cloud service as a real work experience simulation.

4.3. Curriculum Integration between Architecture Studio-3 and Digital Communication-2

Both AD 3 and DC 2 use the UIA Charter for Architectural Education. AD 3 does not include 4.2.6 about Professional Studies in its modules because it is mid-level. DC 2 as a software-based course supports architectural studio in many sub-chapter; chapter 4.1) about Design, chapter 4.2.1) about Cultural and Artistic, sub-chapter (d) about Awareness of the links between architecture and other creative disciplines, chapter 4.2.4) about Technical Studies, chapter 4.2.5) about Design Studies and the last, chapter 4.3) about Skill (Table 1).

Table 1. Architecture Design-3 and digital communication-2 mapping in the charter UIA 2017 revised

Subject	CHARTER / UIA 2017																																				
	4.1 Design				4.2 Knowledge																												4.3 Skill			
					4.2.1 Cultural and Artistic				4.2.2 Social Studies					4.2.3 Environmental Studies					4.2.4 Technical Studies					4.2.5 Design Studies			4.2.6 Professional Studies									
	a	b	c	d	a	b	c	d	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	a	b	c	d	e	a	b	c	d
Architecture Design 3	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v
Digital Communication 2	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v

Assignments in both courses have some parameters, like **A** (creativity), **B** (analyses), **C** (technical knowledge), **D** (design procedures), and **E** (documentation). Each grade from the assignments was collected and compared using 18 samples (50% of participants who took both courses).

5. RESULTS AND DISCUSSION

The comparison between AD and DC 2 has five parameters: creativity, analysis, technical knowledge, design processes, and documentation (Figure 4-8). Students who understand BIM applications have more opportunities to explore and create form-finding and design detail; however, no matter how good the mastery of BIM, students who are lack confidence and effort in creativity do not maximize the utilization of BIM for design exploration. Hence, creativity and innovation (parameter A) have a reciprocal impact between AD 3 and DC 2 when students are more curious about learning, exploring, and mastering BIM as part of the design process.

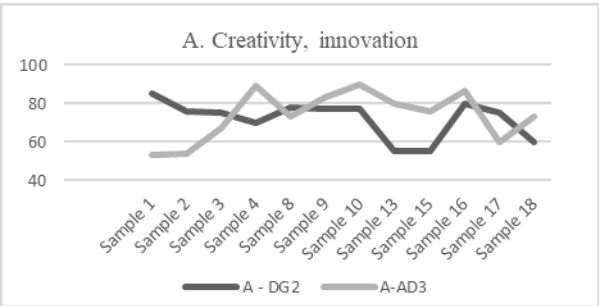

Figure 4 Creativity and innovation parameters for students' achievement in AD 3 and DC 2.

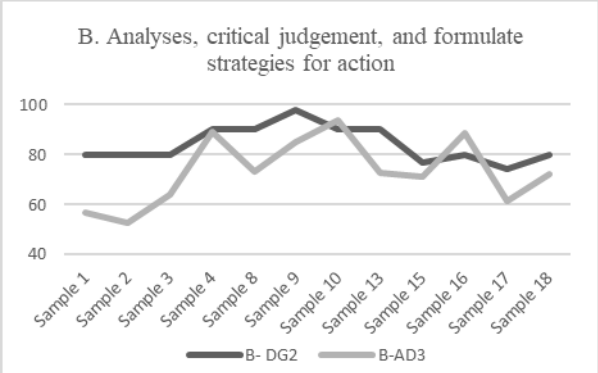

Figure 5 Analyses, critical judgement, and formulate strategies parameters for students' achievement in AD 3 and DC 2.

AD 3 has a high demand for students to analyze, critical judgement and formation strategies (parameter B). On the other hand, DG 2 has limited its study on skills to master in visual communication. Nevertheless, when DG 2 teaches students to analyze building and environment, students are easier to relate in the design process that affects their design reasoning and decision. Therefore, DG 2 for modelling does not affect parameter B that focuses on cognitive learning; but, DG 2 for building and environmental analysis are parallel with the design process in AD 3.

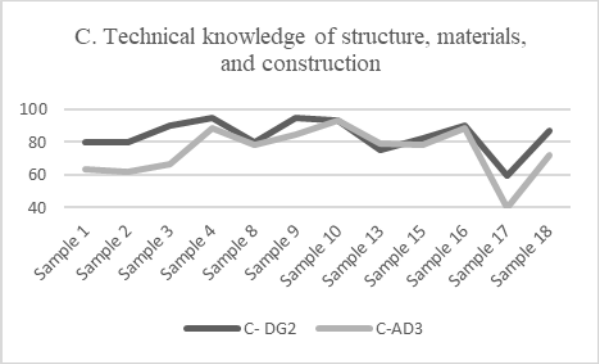

Figure 6 Technical knowledge of structure, materials, and construction parameters for students' achievement in AD 3 and DC 2.

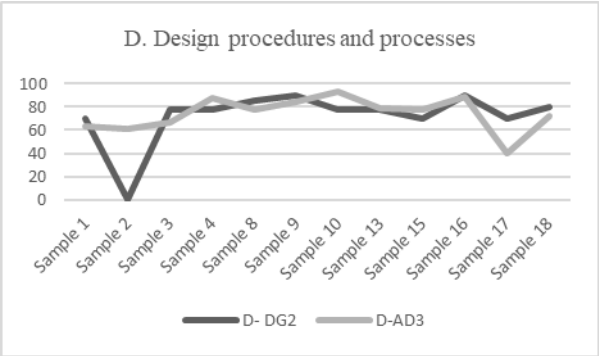

Figure 7 Design procedures and processes parameters for students' achievement in AD 3 and DC 2.

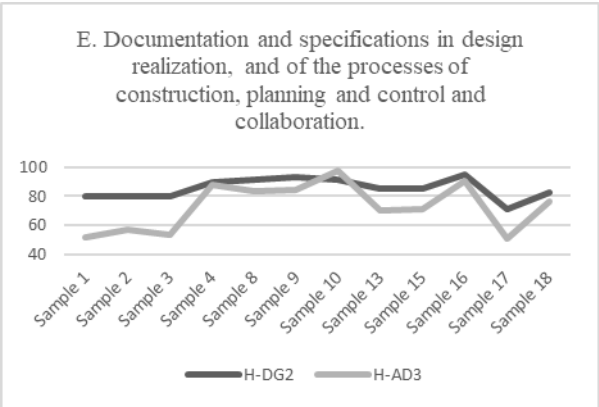

Figure 8 Documentation and specifications in design realization, and of the processes of construction, planning and control and collaboration parameters for students' achievement in AD 3 and DC 2.

The uniqueness of parameters C, D, and E have the same result between AD 3 and DC 2. DC 2 focuses on technical knowledge, design procedure, and documentation that enhance AD 3. Mastering BIM has boosted students' speed to make design products, giving them more time to analyze and think during the design process.

6. CONCLUSION

The integration digital computation in Architecture Curriculum, UMN has given time for students to understand the logic and technical use of BIM which gives more skills in modelling, documentation, and technical knowledge. When the integration of digital computation happens at the same semester to complement Architectural Design Studio, it forces students to practice their mastery in BIM as they have to explore more based on their project design. The presence of AD 2 to support AD 3 are helpful to improve design product and speed. Moreover, BIM utilization has impacted their performance to produce documentation and technical knowledge, ultimately influencing their design intention after simulating building or environmental impact of their design. If students want to learn and practice BIM, it is not only enhancing their mastery in BIM but students will have more time to think and design in the design process. However, cognitive learning, analyzing and formulating strategy, are purely from the design process in the studio.

- To assess the correlation between the Architecture Design-3 and the Digital Communication-2.
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