TRAINING STUDENTS IN ARCHITECTURE IN THE DIGITAL AND ARTIFICIAL INTELLIGENCE AGE

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Abstract: Architecture is one of the technical fields with specific scientific, aesthetic, and social characteristics. The process of training in architecture is closely linked to technological development with the support of computers and design software. In the digital age and artificial intelligence technology, architectural design thinking and methods have changed a lot. With the development of science and technology, computers not only support the design of technical drawings but also affect the architectural creation process, especially artificial intelligence technology. In particular, the requirements for architectural aesthetics in the new era do not stop at works with simple shapes but require works with architectural shapes and the ability to calculate microclimate at a very complex level (parametric design works). Therefore, in the training of architecture majors at universities in Vietnam, adjustments must be made to suit the current trend of technological development.

Keywords: architecture students, digital age, artificial intelligence, parametric design, modern architecture.

1. Introduction

With the advancement of science and technology, supported by software and computers, it is evident that architectural education must align closely with societal needs and incorporate technological innovations in design. These technologies go beyond basic 2D and 3D design software to include BIM (Building Information Modeling) systems and, at a more advanced level, parametric design and AI technologies.

Globally, many universities and design firms have utilized design software integrated with algorithms and artificial intelligence (AI) technologies to create structures with complex and magnificent forms (Hanafy, N. O., 2023; Weller, M. W., 2011; Renzo Piano Building Workshop, 2015). Beyond using design software for architectural creativity and numerical calculations, managing a project - ranging from conceptualization to design, construction, and operation - requires an integrated and unified system. The design phases are interconnected through various departments, following a process where the BIM system is widely and mandatorily applied. The effectiveness of BIM in construction management, from design to execution and operation, has been well-documented (Chu, T. K. L., 2018; Jung, N., 2019).

In Vietnam, the architecture and construction industry is currently developing but generally adheres to outdated design and management models, lagging behind the digital era. This presents a significant challenge for universities, including those offering architectural training programs (Dinh, T. M. H., 2000; Nguyen, T. M. L., & Hoang, S. T., 2020; Ngo, M. V., 2024). However, architecture is inherently a creative field, with works influenced by the distinct styles of individual architects, cultural factors, and societal conditions. Therefore, it is imperative to adapt teaching and learning methods so that architecture graduates can meet the demands of the digital age and artificial intelligence era.

2. Research content

2.1. The current state of architectural thought, creativity, and design in Vietnamese universities

In Vietnam, approximately 30 universities offer architectural training, with around 50% concentrated in major cities such as Hanoi and Ho Chi Minh City, while the remainder is distributed across the northern and southern regions. Over the years,

Vietnamese universities have transitioned from traditional training models to advanced credit-based programs and CDIO (Conceive - Design - Implement - Operate) frameworks. These new programs aim to bridge academic training with industry demands, producing engineers and architects capable of addressing practical societal needs. However, in practice, contemporary architecture graduates struggle to meet the requirements of modern architectural design. Most architects still rely on traditional thought patterns, reflecting a widespread issue in architectural education. Generally, this training process follows these stages:

- **Cognitive development:** The process begins with developing cognitive skills, as architects must possess abilities in visualization, spatial reasoning, and various artistic disciplines. These individual capabilities are nurtured through foundational courses designed to maximize learners' cognitive and analytical potential.

- **Architectural creativity:** Creativity in architecture is a synthesis of technical and societal factors. Beyond spatial and aesthetic creativity involving forms, colors, and details, architectural works must exhibit distinct styles. These styles are shaped by courses on the history of global architectural development, which highlight the diverse architectural movements influenced by eras, regions, and societal tastes. Examples of architectural styles include Classical, Romanesque, Gothic, Neoclassical, Art Deco, Modernist, and Renaissance styles. Additionally, each country, particularly those in Asia and Vietnam, boasts unique architectural cultures alongside global trends.

- **Architectural design**: The final stage involves translating ideas into technical drawings. This comprehensive phase demands skills in drafting, evaluating structural and material impacts on projects, and presenting designs. In this stage, computers and design software play a significant role in maximizing efficiency. As illustrated in Figure 1, traditional training methods typically limit software applications to technical drawing tasks.

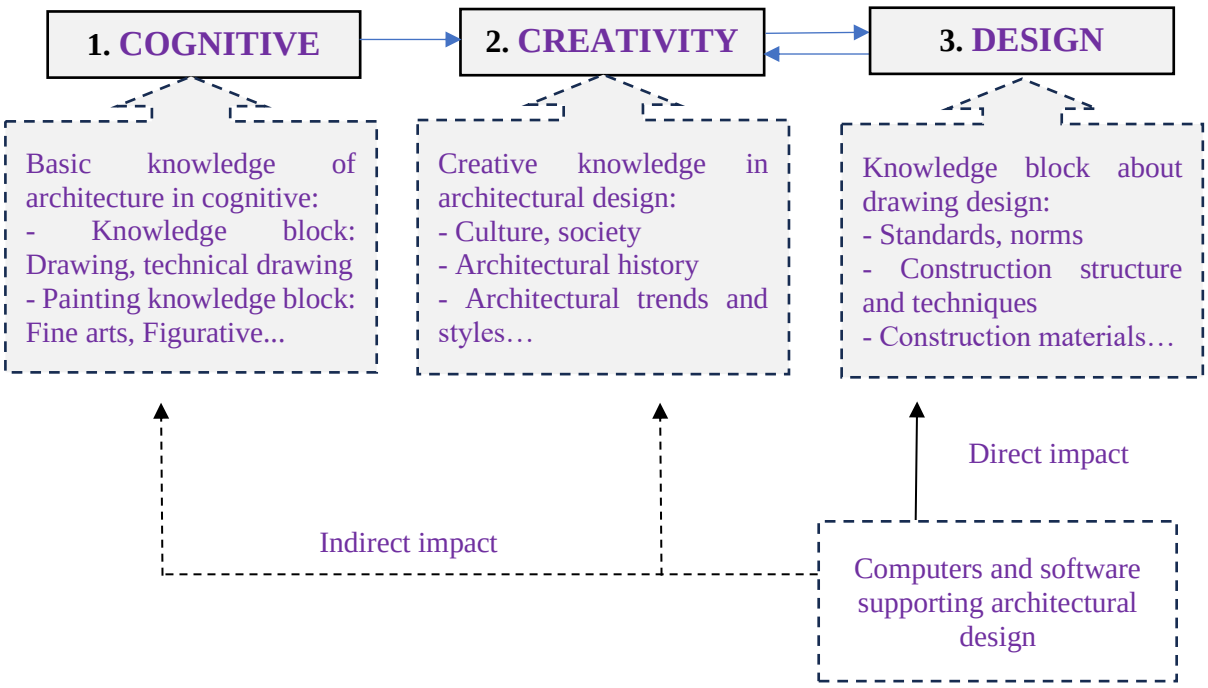

Figure 1: The impact of technology on the traditional training process

2.2 Stages of applying science and technology in architectural design

In Vietnam, universities began integrating computer-aided design (CAD) software in the 1990s, initially using basic 2D and partially 3D tools. Most of these programs were primarily used to assist with technical drawing production. In recent years, some universities have adopted modern design and project management software tools. However, the current level of adoption remains insufficient and lags behind global technological trends. The application of technology in architectural education has evolved through distinct phases alongside advancements in science and technology:

- Phase 1: Limited use of computers and design software: During this stage, the application of computers and software was minimal, focusing primarily on the final phase of design: creating technical drawings. CAD tools replaced traditional hand-drafting methods, significantly improving efficiency. However, these tools primarily supported 2D drawings, with 3D representations remaining underdeveloped.

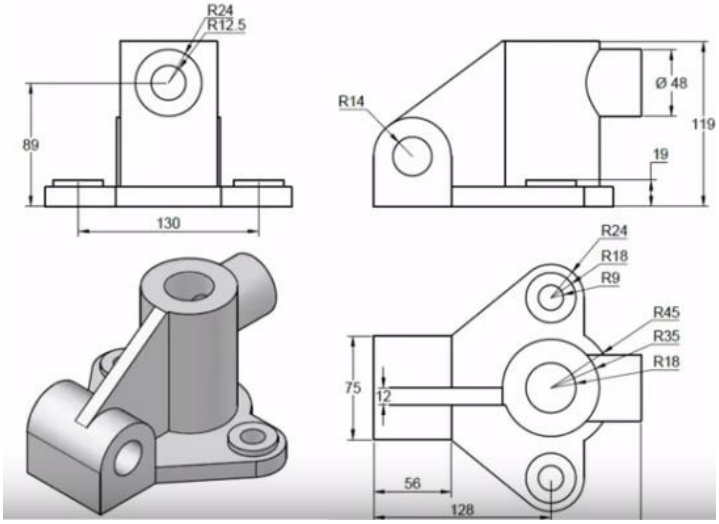

Figure 2. Technical drawing using computer software at a simple level

- Phase 2: Advancements in software-assisted design: As technology progressed, design software began offering comprehensive support to architects, ensuring higher precision and shorter design times. Computers enabled architects to create diverse and complex models and components, catering to the industrialization of design and construction processes. This stage required architects to manage projects through integrated systems, where all changes during design, construction, and operation followed a unified approach.

Figure 3: Construction design management system according to BIM model

One widely adopted system is **Building Information Modeling (BIM)**. BIM has become a standard in global architectural and construction practices. A notable pioneer in BIM research and application is the **Center for Integrated Facilities Engineering (CIFE)** at Stanford University. CIFE has annually evaluated BIM adoption across companies and projects, summarizing the benefits derived from its application. A study of 32 BIM-based projects by CIFE highlighted the following advantages (Chu, T. K. L., 2018):

- 40% reduction in change requests,
- A deviation of only ±3% between budget estimates and final costs,
- 80% reduction in cost estimation time,
- 10% cost savings,
- 7% reduction in project timelines.

- Phase 3: The technological explosion in the digital age: The digital era has profoundly impacted architecture. Beyond producing 3D drawings, software now provides precise calculations, detects conflicts in design elements (architecture, structure, technical systems), and aids in advanced creative processes. Emerging technologies such as artificial intelligence (AI) and parametric design significantly enhance architectural creativity and thinking. Modern buildings demand high levels of aesthetic and structural complexity. Without the support of advanced software and algorithms, translating such ideas into technical designs would be near impossible. Software tools assist in exploring structural solutions and accurately calculating environmental factors such as temperature, light, and wind impact.

A prime example of technology-driven architecture is the Al Bahr Towers, designed by Aedas and Arup. Inspired by the traditional Islamic "Mashrabiya" shading system, the façade features dynamic, patterned panels that provide shade, reduce solar heat gain, and lower carbon emissions by minimizing air-conditioning needs. This sustainable and innovative design highlights the seamless integration of technology with tradition.

Figure 4. The Metropol Parasol Sevilla building uses parametric design with complex structures (Ashui, 2011)

Furthermore, environmental analysis plugins now empower architects to create more balanced, sustainable, and eco-friendly structures. These tools suggest façade improvements to maximize the advantages of external weather conditions, offering numerous options for optimizing building performance.

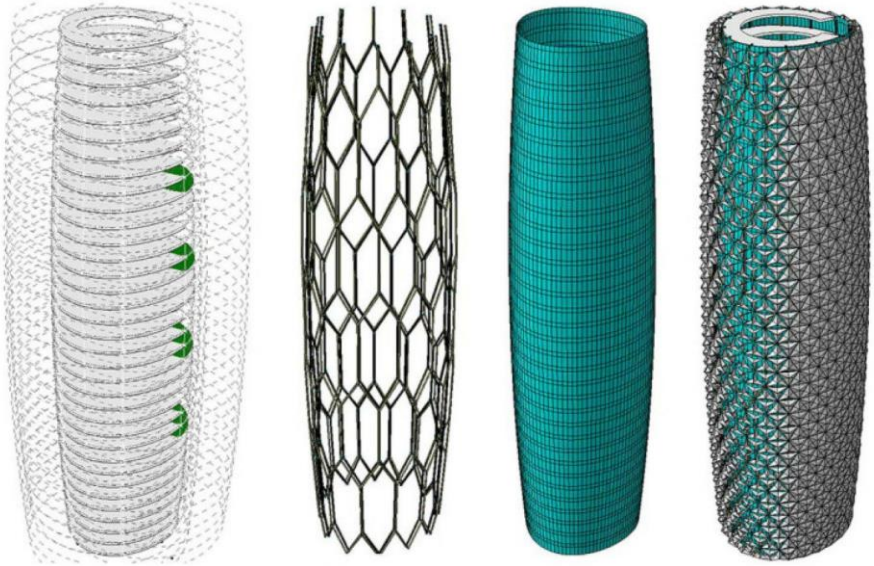

Figure 5. Diagrid-type load-bearing structure and cladding of the Al Bahar Office Tower (Designboom, 2012).

2.3. Training architecture students for the digital and AI era

2.3.1. Prioritizing the application of science and technology in training

The digital era directly influences architectural education, making the integration of design software - from basic to advanced - an essential component of curricula. However, the limited duration of training programs often restricts the ability to include a wide array of software-related subjects systematically. Therefore, an integrated training framework should be developed, with two potential approaches:

- **Basic design software training first:** Students begin with basic design software, then independently advance to more complex tools during project work and professional practice. Alternatively, students are provided foundational knowledge in basic design software early and introduced to more advanced tools during their studies. This method requires significant self-learning efforts and poses challenges for students.

- **Integrated approach:** Basic design software is taught as a foundation for applying technology in design. Students progress through design projects of increasing complexity, incorporating advanced tools in later stages. This approach requires continuity across projects, strong self-learning skills, and more interaction between instructors and students. It is highly effective, enabling students to gradually acquire knowledge from fundamental to advanced levels.

2.3.2. Incorporating technology from the conceptual design stage

Traditional training methods often focus solely on the technical drawing stage. However, the integration of technology must begin at the conceptual design stage. Contemporary architectural design demands high levels of aesthetics, precision, and complexity. AI technology can help students generate multiple design options in a short time, while parametric design aids in conceptualizing complex structures.

At this stage, students need a solid foundational knowledge, as computers generate optimal solutions based on well-defined input data. However, no computer can replace human creativity, especially in a field as imaginative as architecture. Students must view technology as a powerful tool that supports their creative ideas, which must ultimately come from their own abilities.

2.3.3. Integrating project management models into graduation projects

In many countries, the BIM (Building Information Modeling) system is a mandatory requirement due to its proven effectiveness. In Vietnam, numerous architectural design consultancy firms have already adopted this model. Furthermore, the Prime Minister has issued directives approving the roadmap for implementing BIM in construction activities, signaling its inevitability in the near future. Therefore, architectural graduation projects should be treated as integrated design and management tasks. Projects should be evaluated based on students' ability to design and manage buildings using integrated methods for small- and medium-scale projects.

3. Conclusion

The digital and AI era has profoundly impacted all sectors, from society to science and technology. Architecture, as a discipline combining engineering, art, and social sciences, is no exception. Updating the curriculum and content of architectural programs at universities is essential to align with global advancements. However, these changes must be tailored to the specific conditions and circumstances of each university.

While adopting technology is crucial, the core role of architects remains rooted in creative design. As such, foundational knowledge in fine arts and social sciences must continue to be emphasized. Technology integration should enhance, not replace, the creative aspects of architectural training.

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ĐÀO TẠO SINH VIÊN NGÀNH KIẾN TRÚC TRONG KỶ NGUYÊN SỐ VÀ TRÍ TUỆ NHÂN TẠO

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Tóm tắt: Kiến trúc là một trong những ngành kỹ thuật có tính đặc thù, vừa mang tính khoa học vừa có yếu tố về nghệ thuật thẩm mỹ, xã hội. Quá trình đào tạo ngành kiến trúc gắn liền với quá trình phát triển công nghệ với sự hỗ trợ của máy tính và các phần mềm thiết kế. Trong thời đại kỷ nguyên số và công nghệ trí tuệ nhân tạo, tư duy và phương pháp về thiết kế kiến trúc đã có nhiều thay đổi. Với sự phát triển của khoa học công nghệ, máy tính không chỉ dừng lại ở hỗ trợ thiết kế bản vẽ kỹ thuật mà còn tác động vào quá trình sáng tác kiến trúc, đặc biệt là công nghệ trí tuệ nhân tạo. Đặc biệt, yêu cầu về thẩm mỹ kiến trúc trong thời đại mới không chỉ dừng lại ở các công trình với hình khối đơn giản mà đòi hỏi các công trình có hình khối kiến trúc, khả năng tính toán vi khí hậu ở mức độ rất phức tạp (các công trình thiết kế tham số). Do đó, trong đào tạo chuyên ngành kiến trúc tại các trường đại học ở Việt Nam nói chung, cần có sự điều chỉnh phù hợp với xu thế phát triển công nghệ hiện nay.

Từ khóa: sinh viên chuyên ngành kiến trúc, kỷ nguyên số, trí tuệ nhân tạo, thiết kế tham số, kiến trúc hiện đại.