An Assessment of CAD's Role in Knowledge Formation in Architecture/Architectural Engineering Discipline

Verdy Kwee

United Arab Emirates University, verdy_kwee@uaeu.ac.ae

ABSTRACT

In the past decades, spurred by demands from the industries, the architecture and architectural engineering disciplines have integrated CAD learning successfully in their curricula, producing graduates who are technologically adept in this area. While CAD applications are becoming intuitive and have tremendously assisted students and practitioners in the production of architectural abstractions, they seem to remain isolated systems, enhancing little to the formation of knowledge in the field.
This paper discusses UAE University's department of Architectural Engineering struggle to equip students with the skills and understanding to cope with the information age within the limits of current technologies. Capitalizing on the popularity of online dissemination, it highlights the process that is needed for digital architectural information packaging – a possible area of focus in the future development of CAD systems.

Keywords: CAD education, information packaging, knowledge formation
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1 INTRODUCTION

The advancement of CAD technology in architecture has led to closer integrations between 2D documentations and 3D visualizations, building information and its abstractions, design ideas and their realizations. We have witnessed the developments of object-oriented CAD, parametric modeling, Building Information Management (BIM), etc. CAD's have been generally viewed as tools for "decreasing the building costs and at the same time getting better quality and efficiency out of the industry" [1]. There is little argument that it has provided significant boost to the construction industry in terms of speed of production, exchange of information, thus time frame in project completions. CAD curricula of most architecture/architectural engineering schools have played a significant role in this progress contributing significantly to the industry as well. While this arrangement has seen economic benefits to all parties so far, there is a core issue that needs to be addressed in the field: how do we advance the knowledge of architecture and render it more readily accessible to students and the general public? What role could future CAD systems assume? What are the implications?

One way to facilitate the process of knowledge formation is to enhance the clarity through the cohesiveness of architectural abstractions. Although most CAD systems are able to help produce architectural abstractions in the form of 2D and 3D renderings, the presentation or packaging of these

abstractions do require special attention. Architectural information has been traditionally packaged in printed formats through architectural journal and book publications. These days, the same patterns of packaging techniques are translated in digital formats with hyperlinking feature that has allowed instantaneous access. Kwee argues that while speed of information retrieval has improved, opportunities to further advance the techniques of architectural information packaging have remained largely untapped [7].

CAD systems have focused well on the production and display of architectural abstractions, contributing to the exponential growth of data. While the internet has facilitated efficient transmission of architectural data, it is still lacking in the transmission of architectural knowledge. CAD systems are in the position to fill this void. Information that architects add to architectural drawings which are now generally about physical properties of building components could be extended to include the complex layers of design processes. Possessing all the necessary data, we are not limited only to the possibility of building information systems for facility or building management, but the opportunity to tap into the architectural education sector as well by automating information packaging, especially for online dissemination.

This paper discusses current gaps in architectural information packages, theoretical approach to information packaging and the technological situation that appear to limit progress. Through student academic projects, it highlights a typical journey that individuals will have to undertake to address certain aspects of information packaging.

2 ARCHITECTURE AND PUBLICATIONS

To understand architecture, students rely largely on architectural precedents. Being not as transportable as other forms of arts, students and architecture enthusiasts depend on translations in architectural publications by authors who, in most cases do not possess in-depth knowledge of the architectural subject(s) they try to explain. Consequently, authors' false assertion on their authority of the subject tends to lead more to confusion than clarity and understanding. This inevitably prevents the continuity of knowledge formation and further synthesis. To illustrate, Phaidon Atlas of Contemporary World Architecture attempts to explain a Glenn Murcutt's building, The Arthur and Yvonne Boyd Education Centre, in textual descriptions, four photographs, a plan, an elevation and an architect sketch. An excerpt of the text from its publication is as follows:

"….The communal gathering spaces – hall, dining area and verandah – are grand, bold gestures united under a soaring roof plane. The smaller-scale dormitory areas that extend southward along the ridge are pod-like units articulated by concrete blades that screen the sun to the east and west, focusing the dormitories' outlook on to the river below…." [9]. Not only that in the absence of proper visuals to support these texts would leave readers stunned by the linguistic metaphors and similes, the author does not seem to provide the correct fact regarding the materiality of the blades mentioned.

Often, in architectural publications the superficial explanations are masked by glossy still photographs that do not depict the true nature of the buildings. Photographs have been accused by Simon Niedenthal to be 'architectural fiction' [8] to the extent that at times, they are more 'architectural' than the building they illustrate.

As suggested above, there already exists cultural bias in the choices of abstractions used in explaining architectural subjects. This limitation is usually further exacerbated by the ineffective techniques of information packaging. In 2006, a worldwide survey was carried out to gauge the performance of architectural publications in terms of accessibility, clarity, appeal, coherence, organization, completeness and immersiveness [5]. It was concluded that in all aspects, publications have performed below readers' expectation (Fig. 1).

There is a clear gap that needs to be addressed. The solutions seem easier to derive on digital platform than in print media. However, we still lack the proper digital applications that would make it attractive for authors to use. To illustrate, the following section explains typical requirements and processes undertaken to design effective information packaging.

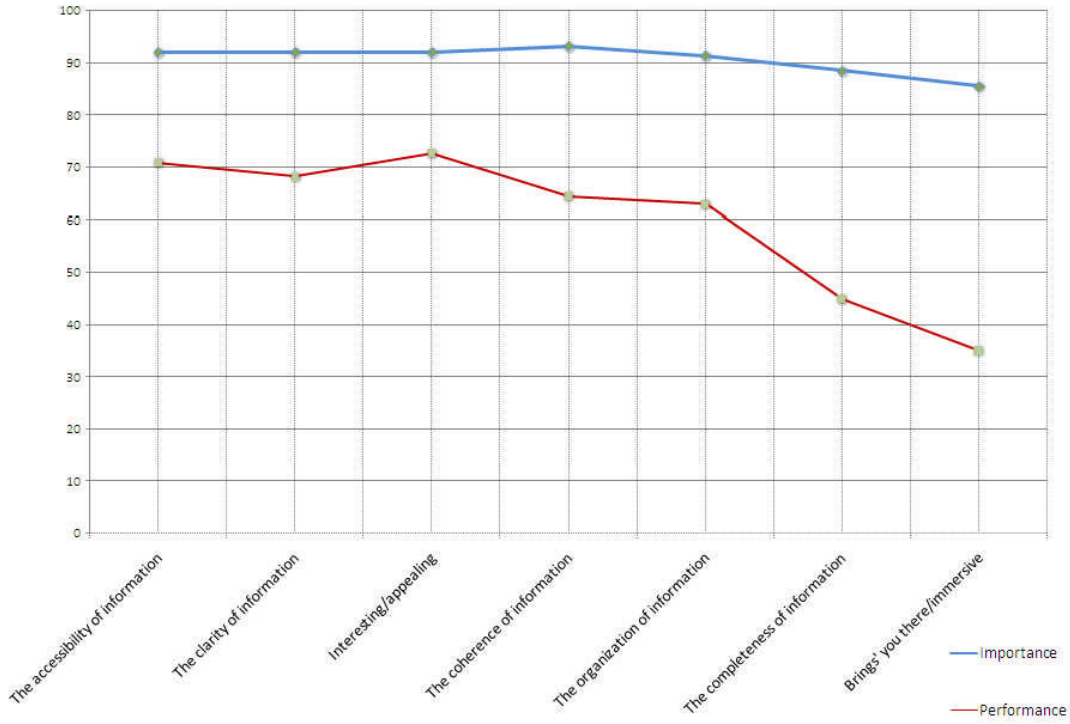

Fig. 1: End-user survey chart showing performance vs the importance of selected aspects in architectural publications [5].

3 PROCESS AND CHALLENGES IN TEACHING DIGITAL COMMUNICATION IN ARCHITECTURE

In 1997, it was noted that architecture schools should avoid "the slavery of drawings [and] students have to be taught more about communication and how to create messages and tell stories" [2]. This section highlights the arduous process in producing online information packaging to "tell stories" to explain architectural issues.

In the past five semesters, within the department of Architectural Engineering, UAEU, one method of teaching CAD has been re-framed in the context of understanding the concept of online communication of architectural ideas. Besides introducing skills and knowledge necessary in producing 'standard' architectural abstractions, the course emphasizes on exploring techniques of integrating information carried by these abstractions in comprehensible, communicative manners. Based on the premise that architecture by nature is largely visual to experience and thus understand, students have been asked to package information of particular aspects of architectural subjects for online presentation.

In the implementation of the academic project, the choices of software applications was mainly governed by the strengths that each had in accomplishing a given task. What the general industry considered as 'standard' also influenced these choices. Lastly, the available expertise to facilitate learning of the software was also taken into consideration. A breakdown of software applications used in the projects is as follows:

- AutoCAD Architecture (Autodesk). The software's primary goal is to produce construction documents. In this project, it is used for the creation of 2D line drawings. Its 3D capabilities are not as intuitive as specialized 3D modeling software.
- 3D Studio Max (Autodesk). As a 3D modeling application, 3D Studio Max handles 3D visualizations, transformation, manipulation, material application, animations more intutively than AutoCAD Architecture, Revit or ArchiCAD. However, it has very limited 2D capabilities.

- Photoshop (Adobe). It is primarily used for image editing in the project, including compression of still images for web publication.
- Flash (Adobe). It is now a common platform for web content, allowing the authoring of interactive graphics. An understanding of Actionscipts and programming logics is necessary.
- Vegas Pro (Sony). A video editing software is needed to modify and/or further enhance movie or animation files.

3.1 Theoretical Framework for Digital Architectural Information Packaging

Developed from Tufte's framework for information visualization in print media [12] and the author's own creative scholarly work that led to the digital presentation of Murcutt, Lewin and Lark's Arthur and Yvonne Boyd Education Centre, Australia [6], a set of fundamental rules had been derived for online architectural information packaging:

- *Depth of information, validity and accuracy*. All of these require extensive research and tight collaborations with experts in the field to ensure that information that needs to be delivered is relevant, valid, accurate and of adequate details. Density or richness of information can rarely be provided by the information package designer alone unless he/she also serves an active role in the procurement and production or design of the architectural object and/or data.
- *Visual emphasis.* This is based on the argument that architecture is more effectively and immediately represented in visual forms than in written texts. The propensity of texts being a more culturally-biased form of representation seems to be another reason. However, this does not suggest diminishing the role of texts which are often integral supporting narratives.
- *Contextualisation of abstractions*. Since each architectural abstraction speaks its own narratives, its location in relation to another can usually affect how it is perceived and understood. Ideally, all similar narratives [in abstractions] should cumulate into larger coherent structures.
- *Information layering*. As an extension to the above point, abstractions that are largely similar, but of differing information dimensions could be layered to highlight the congruity while adding extra relevant information depth. For example, a sectional perspective could be layered upon a sectional working drawing of the same view to visually and informatively complement one another.

Fig. 2: Layering a construction drawing of Murcutt, Lewin and Lark's The Arthur and Yvonne Boyd Education Center and a digital model in interactive manner to increase Depth of Information – the whole could be more than the sum of its parts.

- *Visual continuity* Fig. 3. To better facilitate mental links between different images or abstractions. Due to the ease of hyperlinking of data, abrupt transitions between visual components are commonly observed in many online architectural presentations. Furthermore, an author's familiarity of the subject often renders a false assumption that viewers are also able to connect visual data or information readily. In fact, viewers are usually coerced to provide their own mental translations to link. This would affect the individual's limited cognitive resources as asserted by Scott Johnson [4].

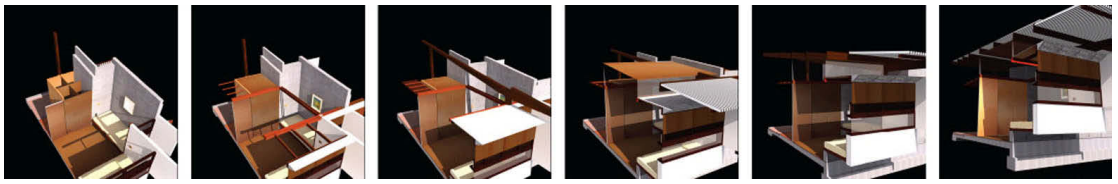

Fig. 3: Tufte's principle of series of thumbnail images could be translated as animation or VR in digital format to achieve similar result.

- *Legibility.* Resolution of images or drawings and the screen that displays them naturally affect how well information is read. Drafting and other graphic software applications have been successful in dealing with this by enabling users to zoom and pan to work with detailed drawings in vector or raster/bitmap formats. However, architectural content providers, authors or distributors have yet to adopt this to improve the legibility of their online data.

In addition to the above, the standard web design considerations do apply:

- *Navigability.* The ease of exploring a site and simplicity of navigation would help in transitioning an audience from one area of content to another. Navigation difficulty may adversely affect a viewer's cognitive thought processes.
- *Graphic composition and design.* The choice of graphics, layout, typography and their properties as well as placements could affect the perception and pre-judgment of the content of a website. Too often, information is unnecessarily and/or inappropriately 'decorated'. To the extreme, some decorations have taken precedence over the content. Tufte drew parallels between them and 'Duck' or decorated shed in architectural design as highlighted by Venturi [12].
- *File size*. Online materials are usually kept to the minimum possible size at acceptable quality for optimum access speed.

3.2 Processes

Despite that they were merely academic projects, the processes would justly represent a typical journey which an author would have to undertake to package architectural information digitally today. The process of digital information packaging in Architectural Engineering discipline can be streamlined into three stages – each requiring unique basic hardware and software to support. These stages are namely:

- *Documentation* – This involves the collection of necessary data, fundamental to the entire process. Depending on the properties and conditions of the subject, such documentation can also become ready-to-use architectural abstraction. For example, in cases of expert interviews, with sound editing, some materials could be extracted and readily included. In most of the student projects, their documentations involved manual measurements, sketches and fact findings. It is usually common that the process of documentation may be redone or revisited at a later stage.
- *Representation* – Generation of appropriate abstractions. Students would have to produce:
    - Textual or verbal descriptions.
    - 2D drawings of the building they wish to explain – floor plans, site plan, etc. They were drawn mainly using AutoCAD Architecture (Autodesk). Some students explored other software applications – eg. ArchiCAD –, which have their own strengths and limitations.
    - 3D representation(s). In many cases, students would have to re-construct 3D models from scratch. Problems occurred when students attempted to import their 2D drawings as basis for their models. They included the difficulty in separating drawing components into identifiable objects for 3D transformations and the occasional inability of the 3D software to recognize lines to be closed or opened (at junctions).

This might result in the improper extrusions of line into 3D elements. Many students chose to digitally trace the imported drawings within 3D Studio Max instead.

The final 3D renditions were usually in three different formats: still image, animation and virtual reality (VR). The choice depended upon the unique usage. For instance, when layering with 2D drawings still images of the corresponding 3D model were usually used. In order to better understand space in relation to a floor plan, 3D VR is an effective mode. To establish visual continuity between 3D plans and 3D sections, short transitional animations might have to be produced.

It does take some time to get students familiar with the technical issues involved in producing quality 3D model renditions which include lighting and material applications.

- *Packaging/Dissemination* – Transformation of representations into easily-absorbed information that would help increase level of understanding within and of the field. The design was as complex as the building information they wished to relay. This was probably the most time-consuming of the entire processes. First and foremost, students needed to organize various architectural abstractions into a hierarchical structure and link related materials in the most seamless manner possible. Based on the framework mention in the earlier section, students were guided to use a web authoring tool, Adobe Flash, to package their information. More time was needed to understand the concept of computer programming and much was consumed in the writing and debugging of codes to achieve particular results in Flash. For instance, to allow an interactive sliding effect of two images or information, students needed to understand the concept of layers, masking, movieclip and be able to write the proper simple codes to manipulate the movieclip containing the mask:

```
this.my_mc.onPress = function() {startDrag(this, false, l, t, r, b);};
this.my_mc.onRelease = function() {
        stopDrag();
};
my_mask.onEnterFrame = function() {
        this._y = my_mc._y;
};
```

The representation and packaging/dissemination stages are sometimes moving in tandem. This may be due to the time needed to prepare follow-up abstractions. The entire cycle could be summarized as shown in fig.4.

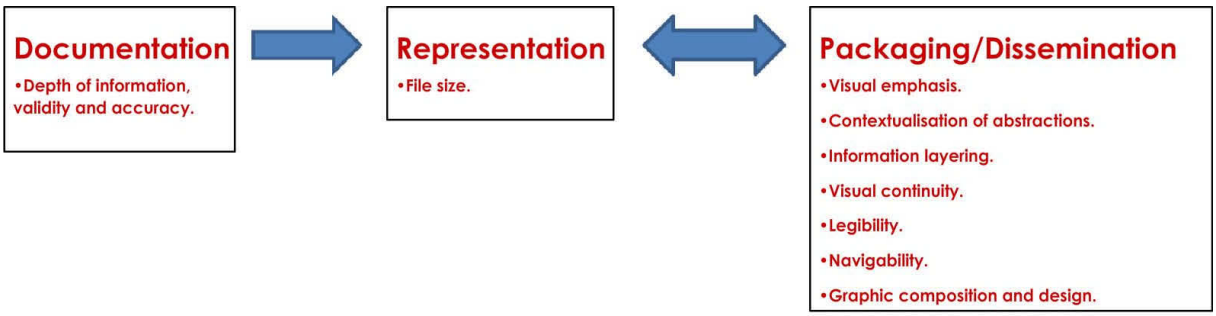

Fig. 4: Summary of processes involved in digital information packaging.

3.3 Limitations and Opportunities

The degree of our student project outcome success naturally varied (viewed from: 'Advanced CAAD Applications' and 'Selected Topics'- http://faculty.uaeu.ac.ae/Verdy_Kwee/podcast/). The finding through a student survey indicated that performance depended primarily on:

- The amount of time they had available to accomplish their set tasks.

- The skills they had already acquired prior to the projects. Some students were already familiar with the software applications which allowed them more time to explore other aspects of the information package design. There are many software applications that one needs to be familiar with in order to achieve the desired results. It remains a challenge to cover them in adequate depth within one-semester long projects.

Learning from the experiences of these guided academic exercises, it seems likely that most authors of architectural publications today may face similar difficulty in investing the time necessary to produce quality digital publications, especially when learning curves of software applications are perceived lengthy. Engaging experts outside the field who have no knowledge nor interest in the field and the packaging of its information could prove counter-productive. Automations would certainly help authors of such publications. CAD systems could also assist authors or designers themselves in allowing additional layers of design reflections, supporting materials and/or comments in architectural documentations separate from physical descriptions now used for construction purposes. All these layers of information should then be able to be organized and published online/digitally readily. By addressing the technological limitations that exist in packaging of architectural information today, it seems likely that the expected paradigm shift especially in architectural/architectural engineering education could be expedited.

However, judging from the slow convergence of technologies in the past decade, despite major take-over's of successful CAD or graphic packages by single corporations, we are probably still far from the idea of knowledge sharing and formation. As the current scenario presents, it has been well-understood that communications between various CAD applications is still hampered by proprietary file formats [11]. This also poses a major uncertainty in the archiving of historical architectural models for future use [3]. In 3D studio Max, it seems currently impossible to exchange files seamlessly between projects done in different versions of the software, forcing users to have to purchase upgrades. A major dilemma that the discipline often encounters is if it should continually support established systems and consequently reduce these systems' competitiveness or help break the monopoly of the market and suffer associated temporary setbacks.

4 CONCLUSIONS

Packaging of architectural information has undergone very little change in the past centuries. Despite the availability of digital platform that revolutionize information delivery, it is arguable that in the past decades it has contributed at any level of significance to knowledge formation, especially in the architecture/architectural engineering discipline. It is quite likely that the problem stems from the utilization of the medium that derives its principles on established conventions of print media. This situation is further aggravated by the lack of skills that authors of architectural publications possess to use digital technologies to enhance information clarity. We have been witnessing a re-convergence of arts and science in the past decades [10], but further technological convergence is necessary to assist in capitalizing on the opportunities that digital platform could afford. The author observes that CAD systems are in the forefront to lead in augmenting knowledge formation in the discipline.

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