The Computer as a Tectonic Design Tool: Comparisons between Virtual and Actual Construction

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Abstract. The potential of the computer as a tectonic design tool is explored in comparison to scaled physical models, drawings and real-scale modelling (actual construction). Analysis of media use is undertaken in a case study of a range of design projects of differing emphases in relation to student perceptions and assessment. Relationships are drawn between representational media actual construction to inform a discussion of effective and authentic means of teaching tectonics within the design studio.

Keywords. Tectonics, 3D CAD, real-scale modelling

Introduction

This paper focuses on the potential of the computer as a tectonic design tool within the context of student’s architectural design processes. Tectonics, eloquently defined by Frampton (1996) as ’the poetics of construction’, is a synergistic composite of art and science and is central to the practice of architecture. Tectonic education provides opportunities for students to develop a repertoire of technical knowledge for application in design processes. It is contended that construction technology, learnt in technical subjects, needs to be reinforced within the design studio in order for higher order learning to be enabled. This occurs within student’s own design processes through the unique problem-based-learning environment of the design studio.

The CUTSD project (Deakin University, Adelaide University and Victoria University of Wellington) addressed the integration of tectonics into design processes, through the self-directed, low risk, computer-driven ‘Games’ and ‘Digital Projects’ (Woodbury, Wyeld et al. 2001; Ham 2002; Ham 2002a). 3D CAD was the principal tectonic design tool employed in this curriculum development project, following successful use in the Construction Primer (Burry 2001) and Form-Making Games (Radford, Woodbury et al. 2001). This paper aims to enhance understandings gained through this project and test the assumption that underpinned the project: that 3D CAD constitutes an effective medium for the teaching (and learning) of tectonics.

The Case Study

The research was conducted within the context of an ethnographic case study of the Deakin University Architecture 2b class of 2002, comprising 89 active participants. Students enrolled in this unit had generally obtained basic skills in drawing, physical modelling and 3D CAD through previous studies, thus generally had some capacity to make decisions on media use based on the appropriateness to the task. Lectures and studio sessions demonstrated the potential of representational media, providing students with ideas for adaptation in their own design processes.

Architecture 2b is based on 4 projects designed to address specific aspects of the founding question for the unit: What is the rela-
tionship between tectonics and architectural design? Projects 1 and 3 (worth 30% each) were largely conceptual in nature, based on the design of a Coastal Discovery Centre (a medium scale commercial building) and a Music Room (a small-scale “masterpiece”) respectively. Project 2 (worth 10%) consisted of the tectonic development of an assembly of individual student’s Project 1, whereas Project 4 required the actual construction selected ‘Music Room’ schemes from Project 3 in teams of 12 people. The scope, scale and complexities of these projects introduced tectonic design on a number of fronts; on a small to medium scale and an individual and collective basis. Assessment was based on resolution of design issues and three dimensional understandings of tectonics based on Vitruvian notions of Firmness, Commodity and Delight.

A rich composite of qualitative and quantitative data gathering methods have been used to address the research question. Three questionnaires based on Likert Scale and text-based responses were delivered to the student cohort immediately after the completion of Projects 2, 3 and 4, followed up by a focus group discussion. ‘Digital Reflective Folios’ (student digital folios with reflective commentary) and project assessment were analysed in relation to media used in development and presentation.

**Media use in Tectonic and Conceptual Design Projects**

Bermudez and King (2000), in researching representational media, have found that digital media are stronger for design development, whereas analogue representations are more suited to the conceptual design phase. They also found that although designers develop and update a media/representation repertoire, they retreat to a comfort zone wherein they actively limit media use under stressful conditions. This research has tentatively confirmed these hypotheses within the context of the case study, however has highlighted the complexity of issues related to media use in the design studio.

Student reflective folios provide a voice for these issues and highlight the rationale behind individual decision making. Often, media were used because of practical issues, not as a result of decisions based on their potential as tectonic and/or design tools. One student’s decision not to use 3D CAD was based on the perception that, ‘the screen was terrible’ in the CAD lab, whereas another student’s ‘Rhino evaluation ran out so it restricted (him) to making a physical model’. Similarly, some students did not use physical models not because they were perceived to produce lesser results, but because large models could not fit into their cars. Thus, issues such as skill, cost, transport and workspace in some cases have a more immediate impact on student’s decision making than the potential of the medium as a tectonic design tool.

3D CAD was used more widely and more effectively in a project requiring tectonic development (Project 2), whereas drawings and physical models were more effective for conceptual design projects (Projects 1 and 3). From the 8 students receiving a High Distinction (>80%) for Project 2, 6 students employed 3D CAD as a sole medium, 1 student used physical models and 1 student used a hybrid of 3D CAD and drawings. In the 13 students in the Pass (50-59%) category, 11 students used drawings as a sole medium, 2 used 3D CAD and 1 student used a hybrid of physical models and 3D CAD. For this project, 3D CAD use in tectonic development provided dividends, whereas drawing use resulted in lower marks.

Typical perceptions brought out by several student’s comments, that that ‘you can fudge a drawing’ and that ‘3D CAD modelling is time consuming’ have led to students of lower abilities using drawings, whereas more able students have
selected 3D CAD as the medium to use in their exploration of tectonics. As another student commented, he ‘used drawings because (he) felt it would be quickest option and didn’t have much time left.’ Hybrid media use for this project was minimal, as students retreated to the comfort zone of familiar media due to the need for quick results.

The relationship between media use and assessment for Projects 1 and 3 was markedly different to Project 2. From the 8 students receiving a High Distinction for Project 3, 2 students used drawings and physical models together, 1 student used drawings and 3D CAD and 3 students used a hybrid of all three media in their presentation. Sole medium use was lower than for Project 2, with 1 student using drawings and 1 student using 3D CAD by itself (see figure 1 centre). From the 17 students in the Pass category, 5 students used a hybrid of drawings and physical models, 5 used drawings and 3D CAD and 4 students used a hybrid of all media. 1 student used drawings as a sole medium and 3 students used only 3D CAD in their presentation.

After a semester of experimentation with different media through three different design projects 3D CAD was considered by 60% of questionnaire respondents (sample size: 41) to be the medium most likely to be used for future tectonic design projects, compared to physical models (26.5%) and drawings (15.2%). This preference for 3D CAD was not translated into preferences for future conceptual design projects, with an even spread of preferences amongst 3D CAD, physical modelling and drawings.

Although 3D CAD was perceived to have produced the best outcome for tectonic design projects it was also perceived to be the most time consuming relative to outcome. Analysis of reflective folios suggests that students of higher design or tectonic abilities also have higher abilities in representational media. This may well explain the concentration of use of 3D CAD by ‘better’ students for Project 2 (see figure 1 left), where students who are more interested in understanding the tectonics of their design select a medium that has the most potential to enhance this self-directed exploration. The same students used hybrid media extensively, where appropriate, in conceptual design projects.

Virtual Construction vs. Actual Construction

Student perceptions of media are dynamic and responsive to evolving skills, experience in projects, assignment requirements, cost, infrastructure and availability of equipment and tools. The introduction of real-scale modelling (actual construction) into Project 4 resulted in a shift of student perceptions. Following the experience of construction of the Music Rooms, student perceptions moved away from 3D CAD as the most...
effective means of developing tectonic understandings.

Student comments highlight the factors of pride, fun and risk inherent in real-scale modelling that are not evident in using representational media. Clearly, the construction of Music Rooms in a team environment within a space of 3 weeks increases the stakes significantly above the projects previously undertaken. The attributes of real-scale modelling (based on ‘full size physical constraints -loads, sizes etc... weights’), in concert with the real risk of failure (described as ‘a daunting task’), the need for finesse and the resultant pride in team achievements leads to more authentic tectonics learning experiences than the ‘low risk’ Games developed through the CUTSD project at Deakin (Challis 2002).

Actual construction enabled students to understand the limitations of the tectonic potential of 3D CAD, stating that ‘computers don’t understand gravity’, enabling connections that ‘wouldn’t work in reality’. Actual construction is limited by the tectonic potential of the artifact under construction and the role of individuals within construction teams. For example, the two highest marked Music Room projects were constructed entirely of fabric (see figure 1 right), thus offering different learning opportunities relative to projects constructed of timber and steel. Given the requirements of the project of sponsorship and a website, some students (predominantly female) found themselves not involved in construction at all, but played very important team roles in sponsorship and the development of websites.

Conclusions

The research concludes that 3D CAD offers valuable opportunities for tectonic design education. 3D CAD was used most successfully in tectonically-driven design projects; however this success did not translate to projects with a conceptual emphasis. Students perceived 3D CAD to offer the most potential as a tectonic design tool until their experience in actual construction highlighted the shortcomings of 3D CAD in terms of physical and tactile capabilities.

Evidence from this case study suggests that high-risk tectonic design projects provide more authentic learning opportunities for students than low-risk Games. Despite the significant potential of actual construction as an authentic means of teaching tectonics, it is limited by serious operational, infrastructure and safety issues. Ultimately, both have their place in the tectonically-driven design studio.

References


