ISSN 2228-9860 eISSN 1906-9642 CODEN: ITJEA8

International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies

http://TuEngr.com

Learning Construction through Model Making and Its Application in Architecture Design Studio

Sujatavani Gunasagaran[1*], M Tamilsalvi Mari[1], Sivaraman Kuppusamy[2], Sucharita Srirangam[1] and Mohamed Rizal Mohamed[1]

[1] School of Architecture, Building and Design, Taylor's University, Selangor, MALAYSIA.
[3] School of Built Environment, University of Reading Malaysia, Johor, MALAYSIA.
**Corresponding Author (Tel: +60-122030241, Email: sujatavani.gunasagaran@taylors.edu.my).*

Paper ID: 12A11G

Volume 12 Issue 11

Received 02 May 2020
Received in revised form 05 August 2021
Accepted 17 August 2021
Available online 24 August 2021

Keywords:
Construction model; Model making; Construction drawing; Architecture education; Design studio; Student project; Construction knowledge.

Abstract

This study aims to discover the study of construction method via architectural model making, as well as the exploration of the potential for using model-making method in the design studio instead of using construction or detail drawings. The study engages a quantitative study utilising a questionnaire of year two undergraduate architecture participants in a private higher education university. Sixty-one complete questionnaires were analysed using the quantitative method of descriptive analysis and content analysis. This study show that by using the mode-making technique, the construction knowledge and learning from the architecture students is increasing but preferred using the drawings to demonstrate for various reasons as tabled. The sample size was obtained from a private higher education institution, and the construct was self-reported. As a result, architectural education may enhance construction teaching and learning while emphasising buildability in studio instruction.

Disciplinary: Architecture, Architectural Education.

Cite This Article:

Gunasagaran, S., Mari, T.S., Kuppusamy, S., Srirangam, S., and Mohamed, M. R. (2021). Learning Construction Through Model Making and Its Application in Architecture Design Studio. *International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies, 12*(11), 12A11G, 1-10. http://TUENGR.COM/V12/12A11G.pdf DOI: 10.14456/ITJEMAST.2021.217

1 Introduction

As the world and architectural education are engulfed by digital technology, 3D modelling and simulation have been experimented with as a design approach in Architecture Design studios. However, some researchers still believe physical model making indicates better learning. Ostwald (2007) mentioned that model making did not receive considerable attention as sketching and drawing and was given minor importance. As noticed by authors and according to Cannaerts (2009),

recently there has been an interest reverting to physical model making in the academic industry and printed media and even exhibition. The architectural physical model type constructed for project 1 and 2 for Building Construction 2 is the structural model (Mill, 2010) and is related to a detailed model used to visualise the relationship between structural systems in space with exact locations of the beam, load transfer, and other technical considerations. A larger-scale can be used to study the detailing of complex connections. While in Building Construction 1, project 1 and 2 is achieved through sketches (Edwards, 2003), construction and detail drawings, and orthographic drawings (Gursoy, 2010) which has sharp-cut, precise and every line has a precise indication with use of known symbols and notation systems. Edwards (2003), in his book, described that sketches of timber doorways and gables at Horyu-Ji Temple (the oldest timber structure in the world), Kyoto, showed the benefit of articulating timber construction for aesthetics in this oldest timber structure in the world.

Learning techniques frequently aid in information acquisition, but deep learning, such as comprehending and showing building and buildability, adds to the complexity of teaching and learning. As a requirement, the accreditation organisation of the architecture programme for Part One (1) in Malaysia expects students to demonstrate clear and logical architectural designs and academic portfolios, as well as the ability to integrate the knowledge of building technology principles, environmental design, and construction methods (LAM, 2016a). Architecture degree programmes in Malaysia last three (3) years and are equal to the Lembaga Arkitek Malaysia (LAM) Part One (1) pre-professional examination issued by the Board of Architects Malaysia (PAM) and the Lembaga Arkitek Malaysia (LAM). LAM Part One (1) is the first level of a two-part board examination, and all architecture students must pass the LAM Part One (1) and Two (2) Examinations before they may register as Graduate Architects with LAM (LAM, 2016b).

This study explores learning architectural structure and method through model making and additional exploration of the preferences of the model-making techniques in architecture design studio compared to using drawings to demonstrate construction knowledge. Research questions for this study are

RQ1 Did the students understand construction knowledge better due to making models compared to drawing?

RQ2 Will the students use the model making to apply construction knowledge in their design studio?

2 Literature Review

Models, as compared to sketches, can aid in the creative process of visualising 3D functions in order to better comprehend complicated visual linkages. Model typically surpasses drawings technique according to Dunn (2007). The information encompassed within a model in terms of construction and structure is deeper as models provide the possibility to realise the design as a whole by portraying relations between different structures and its properties such as size, form, materials, colour, and texture of the design at all in one without any verbal aid. The structural

model helps students to visualise and understand the process and method of construction and enables reflection. Dunn (2007) also points that this cannot be possible for drawings to do similarly, they may mislead the sight and produce a false world. Drawings draw the observer's attention to key features in 2D by controlling the observer's angle or focus of attention (Kvan & Thilakaratne, 2003). Gursoy (2010) said that viewers must be trained to understand drawings and their content (such as standard geometric projections of the plan, section, and elevation), while models do not need specialised training to communicate. Many researchers agree that drawing can influence the designing task of the creative aspects. They mention that constructing a model involves a high cognitive weight, that sketching and getting it done may lessen the subject's cognitive weight by externalising the shape being engaged. According to Voulgarelis and Morkel (2010), the cognitive emphasis of the physical model "enhances communication since the model not only talks, but it is an accessible graphic form and verbally for both student and educator." Ji and Bell (2000) believed structural concepts and principles could be made more observable and touchable, and students would have better understanding and attentiveness. Construction model-making supports problem solving, justification, discovery, and collaborative learning among peers.

According to Biggs and Tang (2007), the constructivist theory is developed, by the knowledge that occurs during the construction of activities. This is identical to doing on learning. To learn construction, both drawing or model-making methods will enhance cognitive thinking, but model making enables students to visualise spatially and the connections between the details of the constructions. Making models in a constructivist learning setting (Holmes & Mullen, 2013) allows students to build their own meaning in acquiring knowledge rather than memorising the information from other relevant sources such as the lecture notes. The students learning and lecturers strive to teach in both ways represent the surface and deep learning (Biggs & Tang, 2011). Surface learning is focused on memorising information and learning by rote, but deep learning is concerned with comprehending the concept, the logic behind it, and recognising how it links to previous knowledge. For architecture students to demonstrate the application of construction knowledge in design, deep learning is essential.

A study explored that if deep learning occurred as a result of a model-making between the drawing and model, it will increase learning achievement. Beagon and Holmes (2014) found that students more emphasis on 3D models than 2D drawing and students feel confident that they could recreate the detail. Demirbaş and Demirkan (2003) the curriculum in architectural design education should be organised to promote and improve student learning. Therefore, the architecture programme must provide courses to integrate design knowledge, technical knowledge, and artistic knowledge to strengthen architectural expression. Thus, this study aims to explore the preference of the students to use model making to enhance buildability in their design. Building Construction modules (BC1 and BC2) are taught in Semesters 2 and 3 of this private higher architecture undergraduate programme. Students in BC 1 are required to sketch details drawing and

orthographic details to demonstrate their comprehension of construction knowingness in two projects. Project 1 needs students to document a site visit that exposes students to various construction principles, elements, construction activities series, detailing the information, the joints, and construction material through real-life projects. It also creates an opportunity to study the relationship between site and construction method. The A3 report compilation of visuals and manual drawings are done in a group (refer to figure 1). In project 2, students show their knowledge of construction detail and specification of a simple building through drawings. This project is designed to apply knowledge of construction detail and specification in a small-scale building design. The construction and detail drawings are compiled on A2-sized paper.

Figure 1: Learning outcome of Project 1 of Building Construction 1.

In BC 2, the first project requires students to design and build a small bus shelter using skeletal construction considering material usage. The shelter must be strong enough, and students will document their grasp of loads, forces, and joints in the skeleton construction. 1:5 is the model scale and the project 2 will be based on the construction lectures. This also will involve the selected case study that is relevant to the project. Students will be required to dissect a model of their choice and analyse the construction methods used in the building. The students' model making should consider the building's structural and construction system and the model scale within the range 1:1000 until 1: 150. Additionally, the detailed model of the 1:5 scale may be selected by the student in order to add more information about the building's structure.

Figure 2: Model of a timber bus stop designed in a group, Project#1 of Building Construction 2 (left) and Tensile Structure Model of ASU Skysong, Arizona, USA, built in a group, Project#2 of Building construction 2. (right)

3 Method

A quantitative study was employed to evaluate the learning process through model making and to further investigate the students' preferences of the model making approach in architecture design studios. Survey research, according to Creswell (2014), describes "trends, attitudes, or views of a population by analysing a sample of that group" (p. 155). The survey is divided into two sections: Section A is about the students' background, and Section B is about the students' preferred learning method and application technique in the architecture design studio.

Table 1: Sample Profile

Characteristics	N	Valid Percentage (%)
Gender		
M	36	59.0
F	25	41.0
Total	*61*	*100.0*
Prior Education		
Foundation	1	1.6
STPM	18	29.5
A - Level	32	52.5
Others	10	16.4
Total	***61***	***100.0***
Ethnicity		
Chinese	41	67.2
Malay	11	18.0
Indian	2	3.3
Others	7	11.5
Total	***61***	***100.0***
Current Semester		
Sem 3	58	95.1
Sem 4	3	4.9
Total	***61***	***100.0***

The components employed a five-point Likert scale (one strongly disagree to five strongly agree) and open-ended questions. The survey was given to second-year undergraduate architecture students at a private higher education school who had completed Building Construction 1 and 2 courses. The quantitative approach of descriptive analysis was used to analyse completed questionnaires. The response rate of 78% is satisfactory (Arber 2001). The sample profile of the responders is shown in Table 1.

4 Result and Discussion

Descriptive analysis and content analysis were conducted to examine the experiences and knowledge gained in construction through model making by architecture students. Content analysis was used to explore the application of the two learning methods, model making or drawings, in Architecture Design Studio. Content Analysis was used to analyse the texts (Popping, 2015) created by the students. Some have more than one answer, and some have none. All occurrence of words (Ryan & Bernard, 2000) was captured for the analysis and code. A few ambiguous answers were discarded. Emerging thematic categories were presented in tables as reasons for choosing the learning method for construction and the application method of construction knowledge in the design studio. Table 2 shows the result for the question, "Do you prefer learning construction through model making or drawing?"

Table 2 showed that most of the students chose model making to learn construction (73.8%) as their preferred method to learn construction, while students choosing drawing were 23%. Very small percentage chose both the method (3.3%). Students who chose both drawing and model-making methods described their reason as both methods will allow them to analyse and understand design and construction in two dimensions (2D) and three dimensions (3D).

Table 2: Student's Preference to Learn Construction

Learning Method	Number	Percentage (%)
Model Making	45	73.8
Drawing	14	23.0
Both	2	3.3
Total	*61*	*100*

Thirteen categories emerged from the reasons described by the student for an open-ended question "Why did you choose the reason above?" These 13 categories are grouped into two themes; "Study Environment" and "Understanding Construction" Students explained reasons for choosing model making to learn construction because the study method creates a conducive study environment (54.4%) than creating a better understanding of construction (45.6%). In Table 3, explaining the theme "Study Environment", students find that hands-on or interactive manner is the best reason to learn construction (15.8%) and that it mimics constructing the real-life project (12.3%). 10.5% of the students reasoned that visualising helps them understand construction and that model enables them to touch and feel as it is tangible, involves the sensory to understand construction and details. Only 7% of the students described three dimensions (3D) of a model as

the reason, and 7% found model making fun. Only 1.8% of the students found model-making challenging. These concur with Beagon and Holmes's (2014) finding. The authors acknowledge the fact that learning should be fun, and it encourages retaining knowledge. Construction is not an easy subject that can be learnt through lectures and reading books for undergraduate architecture students.

Table 3: Content Analysis of Student's Reasons for Choosing Model Making to Learn Construction

Learning method - Model making	Number	Percentage (%)
Study Environment	*31*	*54.4*
hands on/interactive	9	15.8
realistic	7	12.3
visualise / tangible / feel / 5 senses	6	10.5
3d	4	7.0
fun	4	7.0
challenging	1	1.8
Understanding construction	*26*	*45.6*
understand joints and details better by visualising	10	17.5
deep understanding	4	7.0
understand design and structure	3	5.3
construction process	3	5.3
construction method	2	3.5
identify problem	2	3.5
test buildability	2	3.5
Total	*57*	*100*

Students that reasoned under the theme "Understanding Construction" described better understanding of joints and details (17.5), deep understanding (7%), and understanding design and structure (5.3%). Some students highlighted that model making made them understand the construction process (5.3%) and method (3.5%). While a few students described the identifying problem (3.5%) and testing buildability (3.5%) as the reasons. Holmes & Mullen (2013) believed that the model allows students to construct their own meaning in acquiring structural knowledge rather than memorising information from drawings or lecture notes. These stimulate deep learning (Biggs & Tang, 2007). Two students stated that they preferred authentic learning in construction, describing the reason for choosing model making as "Drawing does not give enough depth and mostly just feel like copying the drawing" and "Model-making requires you to be more hands-on whereas drawing can just be copying".

Table 4: Content Analysis of student's Reasons for Choosing Drawing to Learn construction

Learning method - Drawing	Number	Percentage (%)
Study Environment	*7*	*46.7*
fast	7	46.7
Understanding construction	*8*	*53.3*
understand better	4	26.6
can learn more detail	1	6.7
enhance basic skill	1	6.7
show dimension and material	1	6.7
memorise	1	6.7
Total	*15*	*100*

In Table 4, almost half of the students who chose drawing as the learning method to learn construction suggested the reason for their choice as a fast method (46.7%), which they can sketch or draw quicker than making a model. In addition, students 26.6% understand construction better by drawing, as described by Edwards (2003). Each of the reasons had 6.7% of respondents for "can learn more detail", "enhance basic skill", "show dimension and material", and "memorise".

According to Table 5, despite 73.8% of students favoured model making for learning construction, only 45.9% would want to apply this method in their design studio. Almost 40% preferred to use drawing to demonstrate their construction knowledge, and 13.1% would want to use both methods in the architecture design studio. One reason for none was described as, "I would most probably do model making but digitally, as it will be easier to amend things and it gets the job done quicker." About 13% reported they would use both methods as they believe visualising and different perspectives (2D and 3D) as their reasons in assisting them to enhance their design.

Table 5: Student's Preference Method to Apply Construction Knowledge in Design

Application method	Number	Percentage (%)
Model making	28	45.9
Drawing	24	39.3
Both	8	13.1
None	1	1.6
Total	*61*	*100*

The categories that emerged in Table 6 for reasons applying construction knowledge in design through model making are also grouped into two themes; "Understanding Construction" and "Study Environment". However, the reason for "Understanding Construction" (73.9%) precedes "Study Environment" (26.1%) in applying construction knowledge through model making in the design studio for the few students who chose the model-making method.

Table 6: Content analysis of student's reasons for choosing model making to apply construction knowledge in design

Application Method – Model making	Number	Percentage (%)
Understanding Construction	***17***	***73.9***
understand and analyse the structure	8	34.8
visualize; form, detail, design	8	34.8
identify problem	1	4.3
Study environment	***6***	***26.1***
3D	2	8.7
more interesting	1	4.3
Five senses	1	4.3
hands on	1	4.3
challenging	1	4.3
Total	***23***	***100***

While in Table 7, the categories that emerged for reasons to choose drawing as their application method of construction knowledge are "fulfil the requirement of design brief" (25.9%), followed closely by "easier" (22.2%) and "fast" (14.8%). The total is 63% for "Study Environment". While the "Understanding Construction" theme has only two categories; more detailed (25.9%) and "need to improve drawing technique" (11.1%), and the total is 37%.

Table 7: Content analysis of students' reasons for choosing drawing to apply construction knowledge in design

Application method - Drawing	Number	Percentage (%)
Study environment	*17*	*63.0*
fulfill requirement	7	25.9
easier	6	22.2
fast	4	14.8
Understanding Construction	*10*	*37.0*
more detailed	7	25.9
need to improve	3	11.1
Total	*27*	*100*

5 Conclusion

From this study, the answer for RQ1 is that students prefer to learn construction through model making than drawing and confirm that their understanding and knowledge of construction through model making is deepened. For RQ2, students prefer to use the drawing method to demonstrate the construction knowledge in the design studio largely to fulfil the requirement of the design project brief and because it is an easy and fast method. Model making seems to be an underutilised pedagogical learning tool (Ji & Bell, 2000; Voulgarelis & Morkel, 2010;) and can enhance construction knowledge for the undergraduate architectural programme. Therefore, it is proposed that this method is continuously used as a learning method for construction and suggested to be included in the architecture studio design project brief if it is seen as beneficial for students to understand the buildability of their design.

According to this study, the idea of model-making aids the learning in construction and as stated by Forsythe (2009), the model-making provides visual-spatial learning, thus complementing the audio-sequential learning, the traditional lecture-based delivery. The model-making method to learn construction offers a conducive study environment, which is fun, interactive, and tangible. Understanding construction through model making can provide significant understanding into technical construction skills, process, method, and teamwork. Model-making learning method encourages student motivation is strong in terms of concern, learning requirements, self-esteem in outcomes, and pleasure. It is also a good method for learning through collaboration and socialising.

6 Availability of Data and Material

Data can be made available by contacting the corresponding author.

7 References

Arber, S. (2001). Designing samples. In: Gilbert N, ed. Researching social life, 2, 58-82.

Beagon, U., & Holmes, N. (2014). The Role of Model Making as a Constructivist Learning Tool to Enhance Deep Learning in a Building Technology Module. *Irish Journal of Academic Practice*, *3*(1), 11.

Biggs, J.B., & Tang, C.S. (2007). Teaching for quality learning at university. 3rd Ed., Maidenhead: Open University Press.

Biggs, J.B., & Tang, C.S. (2011). Teaching for quality learning at university: what the student does. 4th Ed., Maidenhead: McGraw-Hill/Society for Research into Higher Education/Open University Press.

Cannaerts, C. (2009). Models of/Models for Architecture: Physical and Digital Modelling in Early Design Stages.

Creswell, J. W. (2014). *Research design: qualitative, quantitative, and mixed methods approach.* 4th Ed., Thousand Oaks, California: SAGE Publications.

Demirbaş, O. O., & Demirkan, H. (2003). Focus on the architectural design process through learning styles. *Design Studies, 24*(5), 437-456.

Downton, P. Ostwald, M. Mina, A. and Fairley, A. (eds.). (2007). *Homo Faber - Modelling Architecture*. SIALRMIT, Archadia Press, Sydney.

Dunn, N. (2007). *The ecology of the architectural model*. Peter Lang.

Edwards, B. (2003). *Understanding architecture through drawing*. Taylor & Francis.

Forsythe, P. (2009). The Construction Game - Using Physical Model Making to Simulate Realism in Construction Education. *Journal for Education in the Built Environment*, 4(1), 57-74.

Gursoy, B. (2010). *The cognitive aspects of model-making in architectural design*. MSc Thesis, Turkey: Middle East Technical Unıversity.

Ji, T., & Bell, A. J. (2000). Seeing and touching structural concepts in-class teaching. In *The Proceedings of the Conference on Civil Engineering Education in the 21st Century, 26*, 28-39.

Kvan, T., & Thilakaratne, R. (2003, September). Models in the design conversation: architectural vs engineering. In *International Conference of the Association of Architecture Schools of Australasia, AASA*, 2, 1-11.

Popping, R. (2015). Analysing open-ended questions by means of text analysis procedures. *Bulletin of Sociological Methodology/Bulletin de Méthodologie Sociologique*, 128(1), 23-39.

Voulgarelis, H., & Morkel, J. (2010). The importance of physically built working models in design teaching of undergraduate architectural students. *2ND International Conference on Design Education*, University of New South Wales, Sydney, Australia.

Dr. Sujatavani Gunasagaran is a Senior Lecturer, School of Architecture, Building and Design, Taylor's University. She received a BSc (Architecture) from University of Malaya and an MSc in Building Technology from University Science of Malaysia. She obtained a Doctorate of Education from the University of Selangor. Her research interests involve Sustainability, BIM, Digital Simulation, Building Technology and Design Approaches.

Dr M Tamilsalvi Mari is a Senior Lecturer at Taylor's University. Salvi's research revolves around People, Place/Environment, and Design, particularly focusing on Current Societal and Environmental Issues and Needs for the Complex Decision-making, Design Values of Place and Space (Environmental, Social, and Economy) in Community Housing, High Rise Residential, Educational Facilities and Neighbourhood Business Districts and Design Strategies to Reduce Energy Demand and Carbon Footprint.

Dr Sivaraman Kuppusamy is a Lecturer at the University of Reading, Malaysia. He is a Certified Green Building Index Facilitator and an Active Member in the Association of Project Management (APM-UK). His research interests involve Environmental Architecture, Sustainability in Built Environment, BIM, and Building Technology and Design Approaches.

Dr Sucharita Srirangam is a Senior Lecturer at Taylor's University. She received PhD in Architecture from Edinburgh College of Art, UK and a Master of Architecture from Anna University, India. Her teaching focuses on Architecture and Urban Design Methods and Theories, with projects involving Urban Conditions, Open Spaces, Walkability, and Architectural Design Approaches.

Mohamed Rizal Mohamed is a Lecturer in the School of Architecture, Building and Design. He is a Registered Professional Technologies under the Malaysia Board of Technology (MBOT). He holds a Bachelor's Degree in Construction Management (Honours) and Master of Science in Facilities Management from Universiti Teknologi MARA. He is also CIDB's certified IBS professional trainer. His area of interest are Project Management, Building Conservation, Building Technology, and Industrialised Building System (IBS)

Note: The origin of this article was reviewed, accepted, and presented at the 2nd PAM International Architectural Education Conference (PIAEC 2019) held at the Infrastructure University Kuala Lumpur, Kajang, Malaysia during 1 August 2019.