



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

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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.

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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 knowingsness 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.



5.0 SUPERSTRUCTURE

5.2 SLAB/ FLOOR

INTRODUCTION |
 CONSTRUCTION |
 FINISHES

SURFACE FINISHES HAVE A CRITICAL INFLUENCE ON THE AESTHETIC QUALITIES OF A SPACE. FINISHES FOR FLOOR SHOULD BE DURABLE, COMFORTABLE AND SAFE TO WALK ON.



MERBAU TIMBER STRIPS FOR FLOORING FOUND IN THE SEJATI RESIDENCE SITE



FIGURE 5.2.6 ILLUSTRATES THE METHOD OF LAYING TIMBER STRIP FLOORING. WOOD SLEEPERS AND POLYETHYLENE FILM ARE SANDWICHED IN BETWEEN THE CONCRETE SLAB AND TIMBER PLANKS FOR DAMP-PROOFING PURPOSES.



HOMOGENEOUS TILES BEING USED IN THE CAR PORCH AREA AT THE SEJATI RESIDENCE SITE.



FIGURE 5.2.7 CROSS SECTION OF WOOD STRIP FLOORING

THE DEPTH OF X (MARKED IN ORANGE) IS GREATER THAN DEPTH Y TO ALLOW FOR WEAR AND STANDING. THE TONGUE OF THE WOOD STRIPS DOES NOT FIT PERFECTLY INTO THE GROOVE. A SLIGHT GAP IS LEFT FOR TIMBER EXPANSION.

MERBAU FLOORING IS EXCELLENT IN DURABILITY AND STABILITY, WITH HIGH TERMITE AND WEATHERING RESISTANCE.



FIGURE 5.2.8

MERBAU TIMBER STRIPS ARE MATCHED TO FORM TONGUE-AND-GROOVE JOINTS ALONG SIDES AND ENDS. WOOD FLOORING WILL SHRINK AND SWELL AS ITS MOISTURE CONTENT CHANGES WITH VARIATIONS IN ATMOSPHERIC HUMIDITY.

MOREOVER, THE WOOD FLOORING SHOULD BE STORED IN SITE FOR SEVERAL DAYS TO ALLOW THE FLOORING TO BECOME ACCLIMATED TO PLACE WHERE IT WILL BE INSTALLED.



FIGURE 5.2.9 FLOOR TILES DIAGRAM

CEMENT MORTAR IS USED TO HOLD AND GRIP TILES IN PLACE ON THE SLAB.

TILES ARE LAID ON A THIN COAT OF CEMENT MORTAR AN GAPS BETWEEN TILES ARE LEFT TO GROUT. AFTER GROUTING, THE FLOOR IS LEFT TO CURE FOR A WEEK.



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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
<i>Total</i>	<i>61</i>	<i>100.0</i>
Prior Education		
Foundation	1	1.6
STPM	18	29.5
A - Level	32	52.5
Others	10	16.4
<i>Total</i>	<i>61</i>	<i>100.0</i>
Ethnicity		
Chinese	41	67.2
Malay	11	18.0
Indian	2	3.3
Others	7	11.5
<i>Total</i>	<i>61</i>	<i>100.0</i>
Current Semester		
Sem 3	58	95.1
Sem 4	3	4.9
<i>Total</i>	<i>61</i>	<i>100.0</i>

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
<i>Total</i>	<i>61</i>	<i>100</i>

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 (%)
<i>Study Environment</i>	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
<i>Understanding construction</i>	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
<i>Total</i>	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 (%)
<i>Study Environment</i>	7	46.7
fast	7	46.7
<i>Understanding construction</i>	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
<i>Total</i>	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
<i>Total</i>	<i>61</i>	<i>100</i>

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 (%)
<i>Understanding Construction</i>	<i>17</i>	<i>73.9</i>
understand and analyse the structure	8	34.8
visualize; form, detail, design	8	34.8
identify problem	1	4.3
<i>Study environment</i>	<i>6</i>	<i>26.1</i>
3D	2	8.7
more interesting	1	4.3
Five senses	1	4.3
hands on	1	4.3
challenging	1	4.3
<i>Total</i>	<i>23</i>	<i>100</i>

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 (%)
<i>Study environment</i>	17	63.0
fulfill requirement	7	25.9
easier	6	22.2
fast	4	14.8
<i>Understanding Construction</i>	10	37.0
more detailed	7	25.9
need to improve	3	11.1
<i>Total</i>	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.

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