

# Integration of Structural Knowledge in Design Studio Project: Assessment Study of Curriculum In Architecture Course in University Of Malaya

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## Abstract

Architectural education should advance in parallel with the industrial growth of building technology. Universities as producers of future architects have yet to develop curriculums for building technology to suit the growth of the building industry. This gap between education and industrial growth has been a topic of debate for many researchers who are concerned about architectural pedagogy. Architectural instruction further aggravated the problem whereby in most architectural schools worldwide, teaching is divided between the design studio, where the design projects are taught and lecture classes where the technical parts are taught. The latter should be integrated with design studio to enhance design levels. Students face difficulty integrating and applying the structural knowledge gained from structure classes into their design. One explanation for this deficiency is because the current architectural structure subject's content is borrowed from an engineering syllabus. This study will examine the course content, instruction styles and method of teaching structure subjects and will investigate the learning outcomes of design studio through students' performance and perception in integrating structural knowledge in their design projects. Respondents were students from Year 1 to Year 5 doing their Bachelor of Science in Architecture and Bachelor of Architecture degrees in University of Malaya. Semi-structured interviews were conducted with the design studio coordinators and structure lecturers. This study aims to find the ideal course content/method of teaching to facilitate more integration between structure and design studio.

**Keywords:** *architectural education, teaching method, design, structures, integration.*

## Introduction

The architectural courses offered by University of Malaya (UM) namely, Bachelor of Science in Architecture (BSc. Architecture) and Bachelor of Architecture (B. Arch) have been accredited by both the Royal Institute of British Architects (RIBA) and the local Malaysian Board of Architects (LAM) which grant them exemption from the RIBA Parts 1 & 2 and LAM Parts 1 & 2, professional examinations respectively. As such, the curriculum structure of UM's architectural courses are of international standard, comparable with other courses recognised by the RIBA in the United Kingdom and elsewhere.

One of the main principles of architectural education is that design creativity should be harnessed and organized through certain rules and regulations such that creative ideas generated can be realised via sensible structures and

practical methods of construction. Therefore, it is important to understand that structural correctness is essential to every architectural creation, as stated by Vitruvius, the first architect in ancient Rome through his book *De Architectura*; "*Creativity in architecture design and structural solution seems to have a symbiotic relationship; both are inseparable because each has an effect on the function of the other. Architecture should have firmness (structure permanence) commodity (function) and delight (aesthetic)*" (Robinson, 2001:61)

The flexibility and inherent capabilities of modern structural materials should inspire today's architects to invent new forms and provide innovative solutions to design problems. Structure is the functional element that enables a building to stand erect, carry its entire load and transfer it to the ground through its foundation (Sandaker, 2008). Understanding structure is absolutely essential in

the education of an architect. However, the content, methods and teaching tools currently used in UM were developed outside the discipline of architecture and had been borrowed from engineering programmes. This has led to UM students designing projects which leaned heavily on forms with simple structural solutions. Or, alternatively they may not even express any structural integration in their design proposals.

## 1.2 Architectural Pedagogy

Researchers define architectural design as collaboration between art and science. This definition explains the differences between art and science. Architecture has however, been dominated by science and in architectural education the teaching strategies have been determined by architectural pedagogy. Architectural pedagogy is a style or strategy of architectural instruction and some refer to it as the correct use of teaching strategies for architects. (Department of Architecture, King Fahd Univ., 2005)

Professor Ashraf Salama from King Fahd University stated that the architectural discipline has the main effective factor of creating and developing a humane environment. Hence, architectural pedagogy should move towards the new trend of equipping students well to meet the demands of the fast developing construction industry, particularly in the enhancement of design-studio teaching (Salama 1995a). Architectural education should follow this technological advancement accordingly. This opens a hot debate about the intrinsic nature of architectural knowledge as an academic discipline and the problems faced thereof (Salama, 2005).

On the other hand, Polanyi, defines architectural education as comprising explicit knowledge and tacit knowledge. Explicit knowledge means the intellectual knowledge disseminated and obtained primarily in academic studies while tacit knowledge means the knowledge embedded in the process of making architecture that is essential to design, in other words, the learning by doing (Robinson, 2001: 64).

Diagram 1 illustrates further the concepts of architectural knowledge in relation to other disciplines in traditional discipline boundaries. A large part of architectural knowledge is tacit because the method of teaching depends on the studio master. The studio master should be a knowledgeable person and teaches by examples and coaching, which means the students learn from

observation rather than by being told (Robinson 2001, p66).

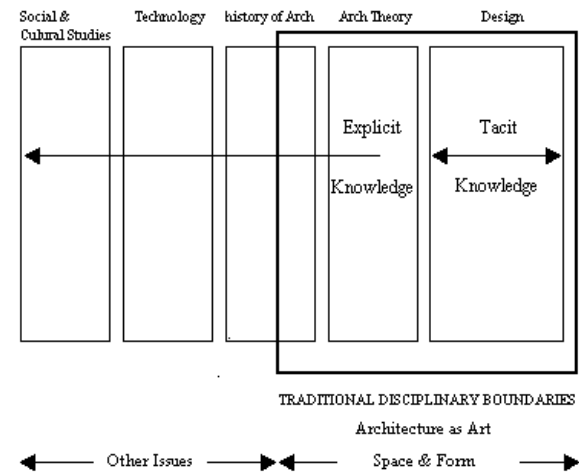


Diagram 1: The traditional discipline boundaries (adapted from Robinson, 2001).

In recent education developments, the syllabus includes a new requirement of architectural practice needs, which increases the complexity of architectural education through the integration of building regulations and codes with history, the arts and theory, urban design, human behaviour, technical aspects, and design methods with ecology and sustainability as the latest requirements.

Consequently, architectural discipline overlaps with almost twenty-one sub-disciplines, as shown in Diagram 2. The premise here is that architecture is complex and there is no single form of knowledge which aptly describes it.

There are a number of international organizations such as the ACSA (Association of Collegiate Schools of Architecture), NAAB (National Architectural Accrediting Board of North America) and UNESCO (United Nations Educational, Scientific and Cultural Organization) which issue charters for architectural education. However, UNESCO (2005) was the only organization which proposed the solution to this educational crisis by putting a standard objective for architectural education so as to designate a boundary for education, as well as made some clarifications toward this discipline in order to find a standard pedagogy.

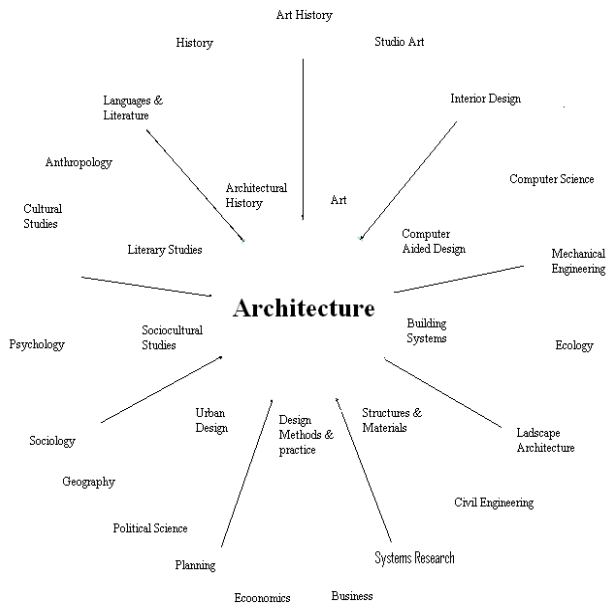


Diagram 2: The relationship of architecture to other disciplines (adapted from Robinson, 2001).

The charter which particularly recommended the technical aspect in architectural education is:

*An ability of the technological application which respects the social, cultural and aesthetic needs, and aware of the appropriate use of structure and construction materials in architecture and their initial and maintenance cost.* (UNESCO, 2005)

Again, in facing the crisis of architectural integration with other subjects, UNESCO emphasizes studio design in the architectural teaching process and divided it into three main parts: design, skill and knowledge; where knowledge should cover cultural and artistic studies, social studies, environmental studies, design studies, professional studies and technical studies. Consequently, technical studies will cover the following:

1. Technical knowledge of structure, materials and construction.
2. Understanding of the process of technical design and the integration of structure, construction technology and services systems into a functional effective whole.
3. Ability to act with innovative technical competence in the use of building techniques and understanding their evolution.
4. Understanding of services system, transportation, communication, safety and maintenance.

5. Technical documentation / design realization /process of construction/ cost/ planning /control. (UNESCO, 2005)

The knowledge defined above managed to control the architectural education process, however, the integration problems remained because of the tension between creative thinking (the artistic side) and technical aspects (the engineering i.e. science and technology side). The problem was further aggravated as architectural instruction in most of the architectural schools around the world is the same. The design studio, being the core of architectural education where the creative side of design projects is taught, is divided from classroom lectures where knowledge of other disciplines is taught.

### The Architectural Education Crisis

Hogue identified the 5 types of studio teaching as:

Type 1: A studio that uses a theory of signification to guide the process of learning design in architectural design studio;

Type 2: A studio that is based on a particular philosophical construction and its translation into a design methodology;

Type 3: A studio that focuses on site specificity and understanding how these notations influence design;

Type 4: A studio which investigates the role of procedures in design;

Type 5: A studio that is predominantly driven by the production of form with respect to material and physical conditions of site, which addresses specific programmatic and technical requirements like construction, structure, circulation, services and authority requirements. (Hogue, 2006)

In UM, Types 1 & 2 studios are taught in Year 1, Types 2 & 3 in Year 2 and a combination of Types 1, 2, 3 4 and 5 in Year 3. The level of complexity of project design also increases with the added year. The integration of all subjects learnt throughout the years of architectural education is expected to happen in Year 3. Unfortunately, this integration of knowledge is not happening as it should, especially the knowledge of structure even though it is repeatedly introduced in every design project since Year 1. As such, the critical question posed is:

### Why are architecture students having difficulty in integrating structure into their design?

According to research collaboration done by the Universities of Buffalo, Utah, Florida, Oregon, and Virginia, the answer is that it is due to three basic problems which are the structures curriculum, the teaching methods and the instructional tools; which are borrowed from engineering courses and this does not satisfy the architecture students' need (Vassigh, 2005). The methodology in teaching structure is subdivided and divides up a structure into extremely small subcomponents using an arcane abstract of symbolic notation. The focus is on quantitative analysis using mathematical formulae and annotations. The lack of integration of structural knowledge in student's design application during the preliminary stages has become one of the major design concerns lest this 'lack of concern attitude' continue when these students later become practicing architect (Ochshorn, 1991). A good architectural designer should be aware that the structural systems affect the aesthetic part of design. Integration of structure should be considered in the preliminary stage of design synthesis because of the influence it will have upon the design.

According to Nervi, architects need a basic qualitative understanding of structural theory in order to design rational buildings, only then, will a structure be born healthy, vital, and possibly beautiful (Salvadori, 1975). It was further concluded that the teaching of a structure course within academic architecture programs faces a fundamental problem in the delivery systems (teaching methods) because the architecture students struggle with a traditional engineering-based approach to structures instruction, which is increasingly unsuitable (Hyett, 2000). Over the last decade, architectural education at tertiary level has been examined extensively with almost universal agreement that the nation's universities are producing graduates who are technically unprepared for the professional practice (UB report -article2005).

University of Buffalo in collaboration with other top universities in USA developed methods of teaching structure to architecture students via a project entitled "Learning Structure Through Advanced Media: A comprehensive Approach to Teaching Structures Using Multimedia" which exposes the structure topics in an innovative instructional delivery system that utilizes high quality digital graphics, animation and audio narration to

demonstrate the structural principles (Donovan, 2005). It is also supported with a structures learning centre website which provides a learning venue composed of terms, concepts and the instructional support relevant to structural analysis and design for architecture students (Refer to figure 1).

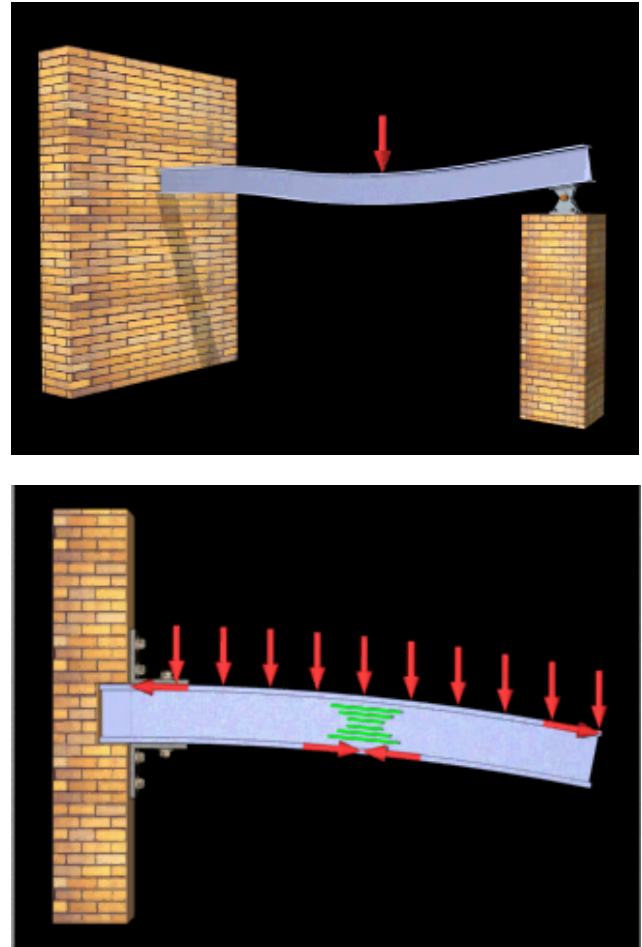


Figure 1: Structural topics in digital graphics, animation and audio narration (Vassigh, 2005).

A project related to teaching called "Technology Initiative" carried out by Professor Kirik Martini from the University of Virginia also explored similar problems (Martini, 1996). The project was intended as a first course in structures for architecture undergraduates and for graduate students with degrees in other disciplines. It sought to develop a student's analytic and critical skills through both mathematical and visual investigation of structure. The project's objective was leaning towards the ability to learn about structure through informed observation and to manipulate structure to enhance

architectural intent, through digital images and online website data and information (Refer to figure 2).

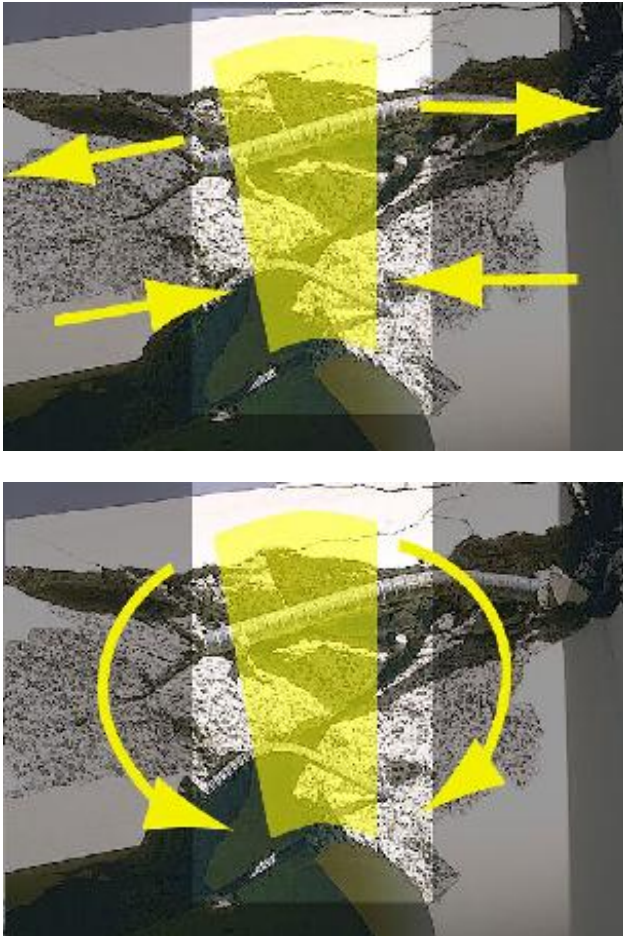


Figure 2: Real life digital images to explain structural behaviour (Martini, 1996).

The world is developing at an increasingly rapid rate, especially in terms of building construction and structural technology. Therefore, the discipline of architecture has an inevitable influence on the creation and development of a humane environment. Thus it is vital for institutions of architecture to be properly equipped with teaching methods that suitably convey the principles and objectives of architectural education recommended by international organizations and assimilated by the students (Ochshorn, 1989). It is important to provide sufficient qualitative knowledge regarding technical aspects which fulfils the students' need. Students would then be able to understand their design in a comprehensive manner which integrates the aesthetic, artistic, humanistic, and scientific aspects with technology holistically.

UM, like many other architectural schools, is facing the same problem of teaching structure. The ability of its students to integrate structure components is not suitably reflected in conceptual design and practice. Most of the structural solutions selected by students for their projects are basic reinforced concrete in-situ post and beam concepts. The external façade design consists of any new trendy featured facade which is borrowed from the latest design magazine, as an added-on feature which is not integrated with the whole building structural design. The structural solution is therefore, complicated, misguided and generally confusing. Many of the structural proposals fail to establish a clear relationship with the total act of architectural design.

The research question posed concerns about the effective architectural structure curriculum content and teaching methods that will lead to a better integration of architectural concepts with structural solutions in students' design application, without major changes to the curriculum and without adding additional burden to the students learning hours. In other words, how to make the subject of structure play a bigger role in the students' designs? This study will serve as a means to find more effective architectural structure curriculum content/teaching methods which can lead to better integration of structural solutions with architectural concepts.

#### 1.4 Methodology

The research focuses on the course objectives and method of teaching structure and the integration in design studio from Year 1 to Year 3 (Cohort 2008-09). The analysis focuses particularly on Year 3 where the integration of various subjects such as structure with design studio is required to be extensive.

A total number of 140 questionnaires were handed to the students and 122 feedbacks were obtained which is 87% of the total response rate. Respondents were asked to provide definite yes or no answers to Part 1 of the questionnaire which asked about the students' awareness of their weakness on the structural understanding and poor integration of structure in their design projects. Part 2 of the questionnaire asked about the students' method of design and studio progress where the integration of technical and creative parts takes place. Part 3 questions asked students to rate the possible solutions to mitigate the weakness in this integration. Ratings are on the scale of 1 to 5 with 1 being the least and 5 the most preferred.

## 1.5 Results and Discussion

Generally, the strength of the architectural programmes lies in the design studios which emphasis on the design, environment, social, cultural, technical and tectonic aspects. UM offers less than 15% of structure related classes such as construction and building analysis in the curriculum. Design studio as the core subject occupies 32% of the curriculum. Measured drawings taught in the first year during the short Semester 1 exposes the student to the real construction world where they are required to observe and translate visual 3D into 2D through working drawing and construction details. This subject indirectly consolidates the students' perspective of structure and construction of single to 3-storey existing heritage buildings. They learn through observation and physical measurement of the building elements.

The current content of structural subjects in UM consists of building loads, frames, cables, tension and compression trusses, deflection methods, timber frames, retaining walls, masonry walls, shearing force and bending moment design of reinforce concrete. These topics are exposed in mathematical formulae. The current structure subjects (methods/contents) fail to establish a clear relationship concerning the total act of architectural design and do not stimulate the students to apply integrated structural solutions in their design other than the simple post and beam methods.

Although, knowledge of structural mathematics is beneficial, the extensiveness of this mathematic knowledge is not required in design studio. The students need to know only simple versions of structure such as the span limits and economics based on design requirements, the structural grid or scheme, and span to depth ratio (Moore 1999). Knowledge of the relationship between the structural system and the building functions is more important to acquire. Students should be able to design structural elements from foundations to roofs, and analyze structural systems including rigid frames themselves.

Structure class is being taught in Semester 2 Year 1, Semester 1 Year 2, and Semester 1 Year 3. The design studio assignments will require the students to consider building structures in all projects. The Year 1 and Year 2 students may not face great difficulty as their design assignments are simple single or double storey structure. The problems emerges at Year 3 when the studio assignment requires buildings with mix-use and multiple

function spaces with a variety of structural loads and spans. Assignments of the structure classes throughout the year do not relate to the projects in studio. It is a stand-alone subject and was not designed to integrate with studio work. The studio design also does not utilise the knowledge gained through lectures from the structure class to help the students visualise their designs in relation to structure applications.

The structure class should focus less on the computational method of structure elements. Issues regarding structural application in design studio should be addressed in structure class rather than to leave it to the studio master to handle in the design studio. Students should be taught to do structural models from their design projects as the structure class assignment aside from just mathematical calculations which do not fully relate to the design project.

A physical model would enable the student to visualise the structural elements clearly rather than in an architectural model which shows more of the space planning and the materials selected. Other problems also arise when the structure subject is taught in a different semester from one where the application is needed. For example, the first structure class is taught during Semester 2 Year 1 where the design studio teaches the basics of architectural design which emphasise more on design concepts. Therefore, it is expected that the student will not able to apply the knowledge learnt from the structure class in their design after a semester break.

In many circumstances students take precedents from elements of Nature to come up with their design concept. Structure class should capitalise on this by analysing the structural concepts of natural elements such as the structure of a bird's wing. Another method of teaching design is learning from case studies. Students like to flip through magazines or search the internet for sophisticated looking buildings without understanding the building systems. Precedent study of the structures of these buildings should also be looked into in the structural class assignments. This will enable students to have a better understanding of the building structural system. Their explorative nature should not be curbed because of their disability to calculate the forces and sizes of structural members. Instead the students should be allowed to give rational ideas on how the supportive members may look like, based on reasoning derived from their design concept. In actual practice the calculations of structural

members will be done by the engineers while the architect proposes the image of the structure. The sizes and

proportion of the structural elements are a compromise between the actual sizes required by the engineer and the

Schedule 1: UM curriculum for studio design and structure course objectives and learning outcome

Design studio		Structure course	
Objective	Learning outcome	Objective of course	Learning outcome
<b>Sem.1, Yr 1: Design studio1</b> 1. Introduce spatial study through space form and light 2. Identify the architectural relationships between design, information and communication 3. Methods of visualising, manipulate space, and form using graphical and physical models.	1. Able to create spatial study through space, form and light. 2. Apply and illustrate methods of visualising and manipulating space and form using graphical and physical models. 3. Analyse and compare the architectural relationships between design, information and communication	<b>No structure class</b>	
<b>Sem.2 , Yr 1, Design Studio2</b> 1. Emphasis on studies in architectural design issues with more contextual studies 2. A hypothetical/real site is chosen as the final project providing a case –study for accumulation of information as establishing design ideas with structural understanding.	1. Identify basic construction methods and site (SWOT) analysis. 2. Initiate a small construction process from concepts to built form and demonstrate ability to work in a team 3. Translate abstract ideas into built form and express personal views on architectural issues	<b>Structure 1</b> 1. To impart basic knowledge principles of structure and constructional process and its importance in built environment.	1. Relate the current application of material for structure and methods of construction 2. Use skills to analyse construction process and establish structural data for building design. 3. Recognise the appropriate design details and construction principles in relation to climatic conditions.
<b>Sem.1, Yr 2, Design Studio 3</b> 1. Introduction to architectural design principles 2. Applying computer graphics as communication tool.	1. Apply the philosophy of architectural design and infuse philosophical idea in the design proposal. 2. Employ basic technical aspects in architectural design.	<b>Structure 11</b> 1. Introduce the building structural system 2. Identify the preliminary structure system selection to facilitate the design of building	1. Identify and describe specific building structural system. 2. Select and specify preliminary structure systems to facilitate the design of a building.
<b>Sem.2, Yr2, Design Studio 4</b> 1. To continue the study on precedents in architectural design with site that has a Historical significant. 2. To understand the design methodology and systematic approach in design conceptual. 3. To understand & develop brief based on the users requirements and needs statement 4. Exploration in various functional aspects of architecture while respecting the man-machine relationship.	1. Express form ,meaning and society 2. Design building of moderate scale. 3. Relate idea and philosophy with construction technology and building services.	<b>No structure class</b>	
<b>Sem.1, Yr3, Design Studio 5</b> 1. To introduce the urban studies and principles 2. To design from macro to micro 3. To expose the student to urban context as a main criteria in design	1. Analyze the urban context of an area of study by applying analytical tools and methods. 2. Schematic design of a multi function and multi-use building of not more than five-story high.	<b>Structure 111</b> 1. Introduce the structural design for concrete steel and timber buildings 2. Identify the structural system for multi storey buildings.	1. Determine the preliminary structure design for concrete, steel and timber buildings 2. Explain the structural system for a multi storey structure.

4. To expose them to local authority's requirements	3. Develop and produce an appropriate architectural solution, studying the building type and precedence, studying the urban context and the site analysis with considerable technical integration. 4. Propose ideas that incorporate sustainable design principle and designing for public spaces.		
<b>Sem.2,Yr3, Design Studio 6</b>  1. To continue the design of a selected project from the previous semester for completion as a comprehensive design project	1. Demonstrate the development of project from schematic stage to comprehensive design scheme. 2. Conclude the conceptual aspects of the design by designing in details the different components in terms of site planning and landscape, structural design, constructional and material design, integrating building systems and services, interior design plus incorporating building by-laws and standards. 3. Develop an architectural solution that incorporates sustainable design ideas.	<b>No structure class</b>	

Source: *UM/Students' Handbook Session 2008/2009*

aesthetics and proportions of the building perceived through the architect's artistic vision.

A survey was done at the end of the second semester 2008/2009 to investigate this problem of integration. Respondents from Year 1 to Year 5 were unable to integrate structure into their design, with third year respondents showing a high percentage of disability even though at this stage they have completed all three structure subject courses. This study focused more on the 3rd year because their design assignment requires a high degree of integration of structure and other components in the final design project of the second semester.

Chart 1 illustrates methods of composing forms where only 9% of the respondents started designing with geometry and integrated the structure together before the functions of the various spaces were considered. The majority of the respondents (33%) started designing with zoning their buildings (arranging types of spaces in relation to building functions and services) and determined the structure simultaneously. Only 22% of the respondents actually integrated structure into their initial design sketches before putting in the spaces which means they already had an image of the building structure before creating the spaces.

Chart 2 shows 62% of respondents are not creative in their structural solutions due to a lack of understanding of

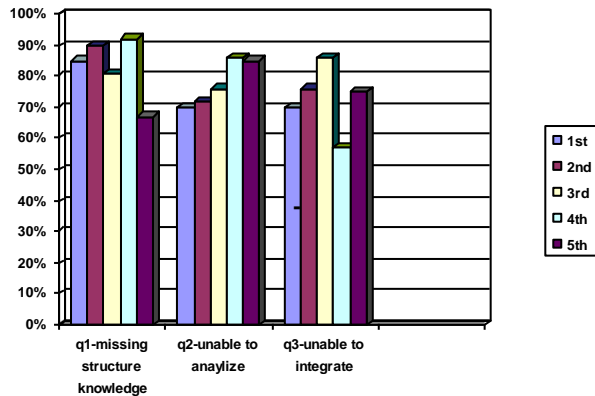
structural application. This response revealed the need to know about structural application rather than mere structural calculations.

Similar to studio teaching, the subject of structures should also be taught by learning, by doing and observation and critical thinking instead of, by listening to and computing the mathematical formulae needed to engage the interest, innovation and confidence of the students.

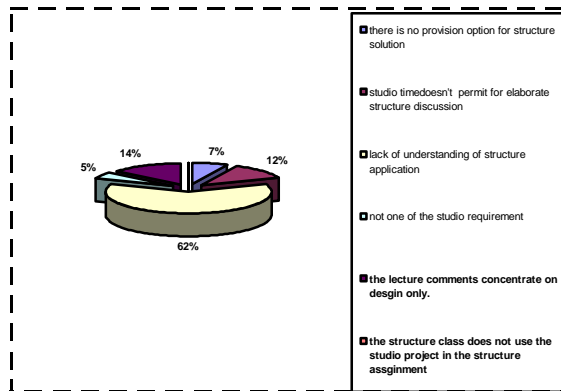
Architecture is very subjective but the way to create architecture is through the reasonableness of decision-making based on fiction (concept and aesthetic), facts (technical knowledge, human behaviour, sociology and psychology) and the ability to make reasonable and acceptable arguments for the decisions made.

When asked where the respondents learnt more about structure integration, 70% answered that it was in construction class. This shows there is integration between the structure and construction class contents and the construction class had managed to capture the students' interest in structure. The construction class method of teaching should also be looked at to see where the similarities and dissimilarities of structure and construction subjects could occur.

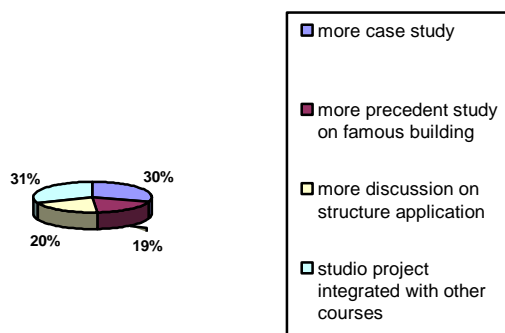




**Chart 1: Respondents' method of composing form**



**Chart 2: Reasons for respondents not being creative**



**Chart 3: Respondent suggestions to modify structure class**

On improvement of the teaching and learning methods, refer to Chart 3, the respondents suggested that studio projects should be integrated with other courses (31%)

and that there should be more case studies on the structure of existing buildings (30%). These responses indirectly suggest how the assignment(s) in Structure Course 3, Semester 1 can be carried out. The first assignment may ask the student to analyse a structure of a selected existing building of similar capacity with the design studio assignment. The analysis may identify the loads of structural elements and selected members sizing based on rules of thumb and some basic calculation formulae. The second assignment should relate to their design project where they might suggest options for their designed building structure and its structural aesthetics rather than the calculation of component members. To raise the level of confidence, the students may need to justify their reasoning behind their selection.

At the end of Semester 1, the 3<sup>rd</sup> year design studio assignment requires students to provide a conceptual design for their comprehensive design project which runs from Semester 1 to Semester 2 (in Semester 1 to provide conceptual design based on urban factors and in Semester 2 to comprehensively upgrade the same project to integrate with the technical aspects). By having the building structure proposed in Semester 1, it will definitely enable the student to integrate the structure early during the preliminary stage, and to identify their mistakes and rectify them in the studio later in Semester 2. The justification for the structure selected was already made during the structure class of Semester 1.

In the earlier structure subjects of Years 1 and 2, the assignments may take the previous design from the studio to analyse the structure components therein. Built physical models of the structural elements will enable students to view their projects based on structures alone. They may be asked to justify the reason for their selection of the structure based on rules of thumb and basic calculations, as part of the assignment. Thus the structure subjects will always be integrated with studio design which will then increase the confidence level and understanding of structure design of the students.

Also, it may be suggested that the students' lack of interest in the subject of structures is due to the traditional method of teaching which may be inappropriate in terms of new advanced structural systems. The architecture students may need to visualise how the structural elements work because architecture students' (in the early learning stage) ability to understand depend mostly on visual and oral communication rather than imagination.

The advancement of computer soft wares has changed the students' approach to learning. Therefore, educators might also need to look at how to raise interest in the subject of structure by using virtual soft wares. If Barbie can change her dress in the Barbie Doll game, maybe designers should also be given the flexibility of choice regarding various options of structure for different types of buildings.

The structure class content emphasizes more on the structural mechanics rather than structural behaviour. Structure systems should be taught as space-defining elements which are integral with design projects where students are required to provide structural solutions for their plans and sections, based on their design.

Structural models for the design especially during the final years should be done in proper scale for testing and re-testing to enable students to understand the relationship between structural patterns and their strengths, deformation and ways to resist it, and the effect of member shaping on overall configuration. The numerical and mathematical formulae should be addressed minimally to clarify the basics of statics. Structure classes should emphasize the structural behaviour rather than mechanics only.

## 1.6 Conclusions

The design studio is the core subject of the architectural education. Therefore, it is highly recommended that the studio assignments be taken and cross-referenced throughout the other technical classes to enhance the students' understanding of a holistic design. By addressing the structure at an early stage of the design, the students' would have a better perception of integrating the structural with architectural design elements and are also able to provide proposals for the building construction system. By creating interest in structure and technology of buildings in the students through analytical games and quizzes; options in structure selection will make the students open up to the varieties of design to select from and encourage them to be more creative. As stated by William J Mitchell (1999), "Architecture is no longer simply the play of masses in light. It now embraces the play of digital information in space", educators may need to look at computer soft wares to bridge the gap. Educators cannot deny the effect computers have on the new generation. However, while the students appear more sophisticated in their approach to learning how to use new

computing devices, the need and desire to understand basic structural design concepts and theories remain virtually unchanged.

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