

A puzzle-based open-ended approach in an architectural design studio

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Abstract

Studies reveal that subjective knowledge and irrational creativity are dominating in architectural design studios recently. Design studios must however facilitate learning about design, learning to design and learning to become an architect. The aim of this research was to study puzzle based open ended approach in an architectural design studio, using a mixed method qualitative and quantitative methods. Puzzles have been used in education to foster diverse thinking skills and self-motivation, they are used as effective instruments in higher education also and findings learnt through puzzle-based learning are applicable to solve problems in reality. The participants consisted of thirty-six students in the sixth semester architecture, who took part in the design task which was introduced as part of 'Architectural Design Studio VI' from January to May 2018. The results of the research proved that the puzzle-based open-ended approach in an architectural design studio improved students' performances.

Keywords: architecture; puzzle-based; open-ended approach

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1. Introduction

Wang (2010) posited that with respect to design pedagogy in general, there is a need for radical changes to occur in design studios. Focusing on architectural design education, studies reveal that subjective knowledge and irrational creativity are dominating in architectural design studios (Koç & Tuztaşı, 2020). This is observed to be one amongst the various other outcomes as teaching methodologies without a holistic knowledge are adopted (Salama, 2016). Critical, creative and pragmatic thinking are the primary criteria in architectural design studios (Ibrahim and Utaberta, 2011). Crowther (2013) reported that design studios must facilitate learning about design, learning to design and learning to become an architect. In addition to traditional one to one studio, introduction of different models with alternate instructors through single, double and collaborative critiques at the desk, outside of studio paves new directions to pedagogy (Gamble, Dagenhar & Jarrett, 2002). Amongst the various directives like transformative design pedagogy (Hadjiyanni, 2008; Fay and Kim, 2017); signature pedagogy (Schulman, 2005; Crowther, 2013); constructivist approach (Kurt, 2011; Güller & Tokuç, 2020); puzzle-based learning (Akin, 2008; Vijayalxmi, 2009; Ramaraj and Nagammal, 2016) which revolve around architectural education, this paper investigates an 'open ended puzzle-based approach' adopted in an architectural design studio.

1.1. *An insight to puzzles*

According to Merriam Webster's dictionary, the term 'puzzle' is used to 'offer or represent a problem difficult to solve with ingenuity'. Its origin of this term dates back to late 1590s. It is either a verb or a noun which is derived from 'pulse'. As a verb, it means 'bewilder, confound'. 'State of being puzzled' is associated with the noun 'puzzle'. It is used to refer to single player games (Kindall et al., 2008). In general, the puzzles are classified as verbal, numerical, graphical, virtual, two and three dimensional. Tiling, sliding and jigsaw puzzles fall under the two-dimensional category, whereas mechanical, construction, interlocking, put together and fold puzzles predominantly are three dimensional.

1.2. *Role of puzzles in education*

Puzzles are fun, engaging and challenging. They are invented to entertain but can also instruct (Slocum, 2001). They serve as vehicles for learning throughout lifetime and as a medium to free the potential of the individuals (Panqueva, 2000). According to Kawash (2012), puzzles can be effectively used to develop problem solving skills in a simple context. Puzzle based learning is used to assist problem-based learning. Studies reveal that puzzles are used to develop skills in domains like mathematics (Tchoshanov, 2011), vocabulary (Davis, Shepherd and Zwiefelhofer, 2009), geometry (Brincková et al. 2007); creativity (Rudiené et al., 2016.); cognition (Gloria et al., 2013) amongst the children. Because of the potentials of the puzzles to foster diverse thinking skills and self-motivation, they are used as effective instruments in higher education also.

Redrafting of puzzles appropriate to science, technology, engineering, and mathematics discipline are to be embedded alongside exercises and problems in traditional teaching (Badger et al., 2012; Levine et al., 2012). It is the representation of hints, goals and rules which assists exploring design more effectively. Michalwicz, Falkner and Sooriamurthy (2011) posited that puzzle-based learning approach encourages diverse ways to frame and solve problems and motivates the young minds; constructs domain specific knowledge, fosters critical thinking. It helps in understanding the problems clearly (Falkner et al., 2010; Hasanov & Akbulaev, 2020). It is reported that the findings learnt through puzzle-based learning are applicable to solve problems in reality (Michalwicz and Michalewicz 2007). Chang (2004) has applied the spirit of puzzles in developing an ongoing design supporting system termed 'design puzzles'.

1.3. *Puzzles in architectural education*

Prashar (2011) stated that the design tasks in basic design studios revolve around 'translation, borrowing and transformation' from different sources like paintings, geometry, dance, nature, materials etc. With an intention to unravel the various elements and principles of architecture, Vijayalaxmi (2012) describes a method to adopt Hejduk's nine squares in a basic design studio. Interpreting the diverse ways through which architects have been inspired with puzzles, Ramaraj and Nagammal (2017) framed 'puzzle based open ended task' in basic design studios. Asasoglu et al. (2010) posited that the 'the success of the experimental approach to teaching basic design have never been investigated'. Therefore, investigating an experimental approach in architectural design studios will be even more demanding.

Architectural designs are 'design puzzles' and there is a lack of formal methods to solve them (Gross & Do 1997; Adebiyi, Sanni & Oyetunji, 2019). Akin (2008) stated that in architectural design, designers need to find the right set of 'frame of references' is mandatory. He draws parallel line between solving the nine-dot puzzle and the architectural design. With this as the background, this study investigated the adopted methodology both qualitatively and quantitatively to construct a deeper understanding of the framed 'puzzle based open ended approach' in an architectural design studio.

2. **Methodology**

According to Creswell (2003), 'mixed methods approach is one which the researcher tends to base knowledge claims on pragmatic grounds. It involves the collection of qualitative and quantitative data either simultaneously or sequentially. The choice of mixed method research revolves around the objective, purpose and context (Venkatesh et al., 2013). It integrates both qualitative and quantitative research techniques, methods, approaches and language into the single study (Johnson and Onwuegbuzie, 2004; Graff, 2016; Heyvaert et al., 2011). One type of data is transformed to the other (Creswell and Clark, 2011). This helps to construct a comprehensive understanding of the phenomenon under study and a richer insight to the framed experiment (Creswell, 2013; Curry et al. 2009; Caruth, 2013). The 'fit of' data integration plays a crucial role for a deeper and holistic understanding of the phenomenon of interest (Fetters et al., 2009; Bryman, 2006). This requires a rational approach which is always a matter of innovation (Fielding, 2012). The crucial issue is that the summative findings of both qualitative and quantitative outcomes yield a richer and deeper understanding of the study which is investigated (Bryman, 2007). Zohrabi, (2013) reported that questionnaire comprising of both open and closed ended questions, interviews and observation are the instruments to be adopted in establishing the validity, reliability and reporting the findings. Capturing the authentically lived experiences of the participants is the primary focus (Johnson and Onwuegbuzie, 2006).

2.1. *The task*

'Design praxis: Modus operandi', an open-ended puzzle-based approach was introduced as part of an architectural design studio at the Department of Architecture, Sathyabama Institute of Science and Technology. It was introduced as a time problem with duration of five weeks for the students pursuing sixth semester during the academic session January to May 2018. Commercial complex and hotel were the identified typologies which were identified based on the curriculum. To give an insight to a different design process and to interpret the essence of a course 'theories of thinking' offered during sixth semester, a puzzle based open ended approach was adopted in the design studio. Three stages were incorporated in the design brief. In the first stage, collective in approach was adopted. From second stage onwards, the task was taken up by the individuals (see Appendix A).

2.2. *Participants*

Thirty-six students (20 boys, average age 19.95 years; 16 girls, average age 19.68 years) pursuing sixth semester architecture took part in the design task which was introduced as part of 'Architectural Design Studio VI' from January to May 2018.

2.3. *Data collection and analysis*

With an objective to gather students' opinions on the framed task, the design process and the emergent outcomes, a questionnaire was framed with open ended and closed ended questions; sequencing of factors which facilitated the design process. The closed ended questions adopted the five-point Likert scales. The framed questions were examined by a senior professor with more than twenty-five years of teaching experience at the Department of Architecture (see Appendix B).

The design process and progress were monitored, discussed, critically reviewed and evaluated by the design faculty during the framed duration. Problem structuring and the progress in design were evaluated in three stages. At the end of the fourth week, skilled assessors with ten years of experience were invited to evaluate the emergent outcomes by individuals. Informal feed backs about the design brief and the outcomes were gathered from the experts.

Cronbach alpha was determined to establish the internal consistency of the framed closed ended questions (Tavakol and Dennick, 2011). Pearson's correlation coefficient was calculated to understand the relationship between the design process and the emergent outcomes (Dorst and Cross, 2001). The responses are mapped graphically using quilt plots (Wand et al., 2014).

3. **Findings and Discussion**

3.1. *Qualitative findings*

The open ended questions like 'What is your approach to your design typology?'; 'List the architectural elements which you incorporated in your design'; 'Write the comments given by the external reviewer for your design?'; 'What did you learn from 'Design praxis: Modus operandi'?'; 'Give your suggestions on the design problem' were framed primarily to understand how the students perceived the design task, approach and the critical comments by the invited skilled assessors. The responses for the framed open-ended questions were consolidated and interpreted to understand the various aspects of the design task from different perspectives collectively.

The responses for the open ended question which addressed the factors which contributed to the enjoyment of 'design praxis' like 'tried new forms and deciphered given plan', 'unraveled the importance of design process', 'evolved massing, elevations and models in the conceptual stage', 'facilitated three dimensioned thinking', 'structural grid was integrated from the initial phase', 'way of decoding the plan was like a game', 'played with levels', 'similar to solving a puzzle', 'looked in design from users' perspectives', 'freedom to play with spaces in floor plan and tried out different massing', 'worked on site plan, massing', 'massing and façade was the focus', 'an insight to integrate services' etc. exhibit the ways through which the students perceived the learning process.

The various approaches revolved around 'integration of design by solving the service core and the structural grid simultaneously', 'evolving structural grid massing & elevations iteratively', 'focus on lighting and ventilation', 'relocation of the spaces in association with massing', 'circulation, fluidity, curved ends,

cantilevered at top floor', 'attractive interiors', 'break out space', 'private and public space', 'interactive space', 'play with levels' etc. .

Different elements which were incorporated in the respective designs were focal points in atriums, French windows, curtain wall, vertical gardening, cladding, bridge, pergolas, projecting members, vertical & horizontal slits , projection of columns & beams to the exteriors which creates a pattern, angular elements, roof gardening, slanting columns, murals etc. to offer a variety of spatial experiences to the users.

'There were too many acute angles which happened to become dead spaces', 'it was a good attempt , try to develop it' , 'it is innovative ;but include more spaces like gazebo', ' more research in terms of columns', 'try to play with volume in the building', 'to change the placement of escalator', ' fluidity in both exterior & interior was good' , ' massing is interesting', 'work in model & section', 'need more understanding of user typology and the scale of respective spaces', 'façade is interesting', 'services need to be worked out', ' the site plan and elevation was good', 'angles need to be worked out in association with massing and the usage of interior spaces' etc (Avcioglu, Çiçek & Başak, 2020).

'Understand massing', 'developing a structural grid with façade as the focus', ' connectivity of spaces ,spatial analysis', '3 dimensional thinking, volume of spaces, service core', 'horizontal & vertical movement', 'hierarchy of spaces', 'solving the spaces considering volume and also structural grid', 'construction techniques', 'to work on elevations and sections', 'placing of service core', 'organization of spaces' etc. describe the knowledge constructed by the young minds.

'Design brief was very well thought', 'unique', 'design problem was very innovative and challenging', 'design problem is new and creative', 'decoding the plans were challenging', 'it was interesting idea was good but there were constraints', 'an insight to consider various parameters like structure, service core, façade simultaneously', 'more time could have been allocated', 'similar to solving a puzzle', were the comments given by the students.

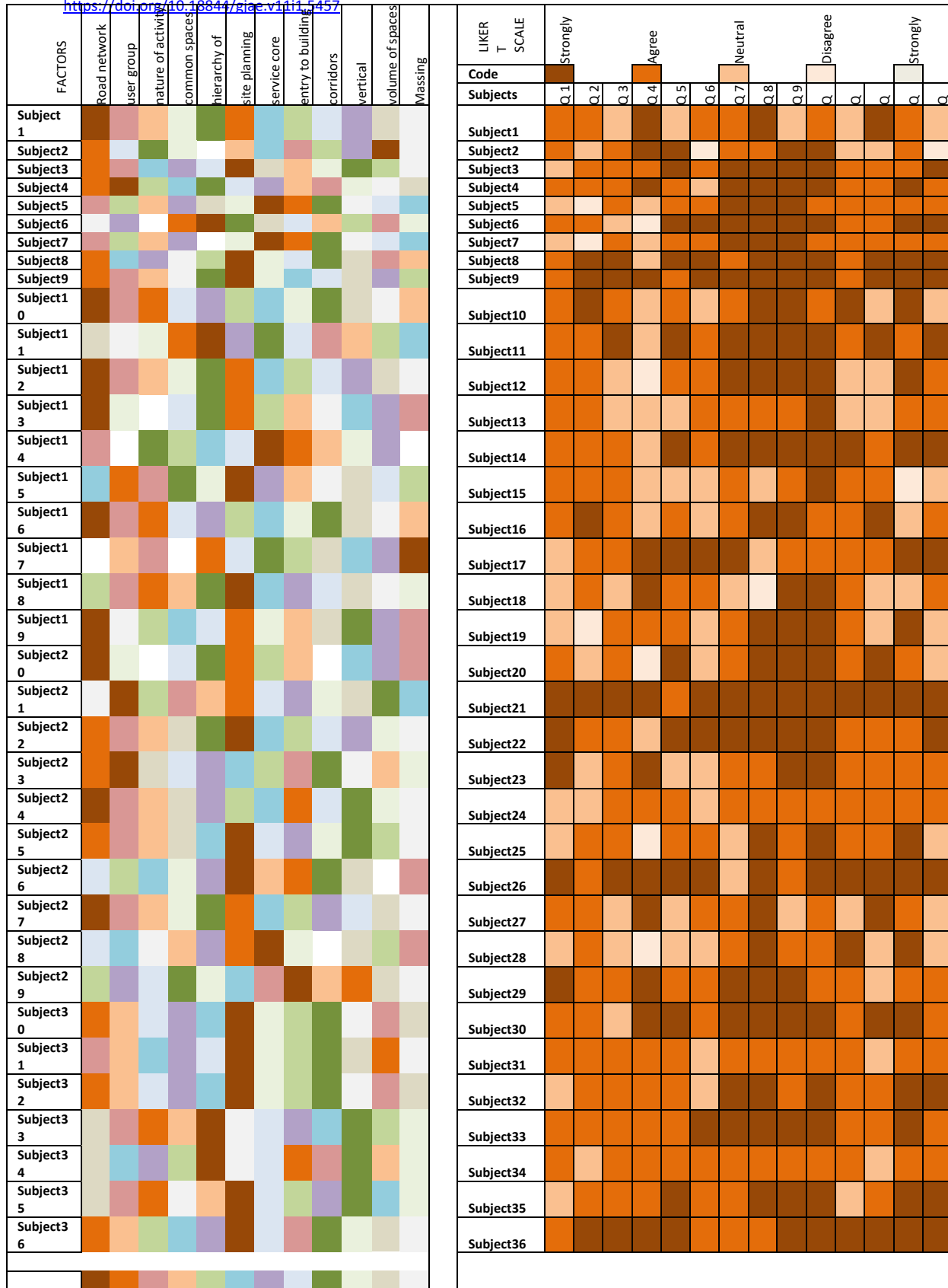
3.2. *Quantitative findings*

Qualitative and quantitative data were collected from the design faculty, skilled assessors and the students for a holistic understanding of the framed phenomenon. The responses to each of the closed ended questions based on Likert scale five-point scale is plotted in the Figure 1b. The percentages for the overall 504 responses falling under strongly agree, agree, neutral, disagree are mapped in figure below. Around seventy percentage of the responses are observed to fall under the 'strongly agree' and 'agree' scales.

3.3 *The emergent outcomes*

The outcomes for both the identified typologies namely the hotel and the commercial complex display the strategies adopted in three dimensioned thinking. The features incorporated in the façade depict that the students unraveled the relationship between the massing and the images in relation with the typology identified.

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(a)

(b)

Figure 1. Quilt plots (a) Sequencing of the 12 factors (b) Responses to closed ended questions



Figure 2. The emergent outcomes

3.3. Calculation

Pearson’s correlation was calculated with the relation between the cumulative marking in the continuous assessment and the final evaluation. The determined value 0.5 shows a moderate relationship. The calculated Cronbach alpha value 0.78 establishes the reliability of the framed questionnaire.

With an intention to explore the responses to the closed ended tasks as well as the way in which the novices have ordered the factors according to each individual’s problem structuring have been mapped in the mosaic plots as mapped in Figure 2. Twelve colours were assigned each of the twelve parameters. The order in which the factors were sequenced by the thirty-six subjects are derives adopting the colors assigned. Following the same principle, five color were assigned to the five-point Likert scales to construct knowledge on how the participants perceived the deign problem.

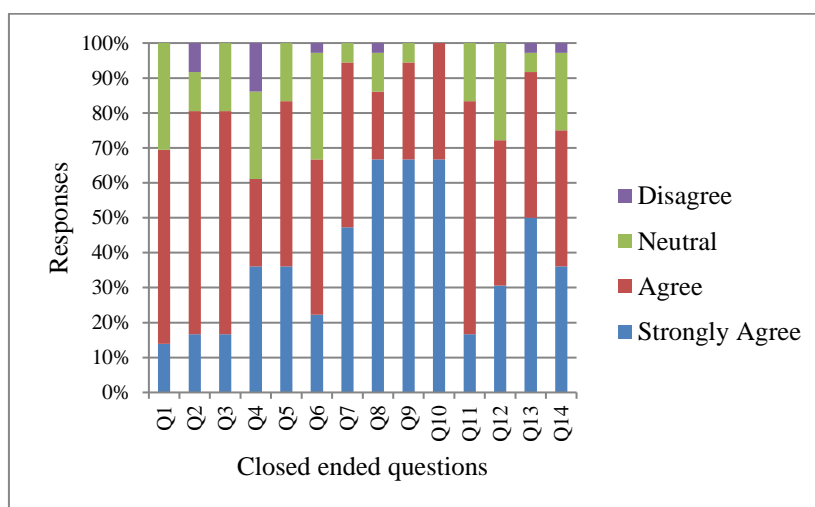


Figure 3. Responses to the closed ended questions expresses in percentage

4. Conclusion

The findings from both the qualitative and quantitative analysis addressing the performance of the students; students’, skilled assessors’ perspectives about the framed design task is explored and are as summated in Table 1. The average score for the sum of the internal and external component is 66.5. Nearly 72% of students secured more than the average value. Nearly 27.28% of students have performed exceptionally well with scores more than 80%. These individuals exhibited clarity in problem structuring. They

predominantly addressed ‘site planning’ as the critical factor followed by the other parameters like ‘road network’, ‘entry into the building’, ‘common spaces’, ‘service scores’, ‘volume of spaces’ etc.

Table 1: The puzzle based open ended approach in an architectural design studio

		Consolidation		Analysis and findings		
Quantitative analysis	Evaluators	Design faculty	Score equal or greater than 70%	Nearly 53% of students scored		
		Invited experts		Nearly 47% of students scored		
		Pearson’s correlation coefficient	the design process and emergent outcomes by internal faculty and invited experts	0.5	Moderate	
	Students	Cronbach alpha	Responses to close ended questions	0.78	Reliable	
		Responses to five-point Likert scale	Strongly agree	36.51%	Nearly 80%	
			Agree	43.26%		
Neutral			17.66%			
Disagree	2.57%					
Students overall performance		Nearly 28% of students secured more than 80%; Nearly 11% of the students secured more than 70% and less than 80%				
Qualitative analysis	open ended questions		Responses	An insight to experimentation, exploration and importance of intrinsic motivation in design		
	Sequencing the 12 factors		Iterative design process	Problem structuring amongst the students who identified ‘site planning’ as the crucial factor had clarity		
	Responses to closed ended questions (1 to 14)		Around 65% of the students opted ‘strongly agree’ for Q8, Q9 and Q10 followed by A13 and Q7	Constructed knowledge	An insight to critical and rational thinking	
			Around 80% of students opted ‘strongly agree’ and ‘agree’ for Q1, Q2, Q3 and Q11		The need for creative and critical thinking	
			All the students opted only ‘strongly agree’ and ‘agree’ for Q10.		Critical, rational and creative thinking is important	
	Design faculty		Students were working with lots of involvement and enjoyed the design process, decoding the architectural drawings were similar to solving a puzzle spatially, however the lack of ‘context’ was a limitation			
Invited experts		Problem formulation	Unique and interesting			
		Most of the students exhibited a clarity in incorporating the structural grid whereas only a few students were able to integrate the services decently				

For the questions seven, eight, nine and ten, the participants have predominantly rated the response ‘strongly agree’. It is observed that for the first three questions, the responses were mostly ‘agreeing’. These responses display that the students constructed knowledge on the need of ideas with three-dimensional thinking in terms of massing, spatial volumes and architectonics.

The 'problem formulation' is observed to be unique, puzzle based, cultivates an insight to the challenges involved in 'collectiveness' from the students' and skilled assessors' perspectives. 'Design praxis' revolves around 'creativity' and 'rationality' pertaining to only the predesigned plans and program. Respect for climate, neighborhood, social and cultural values are not addressed.

This approach has provided an opportunity for design inquiry with adequate scope for the young minds to experiment with outcomes until they get satisfied. The tangible and intangible unraveled and knowledge constructed by the students from the 'Praxis: Modus Operandi' can further be explored and investigated by introducing design problems which require similar design approaches and strategies in the same semester. The typologies can revolve 'apartments', 'serviced apartments', 'schools', 'hostels', 'hotels' in the 'real context'. In addition, puzzle based open ended tasks can also be explored in 'interior design studios', 'tensile structures', 'pavilions', 'portable structures' etc. Irrespective of the domains, there is a need to break the frame of references not only in the problem structuring but also in problem formulation in diverse design studios.

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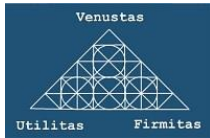
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APPENDIX A

SATHYBAMA INSTITUTE OF SCIENCE AND TECHNOLOGY
Department of Architecture
Design Studio VI (SAR 4062)

Design Project I- PRAXIS: MODUS OPERANDI



“An interplay of Firmitas (Structure), Utilitas (Function) and Venustas (Aesthetics) display architectural quality”

- Vitruvius

Introduction

‘PRAXIS’ is an exercise or practice of an art, science, or skill. It may also to the act of engaging, applying, exercising, realizing or practicing ideas. ‘MODUS OPERANDI’ is a way of doing or accomplishing in a unique or individualistic manner.

The term ‘Design’ is a noun as well as a verb. In general, it is the realization of a concept or idea into a configuration, drawing, model, mould, pattern, plan or specification which aids in achieving the framed objectives. Demkin describes design process as “...**that includes something being drawn / being built as a whole with its mass and its surroundings ...**”.

Architecture is the art or practice of designing and building structures aesthetically, providing a variety of exuberances to the users, visitors and viewers. Knowledge constructed through the design process enhances the critical thinking processes, decision making and problem-solving skills. Architects evolve the conceptual ideas and explore a variety of spaces through ‘drawings’ which are both two and three dimensional. The art of space making involving creativity, rationality loaded with aesthetic sensitivity is challenging. It is in this context, ‘praxis’ and ‘modus operandi’ play a significant role to evolve designs in totality.

Objective: To explore three dimensioned thinking in design through rationally and creatively incorporating structure, service cores, circulation through adopting the strategies and approaches similar to solving open ended puzzles.

Methodology

With an intention to explore the factors involved in the art of space making a shopping complex which is medium rise is identified. Scaled drawings of the identified typologies along with program for each floor level serve as the base for this design. Two stages are sequentially planned, collective tasks and individual design.

During stage I, a group of three to five students are expected to critically interpret and analyze the schematic two-dimensional scaled drawings with respect to the identified program. Inputs on design process will be delivered by experts.

In stage II, the task revolves around the visualization of massing, service core, structure, circulation, aesthetic values and diverse ways to perceive volumes of spaces offering a variety of exuberances specific to the typology. Permutation and combination of spaces creatively and rationally need to be integrated by each individual in order to present the design approach and strategies to the ‘Client’.

Stage I

To read, interpret; explore the possible relationship between spaces horizontally and vertically in the provided scaled drawing collectively in association with the identified programme focusing on structure, service cores

and aesthetics within a span of one week. Knowledge gained through decoding will serve as the base for the next stage, where each individual is expected to explore design uniquely.

Stage II

Each individual need to understand the context, evolve circulation in the site and building; design structural systems and service cores; evolve an architectural language for the building typology with an understanding of materiality. The total floor areas need to be maintained. With respect to massing and layout, twenty percent of variation is permissible. With these design challenges, the emergent outcome needs to be evolved and developed holistically adopting innovative design processes within a period of two weeks.

Stage III

Effective presentation of an Architect's vision through drawings (2D and 3D) Site plan, floor plans, roof plan, façade, structure, services, enlarged sections highlighting the strengths of the design & models. Design processes need to be documented to display the approach and the directions adopted.

Innovations proposed

special lectures on design processes and structures, brain storming sessions, presentation of literature case studies, exhibition of drawings, collective activities will be organized to facilitate both 'creativity and rationality' amongst the young minds.

APPENDIX B

SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY
 (Deemed to be University)
 School of Building and Environment
 Department of Architecture

Instructions: Please put a tick in the box next to the answer of your choice or write in the space provided as the case may be.

Name:		Age:	
Typology: Commercial complex / Hotel		Names of the group members	
What are the factors which helped you in decoding the given plans? (Write the hierarchy of your decoding sequence)			
Road network		Location of the service core	
User group		Entry into the building	
Nature of activity		Corridors	
Common spaces		Vertical transportation	
Hierarchy of spaces		Volume of spaces	
Site planning		Massing	

Design praxis: Modus operandi'		Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Q1	Was it like solving puzzle					
Q2	Did it foster creativity					
Q3	Did it foster critical thinking					
Q4	Was deciphering the plan challenging					
Q5	Were you able to analyze and link the spaces both horizontally and vertically					
Q6	Were you able to identify the architectural elements specific to your typology					
Q7	Did you understand the essence of 3-dimensional thinking					
Q8	Did you understand the basics of structural grid when you did the model					
Q9	Will you develop your design incorporating structure and massing					
Q10	Will you be able to explore this in upcoming design studios?					
Q11	Will you be able to explore this in upcoming design studio?					
Q12	Was the design problem innovative?					
Q13	Is making models collectively learning experience					
Q14	Did you enjoy the design process					

Open ended questions	
What is your approach to your design typology?	
List the architectural elements which you incorporated in your design.	
Write the comments given by the external reviewer for your design?	
What did you learn from 'Design praxis: Modus operandi'?	
Give your suggestions on the design problem.	
Signature with date:	