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SYNERGISTIC MODEL FOR SUSTAINABLE ENVIRONMENTAL DESIGN PEDAGOGY IN ARCHITECTURAL EDUCATION IN INDIA

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This paper presents a Synergistic model for Architectural Design studio to teach environment sustainability in undergraduate architectural curriculum. This model is based on conducting design studio integrating with the theory and other subjects taught in the given semester. Such a model has advantages of assimilating of the knowledge in all subjects, hands-on experience and parametric studies using computer modelling and scientific calculations and development of a critical judgment. This model demonstrates fundamental changes from the conventional to integrated design studio.

Keywords: architectural education, sustainability, curriculum, synergistic approach, architectural design studio.

1. Introduction

The global manifestoes on the Sustainable development have been emphasizing Education as a strong medium to spread the awareness Environment and Sustainable Development, for example WECD (1987, p.43), Agenda 21 UNEP (1992), Resolution 57/254 (UNESCO 2005), the Bonn Declaration (UNESCO 2009), the G8 University Summit (2008), Agenda 19 (UN 2012). India's higher education system is the third largest in the world, after China and the United States. In 2005, the Government of India constituted the National Knowledge Mission (GOI 2009) to prepare a blueprint for reform of knowledge related institutions to meet the challenges of the future. The NKC has recommended that professional education should develop contemporary curricula and encourage research. This paper addresses issue of integrating Environmental Sustainability in Architectural Education in India.

2. Aim and Objectives

The aim of research is to formulate a synergistic model for teaching environmental sustainability in the architectural education at undergraduate level in Indian schools. The objectives of the research are:

- to understand the normative framework of higher education in India
- to understand State-of-the-art of Environmental Sustainability in Architectural curricula
- to review the models of studio teaching for architectural design
- to develop the synergistic model for studio integrating environmental sustainability
- to experiment with class room teaching of the synergistic model for studio teaching
- to validate the synergistic model for studio teaching .

3. Literature Review

An extensive literature review was taken up of the published and unpublished resources such as Elsevier Science (www.sciencedirect.com), Emereld Insight (www.emereldinsight.com), Scopus (www.scopus.com), Springer (www.springerlink.com), Proquest and institutions working on architectural education.

3.1. National Skill Quality Framework (NSQF)

The National Skill Quality Framework of the Government of India was adopted in 2013 as a common reference framework to link qualification systems together and act as a "translation device to make qualifications more readable and understandable across different countries and systems in India" (GOI 2013). The NSQF structures learning in 10 levels spanning the full scale of qualifications; level 7 correspond to undergraduate degree, Table 1.

3.2. State-of-the-art of Environmental Sustainability in Architectural curricula

Globally, teaching practices of design studio is classified in conventional, revolutionary and virtual, Table 2. The EDUCATE project analyzed the-state-of-the-art of environmental sustainability through study of current curricular structures, course syllabi, delivery methods, assessment criteria, etc. of European and non-European countries (Altomonte 2012). The level of integration are: satellite, partially-integrated or fully-integrated structure, Fig. 1. In India, architectural schools adapted the minimum standards of architectural education as laid down by the Council of Architecture, statutory body of the Government of India (COA 2008). The academic architecture is neatly divided into "studios" and "support courses," Fig. 2. Design Studio accounts for about 40 %.

Table 1

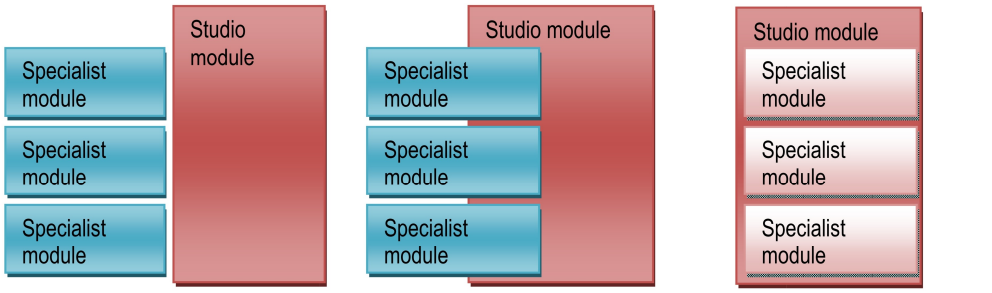
NSQF Level 7 Undergraduate degree is defined in terms of five learning outcomes

Process: requires a command of wide ranging specialized theoretical and practical skill involving variable routine and non-routine context
Professional Knowledge: Wide ranging, factual and theoretical knowledge in broad contexts within a field of work or study
Professional skills: Wide range of cognitive and practical skills required to generate solutions to specific problems in a field of work or study
Core skills: Good logical and mathematical skill understanding of social political and natural environment good in collecting and organizing information, communication and presentation skill
Responsibility: Full responsibility for output of group and development

Table 2

Traditional, revolutionary and virtual models of studio teaching (Salama 1995)

The Models	Authors & Schools	The Teaching Formats
The Conventional model		
Beaux Arts	The Ecole des Beaux Arts, France	Teaching theory in the classroom and design in the ateliers (studios)
Bauhaus	Dessau, Germany	Technological developments after the Industrial Revolution
The Revolutionary models		
The Experiential (Case Problem) Model	*Barttlet School of Architecture, England* Marnot and Symes (1985)	It calls for a productive thinking. Students work in groups, but defining the work of each stage in sections that can be undertaken by the individuals.
The Analogical Model	*University of Cincinnati, USA.* Simons (1978)	It aims at developing the students' capabilities to use analytical data in design, and at enabling them to perceive limitations as well as positive data from the information at hand. The students work individually and in groups.
The Participatory Model	*North California State University, USA.* Sanoff (1978)	It focuses on providing students with direct experience through dealing with clients in structured group discussions, using simulation games. The students work individually and in groups.
The Hidden Curriculum Model	*Miami University, USA.* Dutton(1987)	It focuses on how studio knowledge should reinforce certain ideologies, values and assumptions. Competition is the major motivation in the studio. The students work individually or in groups.
The Pattern Language Model	*University of Oregon, USA.* Davis (1982)	It focuses on group work. Group discussion is a procedure to reach consensus rather than compromise. Developing critical abilities is a major concern, since the student is forced to make judgements above the work of peers.
The Concept Test Model	*Carneige Melton University, USA* Ledewitz (1985)	It focuses on motivating the student, since it is based on the student's perception of a need for knowledge. Students have to understand the difference between external sources of knowledge and their own expectations. Self-evaluation is fundamental where the object is not rationally, but reflective.
The Double Layered Model	*Technion School of Architecture,* Goldschmidt (1983)	It conceives the fact of individual differences, and discourages the ideas of making readymade interpretations. It focuses on the discrimination between instruction and reaction modes, since it relies on group discussions and desk crits.
The Energy Conscious Model	*University of British Columbia, Canada* Cole (1980)	The format is a combination between a design studio and a seminar class. It focuses on the significance of knowledge, how and when it should be introduced. It enhances the students' abilities to translate theory into design. Students work individually.
The Exploratory Model	*University of Minesota, USA.* Robinson and Weeks (1983)	The format is a seminar class. It deals with two types of student abilities, verbal and visual. It allows the student to be involved in an exploration of the problem, while being involved in the design process itself. Students work individually.
The Interactional Model	*University of Colorado, USA.* Gertenter (1988)	The format is a design studio. It focuses on how knowledge can be matched with the ability to assimilate it. Design problems should be assimilated by the students' cognitive schemats and then accommodated within the acquisition of new knowledge.
The Virtual models		
Virtual Design Studio (VDS)	*MIT, The Hong Kong University, ETH Zurich* Salama (2005)	The independent variables in this research are the site-related codification language and the phase in the VDS knowledge dynamics.



Satellite structure
Material is delivered via a lecture series and typically assessed independently of studio (e.g. by examination)

Partillay Integrated structure
Material is delivered via a lecture series and is partially or fully assessed within studio through project work

Fully integrated structure
Material is delivered to meet the demands of studio in terms of both content and timing. Assessment is integral with studio project.

Fig. 1. Visualization of Integration of Sustainable Environmental Design (pale blue) with Studio (pale red)

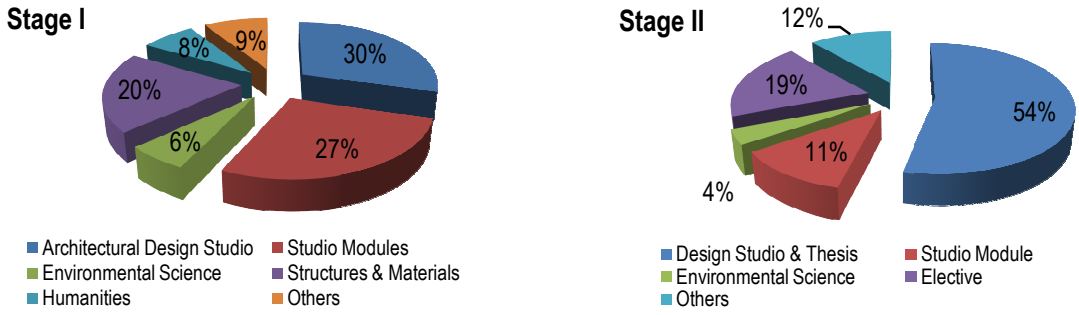


Fig. 2. Architectural Curriculum prescribed by the Council of Architecture Stage I (Initial Three years of B.Arch.) and Stage II (two years of B.Arch.)

The Bachelor of Architecture curriculum at the DCR university of Science and Technology, Murthal is characterized by a satellite structure of delivery, Table 3. In the Stage I of the degree (the first six semesters) the students are introduced the principles and strategies of energy efficient, water efficient, waste management in the modules of building services and landscape design. In the second stage the students can take up electives such as Energy Efficient Design, Sustainable Architecture and Cost effective construction in the eighth and ninth semesters.

4. Synergistic (Integrated) Model for Sustainable Design Teaching

Globally, though there is considerable differences in the system of educating future architects, there is one remarkable similarity—the overriding primacy given to the architectural design studio as the main forum of creative exploration, intellectual engagement, interaction, and assimilation to solve real world problems.

Conventional lecture and seminar formats alone cannot adequately teach the necessary skills to understand the complex association of climate and comfort with technological solutions and architectural expression as necessary for sustainable design. They need to be supplemented with active, experiential learning methods (Truscheit and Otte, 2004/5). The studio format is ideal for this type of active, experiential learning because it inherently incorporates the four basic steps of the experiential learning model cycle as outlined by Svoboda and Whalen (2004/5): act, reflect, reframe, and apply. For application in the studio setting, and as used in this study, these steps were modified slightly and applied as: Context analysis, Concept development; Act; Reflect and Assess; Reframe; and Apply and rework. These steps are then reiterated several times through the design and development phase of the studio, Fig. 3.

This research proposes a Synergistic Model for teaching environmental sustainability in the architectural education at undergraduate level in Indian schools. The model is derived from experiential and project models of studio teachings. Synergistic teaching means integrated curriculum, interdisciplinary teaching and thematic teaching.

> "A process of teaching, whereby all the subjects are related and taught in such a manner that they are almost inseparable. What is learned and applied in one area of the curriculum is related and used to reinforce, provide repetition, and expand the knowledge and skills learned in other curriculum areas."

Table 3

Curriculum structure first to tenth semester B.Arch. at DCRUST, Murthal

	Lecture Modules (Structures, History, Humanities, other)	**Environmental Lecture Modules**	**Studio Modules (Design, Building Construction, Graphics, Drawing, CAD)**
I semester	AR105-G Struct. Design– I (3 Cr) AR111-G History of Arch.-I (2 Cr) AR113-G Arch.Design Theory-I (2 Cr) AR115-G Workshop – I (4 Cr)		AR 101-G Arch. Design (6 Cr) AR103-G Build. Con.& Mat–I (4 Cr) AR107-G Arch. Drawing –I (6 Cr) AR109-G Graphics – I (4 Cr)
II semester	AR106-G Struct. Design – II (3 Cr) AR114-G Arch.Design Theory– II (2 Cr) AR116-G Surveying-II (2 Cr)	AR-110-G Building Services – II (2 Cr) GES101 Environmental Science	AR102-G Arch. Design II (6 Cr) AR104–G Build.Con.& Mat.II(6 Cr) AR108-G Arch.Drawing –II (6 Cr) AR112-G Graphics – II (4 Cr)
III semester	AR205-G Struct.Design–III (2 Cr) AR213-G History of Arch.III (2 Cr) AR 215-G Workshop – III (4 Cr)	AR209-G Building Services –III (2 Cr)	AR 201-G Arch.Design III (6 Cr) AR203-G Build. Con.& Mat.III (6Cr) AR 217-G Arch. Drawing–III (6 Cr) AR 213-G Graphics – III (4 Cr)
IV semester	AR206-G Struct. Design–IV (2 Cr) AR212-G Arch. Design Theory–IV (2 Cr) AR214-G Commun. Skills-IV (2 Cr)	AR210-G Building Services –IV (2 Cr) AR216-G Theory of Landscape Design–IV (3 Cr)	AR202-G Arch.Design IV (6 Cr) AR204-G Build.Con.&Mat.–IV(6 Cr) AR208-G Comp. in Arch.-IV (6 Cr)
V semester	AR305-G Struct.Design– V (3 Cr) AR313-G History of Arch.V (2 Cr) AR315-G Build Byelaw & Off Mgt (2 Cr)		AR301-G Arch.Design-V (12 Cr) AR303-G Build. Con.& Mat.V (6 Cr) AR309-G Comp. in Arch.-V (6 Cr)
VI semester	AR306-G Struct.Design- VI (3 Cr) AR308-G History of Built Envir-VI (2 Cr)		AR302-G Arch.Design VI (12 Cr) AR304-G Build.Con.& Mat.VI (6 Cr) AR310-G Comp. in Arch.-VI (6 Cr) AR314-G Graphics – VI (4 Cr)
VII semester AR402-G Practical Training			
VIII semester	AR406-G Urban Design (4 Cr) AR408-G Interior Design(4 Cr) AR410-G Housing (4 Cr) AR412-G Reg. Planning (4 Cr) AR414-G Conv. B.Hertg (4 Cr) AR418-G Build Maint. (4 Cr) AR416-G Indian Arch. (4 Cr) AR422-G Rural Arch. (4 Cr) AR424-G Adv. Struct.Design (4 Cr)	AR420-G Energy .Cons.Arch.(4 Cr)	AR402-G Arch. Design VIII (12 Cr) AR403-G Build.Con.& Mat.VIII (6 Cr)
IX semester	AR505-G Town Plang. (4 Cr) AR509-G Traffic & Trans(4 Cr) AR511-G Const.Mgmt (4 Cr) AR513-G Multi.Story Build. (4 Cr) AR515-G Low cost build (4 Cr) AR519-G Arch. Journ. (4 Cr) AR 521 Disaster Mgmt (4 Cr)	AR517-G Sust. Arch. (4 Cr) AR507-G Land. Arch. (4 Cr)	AR501-G Arch.Design IX (12 Cr) AR503-G Build. Const.& Mat.–IX (6 Cr)
X semester AR 502-G Thesis Project			

Studio		**Environ.**		**Elective**		**Other**	

The model was evolved and implemented on the fifth semester B.Arch. students (41 numbers) in July-November 2013. These students had already studied first principles of sustainable design in their first four semesters of the programme in theory subject of Building Services (Climatology, water supply, plumbing), environmental science and traditional architecture. While as the fifth semester theory subjects included Architectural History (Industrial revolution and colonial India), Building Byelaws and Office Management, Building Services (Fire fighting and acoustics), Estimating and Costing, Computer application in architecture, Fig. 4.

5. Implementation of Synergistic Model for Sustainable Design Teaching

Design of Jawahar Navodaya Vidyalaya (a fully Residential Senior Secondary School) on a site of 12.5 acres in Farukh Nagar, Gurgaon, India was taken up as the project for the fifth semester B.Arch. Design

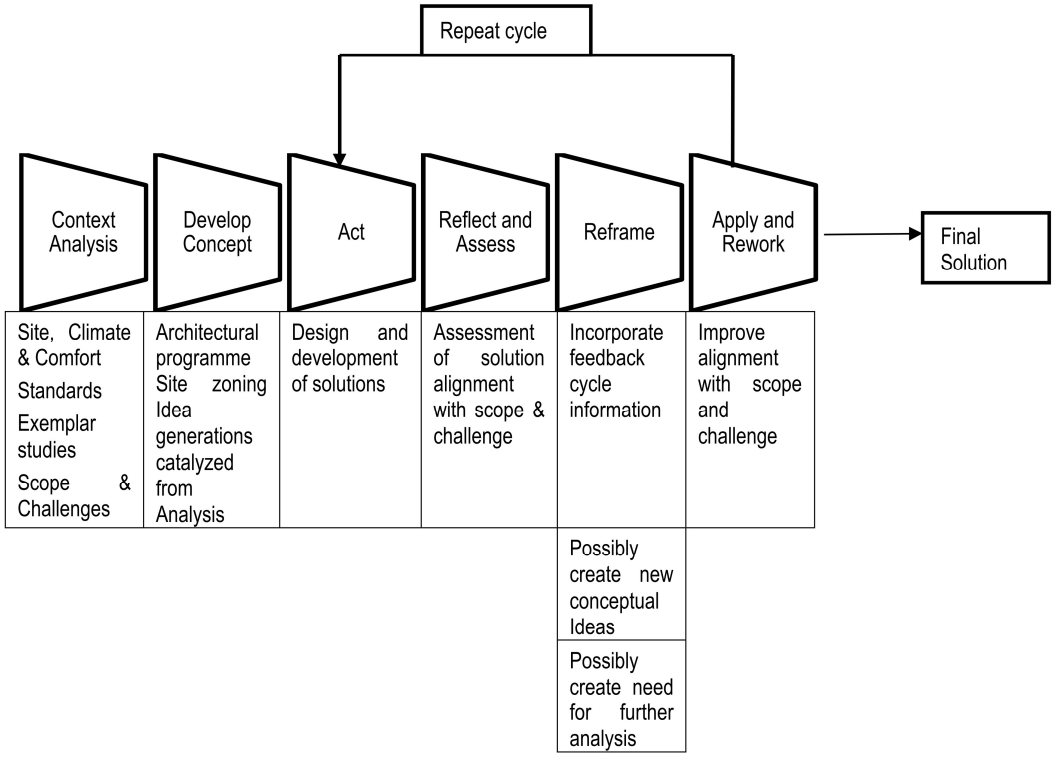


Fig. 3. Steps for studio teaching

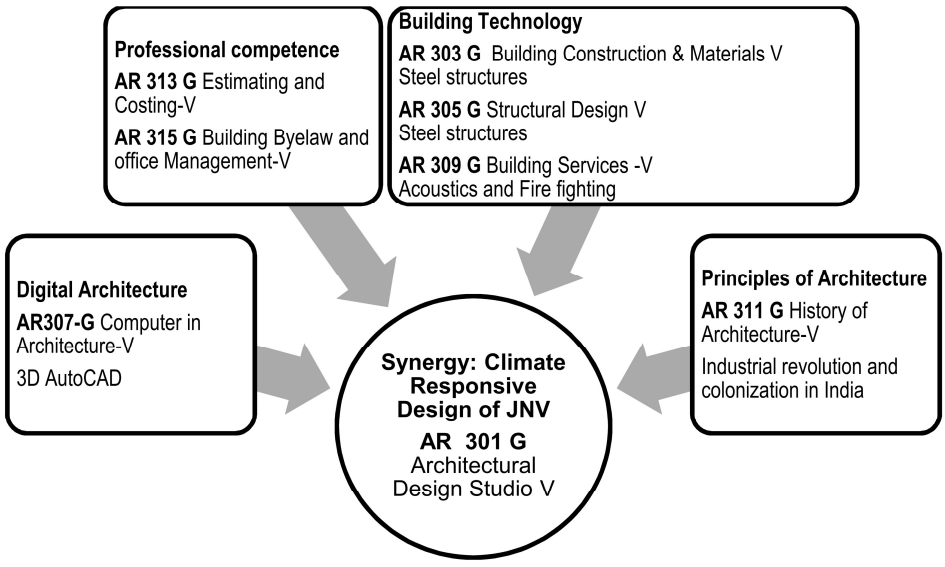


Fig. 4. Integrated studio teaching V semester B.Arch., DCRUST, Murthal

studio. It's a ongoing project of the Ministry of Human Resource Development, Government of India to set up Jawahar Navodaya Vidyalaya (JNV) in every district to provide education to children from every section of society. The architectural programme of the project consists of school building, two dormitories, residential area with set of four housing units 40 sq. m, 50 sq.m, 60 sq. m and 106 sq. m, cafeteria, guest house, multipurpose and sports facilities.

An integrated course plan for twelve weeks was evolved for the fifth semester B.Arch. Architectural Design Studio such that topics learned in the theory and other subjects and the assignments/exercises in theory and other subjects were integrated with the Architectural Design Studio project, Fig. 5. An integrated team of five teachers taught theory subjects as well as were involved architectural design studio.

5.1. Aim and Objectives of the Studio Project

- To understand the principles of environmental sustainable design of Institutional/ Students accommodation projects.
- To make a comparative analysis of examplar buildings in terms of principles of sustainable design.
- To appraise context: site, climate and environment.
- To integrate the knowledge gained in the theoretical subjects in environmental sustainable design of Institutional/Students accommodation projects.
- To apply the relevant Byelaws/Standards/ Codes for design of Institutional/Students' accommodation projects.
- To learn the skills of making the presentation drawings of the designed project on digital mode. To able to learn the skills of making 3D views/walkthrough images etc.

5.2. Knowledge

The Knowledge associated with sustainable environmental design can be categorized under three distinct domains, application and case studies, tools and issues and principles (Altomonte 2012). The studio project was conducted to assimilate knowledge in three domains, Table 4 to 6.

5.3. Teaching and Learning development

As a first step the students study the climate of the region, Fig. 6 and thermal comfort requirement for human with the help of psychrometric chart overlaid with the comfort zone and twelve months ambient conditions. The climate data and sunpath diagram was used to find optimum orientation for the given latitude. The second step was concept development, sustainable site planning creating comfortable microlimate, Fig. 7. Passive and active strategies were integrated by the students in their design, Fig. 8. In order to visual comfort in the learning spaces, study of daylighting was taken up.

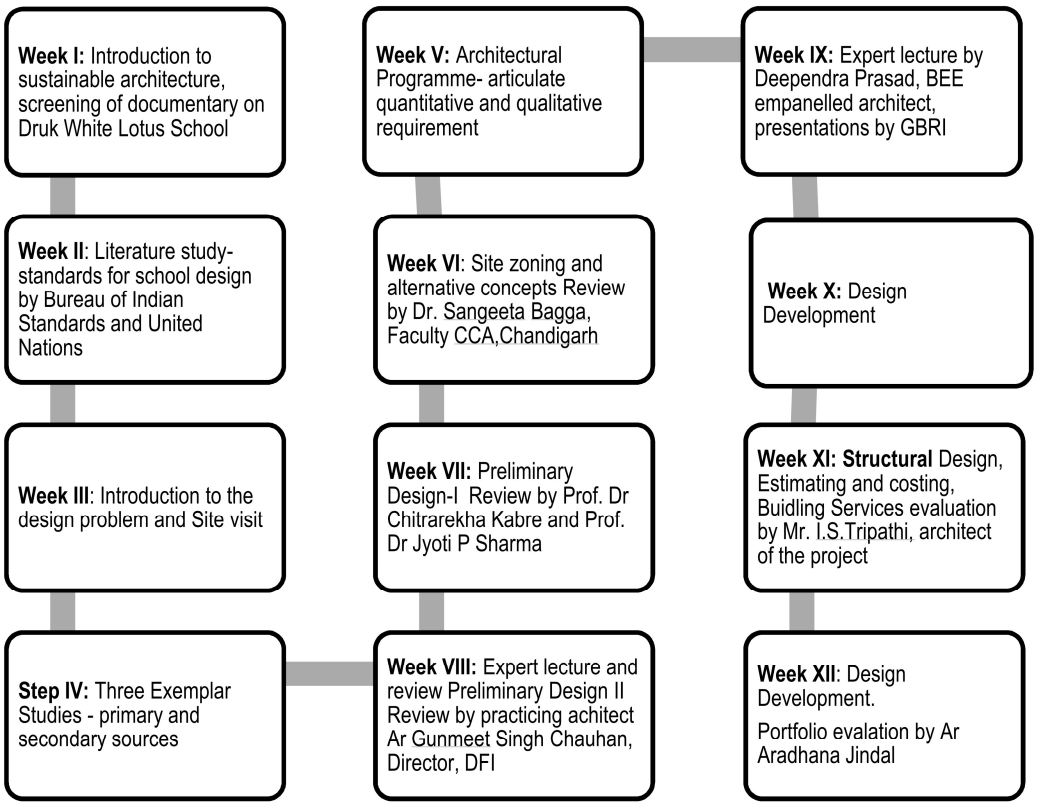


Fig. 5. Weekly activities of design studio

Table 4

Application and case studies

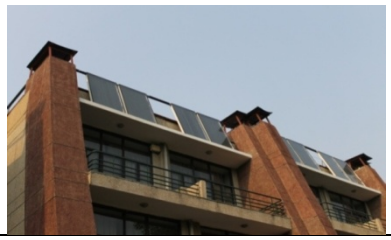
Date	Case Study	Learning outcomes
First day	Druk White Lotus School Architect Norman Foster's documentary	Application of passive design principles
30 July 2013	Jawahar Navodaya Vidyalaya , Mungeshpur , New Delhi	The prototype design by CBRI, Roorkee
05 August 2013	Jawahar Navodaya Vidyalaya, Farrukh Nagar, Gurgaon	The prototype design by CPWD, New Delhi
Secondary sources	The Shri Ram School, Gurgaon (Neeraj Manchanda)	Sustainable Design practices for schools in India
Secondary Sources	The Doon School, Dehradun (Khosla Associates) Modern School , New Delhi (Sachdeva Eggeleston and Associates)	Spatial planning principles of school
12 September 2013	TERI University, Vasant Kunj, New Delhi TERI Retreat, Gual Pahari, Gurgaon 	Principles of passive design, evaporative cooling Earth air tunnel, bio mass for energy
07 October 2013	Motilal Nehru School for Sports, Rai, Sonipat Department of Architecture, Haryana.	Campus planning, passive principles

Table 5

Tools

Date	Resource Person	Teaching objectives	Learning outcomes
24th October 2013	Mr. Rajendra Choudhury, Kalpakrit Sustainable Environments Pvt. Ltd.	Climate, comfort and energy modelling of a classroom using eQuest software	Climate analysis and comfort studies, Fig. 6
12 November 2013	CSIR-Central Building Research Institute, Roorkee	Alternative building technology	Application of appropriate building technology

Table 6

Issues and Principles

Date	Resource person	Teaching Objective	Learning Outcome
12th September 2013	Dr Shalin Singhal TERI University, New Delhi	Creating Leadership for Sustainable Urban Development	Appreciation of role of an architect in developing sustainable built enviornment
01st October 2013	Goonmeet Singh Chauhan Director, Design Forum International, New Delhi	Contextual Design	Principles of architecture to integrate the context in design
15th October 2013	Ms. Ankita Shukla, Director India, Green Building Research Institute, USA	Global overview of green ratings	Basics of Leadership Energy & Environental Design (LEED) and sustainability
8-9 November 2013	Dr. Sangeeta Bagga Chandigarh College of Architecture	Campus Planning	Principles of sustainable campus planning
13th November 2013	Shri Deependra Prashad BEE empanelled architect	Sustainable Design of Schools	Space optimization, efficiency of plan

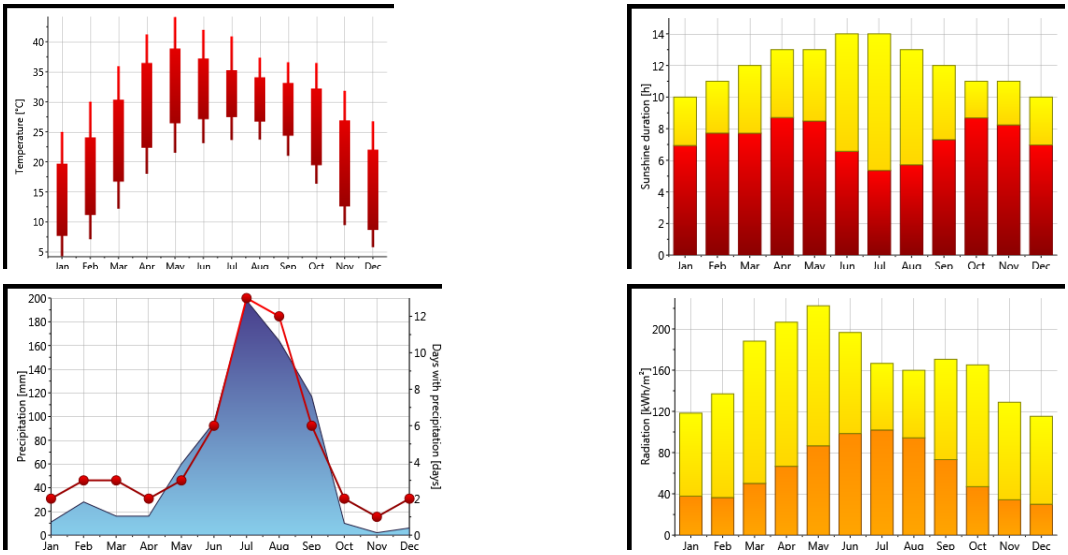


Fig. 6. Climatic analysis of New Delhi
Source: Weather tool

Fig. 7. Sustainable site planning, Tanuj Kalra

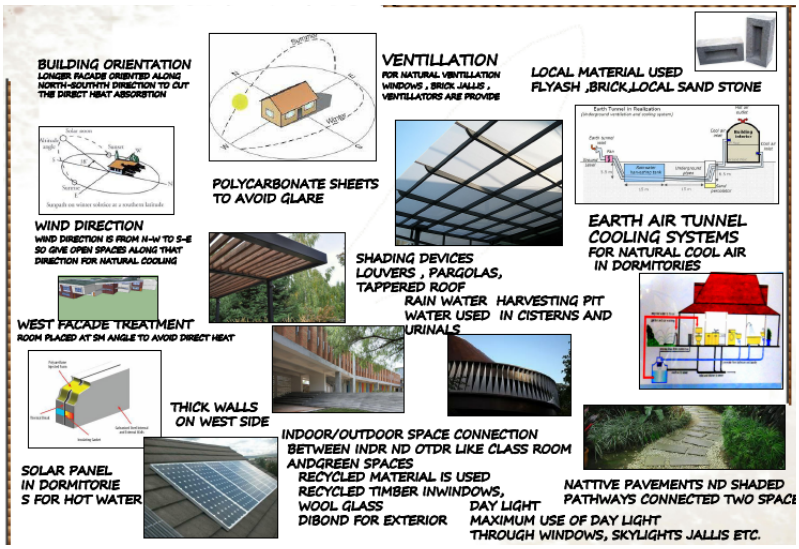


Fig. 8. Passive and Active strategies for energy concious design, Ankita Kundu

5.4. Assessment Criteria

The experts from the academics and profession were invited to review and give critique at various stages of design development to the students, Table 7.

Further the students's performance in Architectural Design Studio was correlated with theory and other subjects showed strong correlation with Building Construction, Building Services, History of Architecture, Building Byelaws and Office management, Table 8. The sturctural design showed weak correlation with architectural design. While as Computer in Architecture and Estimgating and Costing showed moderate correlation with Architectural Design.

6. Critical issues in the teaching of environmentally sustainable Design

This model of integrated environmentally sustainable design education succeeded in helping students to meaningfully integrate climate responsive design thinking into their design. The instructors and reviewers witnessed a profound change over the course of the 12 weeks in the students' abilities, confidence, and skill in framing design questions and then investigating and weighing both poetic and pragmatic environmental design considerations. The instructor hopes that this studio has laid a solid foundation that will positively support the students' ability to address environmental design in their future education and practice.

Lessons for design educators include:

1. Dissolve the Boundaries between theory and other courses and Design: This integrated model of design with other subject studio is but one way to bridge the gap between the theory and other courses and the design studio. Even if it is not possible to make significant curricular changes, find creative ways to integrate the design and theory courses.

2. Promote Integrated and Iterative Design Thinking: The greatest benefit from the design/theory/other integrated course was the growth and change that was evident in the students' ability to frame critical design questions and to address these questions with a high degree of skill and confidence. Iterative and integrative processes were essential in moving design thinking to a deeper level.

3. Prioritize Climate Responsive Design: Composite climate passive strategies for natural ventilation, passive cooling and daylighting, were the foundation of the course. Passive design was considered a primary means to meet energy demand for lighting, cooling. Innovative approaches to building materials, envelope, and renewable energy systems must be integrated with passive design strategies.

4. Explore Qualitative and Quantitative Assessment Methods: The course emphasized the importance of both qualitative and quantitative design tools as means to develop and assess the architectural quality and performance. Other methods of assessment included sketching, diagramming, eQuest studies for parametric studies, Daylight factor analysis

Table 7

Team of experts for assessment

S.No.	Stage of review	Name of Expert and Affiliations	Outcomes
1.	Context analysis	Ar Ravi Vaish, Studio coordinator, DCRUST, Murthal	Project and context familiarization
2.	Concept development	Dr. Sangeeta Bagga Chandigarh College of Architecture	Assessment of alternative concepts
3.	Preliminary Design	Dr. Chitrarekha Kabre Dr. Jyoti P. Sharma Dept. of Architecture, DCRUST, Murthal	Assessment of design with respect to scope and challenges
4.	Revised Preliminary Design	Mr. Goonmeet Singh Chauhan Director, Design Forum International, New Delhi	Assessment of design with respect to scope and challenges
5.	Detailed Design	Mr. Indu Shekhar Tripathi Practising Architect, NOIDA	Assessment of design with respect to costing, structural design and building services.
6.	Final Design	Prof. Aradhana Jindal, Principal, School of Architecture, MM University, Ambala City	Assessment of holistic design

Table 8

Correlation of the Architectural Design studio with theoretical and other subjects

	Dr Jyoti & Ar Ravi	Er Pankaj	GATE scholar	Ar Ravi	Dr Jyoti	Ar Parveen Kumar	Ar Satpal
Ar Ravi Vaish	B.ARCH-V sem	(Other subjects)					
Arch.Design-V sem	AR303-G (BCM)	AR305-G (St. Design)	AR307-G (Comp in Arch)	AR309-G(Bldg Services)	AR311-G (Hist of Arch)	AR313-G(Est & Cost)	AR315-G(Bldg Byelaws)
	0.543401	0.29643	0.299	0.61605	0.649648	0.315027	0.445681
	Strong positive	weak positive	Moderate positive	Strong positive	Strong positive	Moderate positive	Strong positive
Sig (2 tailed)	0	0.064	0.058	0	0	0.046	0.003

5. Promote Meaningful Collaboration: Collaborative teaching and learning was essential, for no faculty or student can be an expert in all aspects of environmental sustainable design. A team of instructors, visiting critics, and professionals was essential in providing the necessary expertise. Students gained valuable experience collaborating and sharing responsibilities.

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СИНЕРГЕТИЧЕСКАЯ МОДЕЛЬ ПЕДАГОГИКИ ЭКОЛОГИЧЕСКОГО ДИЗАЙНА СРЕДЫ В АРХИТЕКТУРНОМ ОБРАЗОВАНИИ ИНДИИ

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В работе представлена синергетическая модель для архитектурной студии дизайна с целью преподавания устойчивости окружающей среды по учебной программе студентам архитектуры. Данная модель основана на деятельности студии дизайна, интегрирующей с теорией и другими предметами, преподаваемыми в заданном семестре. Такая модель имеет преимущества ассимилирования знаний по всем предметам, практическим навыкам и параметрическим исследованиям с использованием компьютерного моделирования, научных расчетов и выработки критического суждения. Модель демонстрирует фундаментальные изменения студии дизайна от консервативной до интегрированной.

Ключевые слова: архитектурное образование, устойчивость, учебная программа, синергетический подход, архитектурная студия дизайна.

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