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Pedagogic practice for sustainability: A classroom experience for the course sustainable architecture

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Abstract
Sustainability education and awareness is quite relevant for the professions involved in construction industry, as it is responsible for 40% of total carbon emissions responsible for global warming. The GTU integrates sustainable architecture; a 2-credit course during the fifth semester in Bachelor of Architecture curriculum, that focuses on building know-how about sustainable built environment. This article aims to highlight benefits of education for sustainable development (ESD) given by UNESCO as a base of formulating this interdisciplinary course of sustainable architecture during formation years of students. It even sheds a light on vastness of the course that promotes varied pedagogic approaches and describes the effectiveness of key elements of it that relied on critical speculative thinking for the future. The evolution of the pedagogic practice on various provocative thinking exercises, with participatory and reflective processes that culminate with the help of dynamic simulations building analysis.

Keywords: design process, critical design, sustainability, ESD, speculative thinking, education as sustainability

Introduction

Architecture is one of those professions that are responsible to envisage the built environment that should respond to the ecological biodiversity. The construction industries; every actors – architects, engineers, and construction management teams including the clients should show distinguished interest for this cause. Sustainable designs have emerged as a paradigm to strengthen this knowhow in professional platform.

While the construction industry embraces sustainability, it has raised questions about the role of education in terms of value addition and building know-how amongst the present and future generations [1, 2].

The inclusive courses of sustainability that are developed within university curriculum are the examples of these efforts [3]. While they emerge as an UNESCO initiative of envisioning a holistic integrative transformation within the educational sector, this particular course at GTU lays stress on formal orientation toward sustainable architecture paradigm. The vastness of the course is advantageous in terms of selecting varied approaches for deriving pedagogic practices.

This flexibility was explored and evolved to promote the eight competencies defined by UNESCO in 2017 as Education for Sustainable Developments (ESD) [4].

Mentioned below is the course curriculum as provided by the university, for Subject Code: 1055005 – Sustainable Architecture [5].

The flexible trajectory of the course promoted experimentation in the subject transmission as well as gave immense opportunities for transformation of the necessary skill required by an undergraduate student to acknowledge the importance of sustainability paradigm and its relevance to construction industry and architecture precisely.

Focus: Sustainability & Energy efficiency techniques for buildings in various climates.

Content

- Introduction to various rating systems for energy efficiency.
- Introduction to various energy stimulation software.
- Site planning aspects in order to achieve sustainable design.
- Application of building materials for energy efficient and green design.
- Case studies & examples of various local, National & Global projects of sustainable Architecture.

This course is a two credit subject with two hours per week dedicated for the studio and lecture based deliverables. As ESD became the base for conducting the course; it had to rely on inclusion of diverse topics highlighting the role of sustainability in built environment and its application in the construction industry.

2. Materials and Methods

Introduction through lectures to the principles of sustainability in architecture – green buildings, eco-friendly buildings, net zero energy buildings, zero emission buildings, bioclimatic, active and passive designs etc.[6, 7] These lectures substantiated with case studies of the sate-of-the-art buildings and technologies, providing necessary knowledge and strategies that the students can use in their design projects. To make the course a transformative learning experience on the contrary to transmissive learning experience,[8] the lectures acted as a knowledge transmission mode while the studios as reflexive exercises.

Strategically planned design process that relied on diverse topics of sustainability like, environmental balance, energy efficiency, resource consumption, built form and its impact on building performance along with the parameters of climate were made available with the help of lecture series. These took care of the competences building in terms of

transforming the learning experience with the objective of reflective and critical thinking for both global and local scenarios. While the ESD competencies framework was the base for addressing varied issues of sustainability within the course, it even employed the three-dimensional differentiation of environmental program as suggested by Vincent and Focht (2009) [9] The corresponding analogous nature of these two frameworks enabled to foresee the merger of these and acted as a primary methodology for lecture delivery and guidance. The criteria mentioned below underpinned the placement of varied aspects in the course.

1. Orientation to curriculum – through the lecture series for sustainability in construction industry
2. Curriculum breadth vs. depth – selection of different aspects based on personal awareness and self-motivation.
3. Fixed vs. flexible-flexibility with regards to topic exploration

These criteria's were distributed within the 16 weeks design studio had two separate focus areas: competency building and design project manifestation [2].
Further a structured questionnaire to quantify the effectiveness of the course and the didactics followed in the course was carried out with a help of a participator survey; with the students who attended this course.

2.1 Competency building

There have been number of discourses which agree that citizens need to constructively and responsibly engage for incorporation of sustainability. This is dependent on key competencies that include cognitive, affective, volitional and self-motivational attributes of an individual.[3]

> "Competencies describe the specific attributes individuals need for action and self-organization in various complex contexts and situations." [3]- (UNESCO, 2015)

The multidisciplinarity of sustainability requires orientation towards the emergence of this paradigm, which were delivered as lectures and documentaries that differentiated the liberal arts vs. professional training reliance. The iterative design development discussions relied on the varied domains of complex systems that are deeply embedded in sustainable architecture. The objective here was to provoke the imaginative minds to anticipate the future and apply the precautionary measures to overcome the anticipated issues while designing built environment. [4, 10, 11] To integrate ESD competencies as a base for this course, it implemented inclusive critical thinking techniques, and it was observed that this framework has got numerous layers that are juxtaposed with each other and are not sequential but cyclic in nature. Figure 1 below shows the cyclic system boundaries followed in the course; which has number of repetition of diverse opportunities in architectural design.

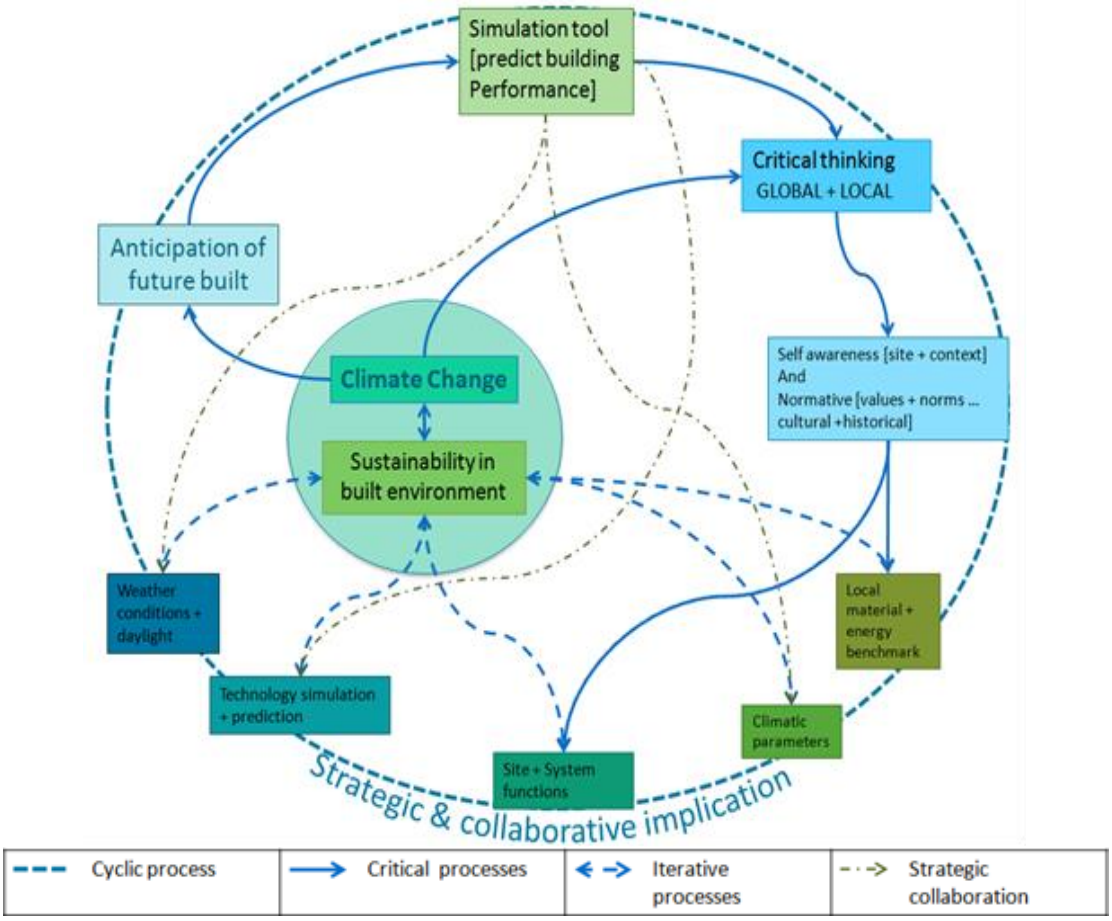

Fig 1: Cyclic system boundaries for architectural design

The initial lectures were based on the effects of construction industry on global warming and the diverse stresses of climate change with showcasing the movie An Inconvenient Truth.[12] These were planned to ethically reflect about the present, and ultimately to predict and foresee the role of architecture for present and future.[10, 4]

The correlation of the ESD competencies along with lecture and documentaries; stressed on strategic planning in every deliverables to inculcate self-awareness about sustainability and plan innovative strategies that could be integrated in the design process. Based on the breadth vs. depth of the course, the in-depth exploration of various topics of sustainability in built environment was collectively developed in a group of four/ five students; i.e. an individual did in-depth research on one topic. While working in group, the participatory approach questioned and gave opportunity to reflect on the selected options; hence enabling discourses about sustainability, which is ideal for groups. This became a platform of collaboration and knowledge / skill sharing; with empathic leadership skills, the group members cooperated with each other in the problem solving and project design. This brought in varied perspective and promoted cognitive brainstorming amongst group members as well as dealing with conflicts and agreements [13].

Being an architectural design studio the contextual parameters of the site acted as an aspect that promotes normative values appreciation. The reflection of values and norms as well as cultural significance within the design project underscored acceptance and trade-offs while responding to climatic concerns. The motivation and self-awareness of becoming the forerunners' of promoting and thinking sustainable designs was engraved in the course structure [2].

2.2 Design Project manifestation

The varied topics of the course gave opportunity for project development in a group, which became a platform for engaging discourses about sustainability. These discussions were based on the students' self-motivation and personal awareness about different philosophical / disciplinary orientations about emerging trends in practice and theory of sustainable design - an interdisciplinary subject. [1]

The group members' enthusiasm brought in variations in terms of ideological shifts. The students were promoted to use varied conceptual derivation as a pivotal design benchmark for their group. For example numbers of groups were motivated for resilient built environments, whereas few were trying to find clues in the historical and cultural significance of the location and at the same time some were thinking of active and passive architecture. This pedagogic shift; paved ways for in-depth exploration of diverse topics, therefore adapting to changing demands of the students' research [1, 8]. Students were introduced to energy simulation tools that helped in analysis of energy efficiency of the buildings along with other tools for extracting the climate files. These computer sessions took care of the in-depth use of simulation tools like Autodesk Ecotect Velux, Climate Consultant etc, used in their design project.

Individual members had diverse roles-expertise to be achieved at the end of the semester. An agreement was needed within the group on design solution based on the research / study undertaken by each. Each student enriched the group's performance through the knowledge acquired by in-depth examination and analysis.

3. Course integration as ESD

The course even used Sterling's (2001) holistic system thinking approach to sustainability in education, where transformative learning by the students was dependent on transmissive learning through lecture series on various topics of the course.[14] Also the previous semester theory course – Environmental Science; highlighted the role of climate while designing built environments. This particular course broadened their perspective within the climate responsive building strategies and conception with diverse interpretation brought in by different group members.

Different stages of the course and competency development; as highlighted in figure 1 the implementation of ESD is not a sequential process but an iterative cyclic process for design evolution and skills attainment. The figure 2 below shows the iterative steps involved while practicing ESD, which highlights the system thinking competency is dependent on critical thinking and self-awareness competencies. These competencies promote the use of normative values and anticipatory speculation thinking, which in turn promotes collaborations and integrative problem solving. These competencies holistically help in strategizing varied goals for achieving sustainability. For this course the cyclic repetition of normative and anticipatory awareness through integrative problem solving technique evolves into collaborative efforts to strategies the design project

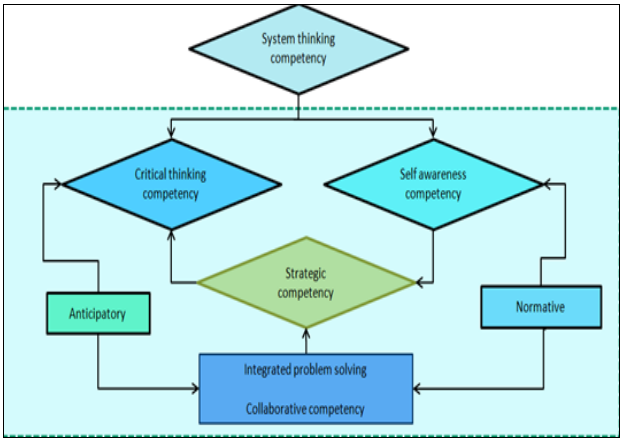

Fig 2: ESD System thinking boundaries

The aim of 1055005 – Sustainable architecture was to provide a platform for greater understanding of the sustainability paradigm. It was designed in such a manner that the ESD competencies provided a framework for arranging diverse topics through the 16 weeks. The integration of diverse topics with ESD competencies was achieved in following sections.

1. System thinking competency - initial lectures and documentaries substantiated the system boundaries and the students were asked to critically think and speculate the future scenarios of earth.
2. Anticipatory competency - initial lectures and documentaries with provocative reflexive brainstorming process promoted reflections on anticipatory trends within construction industry. Also how the various stresses of climate change impact the existing built environments.
3. Normative competency -The site selection was to be decided by the group, which took care of the normative

values, due to their personal awareness about the values and norms of the selected site. This exercise promoted the group to relate to the cultural and historical significance of the site and location. Sustainability values and their reliance on the contextual parameters. Trade-offs while selecting various strategies as per the climatic concerns. No standard solution is available. Critical thinking and questions the local trends observed in the society.

4. Strategic competency - Based on the breadth vs. depth of the course, the in-depth exploration of various topics of sustainability in built environment was collectively developed in a group of four students. This gave opportunity of collaboration and knowledge / skill sharing platform and strategizing an optimum / best outcome.
5. Collaborative competency - With empathic leadership attribute the group members collaborated in the problem solving and project design. This brought in varied perspective and promoted participatory problem solving as well as dealing with conflicts in group.
6. Critical thinking competency - While working in group the critical thinking approach questioned and gave opportunity to reflect on the selected options with sustainability discourse at the back of the mind. Speculative thinking after each lecture to stimulate their cognitive process.
7. Self-awareness competency -The motivation and self awareness of becoming the forerunners' of promoting and thinking sustainable designs was engraved in the course.
8. Integrated problem-solving competency - The cyclic process results into an integrated problem-solving competency that promotes sustainable development.

In this process it introduced the students to diverse transformative skills to bring together with the multidimensionality of sustainability paradigm. The course emphasized that it became transformational education platform and developed the professional skills and competencies necessary to enforce sustainability in architecture education.

4. Effectiveness of course

During their 16 weeks semester, the students finished their final design project, as per the GTU course contents; in depth research of topics was done by individual students making it a mutually dependent design project. The knowledge sharing of diverse concerns was structured into the transformative and transmissive skill attainment aspect as per the analogous framework followed with ESD and education as sustainability; its effectiveness has been show in the table 1 below.

Table 1: Effectiveness of ESD and education as sustainability

ESD Competency	Education as Stustainability	
	Transmissive Skills	**Transformative Skills**
System thinking competency	Lectures	Speculative Scenarios
Anticipatory competency	Sustainability and built environment.	Impacts of global warming on built environment and changing trends in construction industry.
Normative competency	Impact of cultural and historical significance on norms and values.	Site selection and location impact.
Strategic competency	Computer labs of Climate consultant, Velux Daylight and Ecotect.	Use the simulation tools to confirm the design manifestation with theoretical studies.
Collaborative competency	Groups' mutual dependency.	Diverse research topic establishes discourse on sustainability.
Critical thinking competency	Of future scenarios both locally and globally.	Future anticipatory speculations.
Self-awareness competency	Cognitive awareness.	Contextual awareness of site settings.
Integrated problem-solving competency	Cyclic iterative process.	Decision making and iterative process.

This table highlights the transmissive and transformative skills that the course followed with provocative critical thinking process during the group discussions within each group. All the enlisted competencies needed a brainstorming sessions with the students and respective computer labs to promote hands on experience with these new tools. A structured survey was conducted six months after the course was completed. This survey consisted of 20 questions which included both qualitative and quantitative response, with 'yes/no' and majority quantitative questions using linkert scale that ascertained ESD skills transformation.[1] As the design project was worked out in a group, each student was encouraged to participate in the Google Forms administered survey.

The link for the survey was emailed and WhatsApp' ed to all the students, and a reminder was sent twice within two months duration. 27 students participated in the survey out of 72 students who had enrolled for the course of sustainable architecture; which is 37.5% participation for the online surveys. At the commencement of the course students were asked to create their own narratives based on the documentary shown to them as well as the normative cultural values that would impact the sustainability of built environment.

These narratives were majorly governed with Brundtland reports definition of Sustainability [9]; whilst there were a handful of students that related to the normative values and self-motivation towards this paradigm.

For example, one student mentioned sustenance of natural biodiversity as an important minimum resource depletion:

- "Has minimum carbon footprint and has minimum use of materials with are harmful to nature."

At the same time, another student mentioned empowering the energy efficient buildings modern trends by incorporating traditional construction techniques:

- "Due to the intense changes in climatic conditions…it is extremely important to incorporate vernacular techniques and passive strategies…that save energy consumption in built environment."

Such diverse perceptions of the narratives gave rise to varied approaches to experiment ESD in this course. Some students mentioned during the survey about wider exposure and new perspective developed while conception of the design project.

- "Different as a subject and also the way of designing. Enjoyed the experience of designing in a group. In order to achieve good response to climatic conditions, the spaces and forms were not compromised."
- "We learnt many important elements and aspects that do depend on sustainability of the building."
- "Got to learn a lot about making a building efficient with not sacrificing on the design."
- "It was a new experience for me to design something which is not just aesthetically good but also sustainable and comfortable."

The design project was to be conceived as a group work, where group dynamics and critical reflective sessions were the influential part of the decision making. The students mentioned the challenges faced while working in the group and affirming on varied skills like leadership, logical reasoning, dependency and role of mutual benefits.

- "It was a good learning process we learned how to keep the essence of our individuals while working in group."
- "It was very good and we learned many new things as a subject as well as how to work in a group."
- "It was challenging to manage the team but the research and logical reasoning was helpful."
- "The experience was uncommon and very helpful which made us understand the complications and benefits possessed in groups."

The pedagogic approach ascertained that the transmissible skills were broadened throughout the weekly session of the semester. Along with these skills the reflective process made sure to encompass transformational skills that developed into professional competencies. This approach gave opportunities to both the students and tutor to identify the future governance of the design project that were addressing local issues yet embracing global trends. To find out the impact of the didactics follow in course; a qualitative questions were posed; where all the respondents of the survey enjoyed the course structure and the tools taught - with 100% of them responding 'yes' to these questions:

1. "How was the overall didactics (exercises) that were floated in studio, Were they engaging in group work?"
2. "Did you learn new skill sets during the Sustainable architecture course?"

At the same time the qualitative responses show why they enjoyed the course and overall didactics floated in the studio. These responses highlight the role of transformative skills that were instrument to make the experience a more enjoyable. The students acknowledged the sensitivity towards the site settings as well as cultural significance, whilst highlighting the need for more in-depth exploration that can be done in varied topic.

- "New perspective towards new objective."
- "Good, realized have to learn a lot in this field."
- "It was a fabulous experience and I learned so many things which I didn't expect."
- "It was a theoretical as well as practical studio where we learned new software's and even understands the sensitivity of the context and climate on the site."

The learning outcome at the end of the semester showed the enhancement of varied skills set that the students will use during their coming years in education and practice. A quantitative question on the skill set that can be used in the future education and practice scored 100%; for the question:

1. "Which of the skill sets will you use in future?"

These skill sets included climate data simulation, daylight simulation, and energy benchmarking (rainwater harvesting / energy generation with PV) and u-value calculator. With each skill set having approximately 35% due to the fact of working in a group and undertaking research on a specific skill.

Further observation for the course was also derived through the quantitative question in terms of more lectures pertaining to various topics covered during the semester; for the question:

2. "Should there be more theory lectures for various topics / tasks / exercises floated in the studio?"
3. "If yes which topics need more elaboration?"

54.2% students responded 'yes'; highlighting the need for more theory sessions for energy benchmarking; it scoring the highest with 50% students felt a need for much elaborated sessions. Contrary to climate file simulation, daylight simulation and u-value calculations which were more to do with cognitive architectural design understanding. As an educator one feels, the extensive calculations demanded for energy benchmarking were not accomplished by the students due to the technicality of it.

5. Discussion

During this course; a two credit subject that revolves around sustainability in built environment. The benefits its flexible curriculum provided to the educator to experiment the pedagogic practices saw the conception of a newer inclination to encompass ESD and Education as sustainability. The transmissible and transformative skills which contributed to developing the cognitive understanding within the students, and be prepared with promising roles they can play to design sustainable buildings will minimal carbon emissions. Furthermore it is observed that to make this knowledge transformation more engaging, the educators need to be proactively involved with the present and future trends sustainability would take. Especially epistemological interpretations of this paradigm can be perceived differently with respect to cultural and historical significance. This survey showed that didactics followed in the course were enjoyed by the students due to the fact that it offered new knowledge and set higher benchmarks for each deliverables. This research is important to understand the incorporation of education for sustainability as well as the future follow-ups for this course.

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