Macrothink Institute™

Journal of Studies in Education
ISSN 2162-6952
2025, Vol. 15, No. 2

Towards a Deep Learning Framework for the Architecture Studio: Empirical Validation of a Course-Level Project-Based Learning Model

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Received: Feb. 20, 2025 Accepted: April 15, 2025 Published: May 1, 2025

doi:10.5296/jse.v15i2.22812 URL: https://doi.org/10.5296/jse.v15i2.22812

Abstract

Architecture education is fundamentally centered on the design studio, a critical space for student learning and problem-solving. A conventional studio (referred to in this research as the non-PBL studio) follows a critiquing method where students work individually on semester-long projects, often ignoring stakeholder involvement and thus lacking in design innovation. In contrast, Problem and Project-Based Learning (PBL) frameworks, widely used in medical and engineering education, address these limitations. A Course Level

Project-Based Learning (CLPBL) model is designed and implemented across two consecutive studio cycles at a private university in Bengaluru, India. Student performance from the two consecutive cycles of CLPBL vis-à-vis earlier cycles of the non-PBL method is analyzed and compared at the third year of an undergraduate architecture program. A mixed-methods approach is adopted to establish Deep Learning using two indicators. Empirical validation of students' scores, done using the statistical tool R and analyzed for significance using an ANOVA, Student's t-test, and Wilcoxon tests. Questionnaire surveys, used to elicit responses on Deep Learning and greater student satisfaction in CLPBL, are validated using the same statistical tools. The model identifies 5 indices of Deep Learning (DL) drawn from the implemented CLPBL, which align with PBL attributes for Engineering, but are tailored to Architecture Studio learning. In conclusion, the paper suggests a Deep Learning Studio framework for replication in architecture education, while remaining within the prescribed guidelines of the Council of Architecture and National Education Policy 2020, in the Indian context.

Keywords: Project-Based Learning (PBL), Studio pedagogy, Deep Learning, Taxonomy of Learning, Assessment tools

1. Introduction

The curriculum of architecture education in India extends over 10 semesters, totalling 200 to 300 credits, with each semester typically of 16 weeks duration, followed by an end-of-semester evaluation in terms of review and written examinations. Each semester has 20 to 30 credits to be earned, and these are distributed among the Design, Technology, Skill-building, and Specialization streams. The architecture design studio is the epicentre of learning, with 8 to 15 credits, progressively increasing in complexity from semester 1 to 10, culminating in a dissertation or thesis. The traditional approach towards a design studio builds problem-solving skills among students for a given situation, but is criticized by professionals as the learning is superficial and at the surface level (Ashraf Salama, 2008). Students find this didactic, teacher-driven method to be passive and find low engagement and level of participation, as the problem is pre-determined and too well structured (Bejder et al., 2017). Solutions are far removed from real-world situations without applying critical thinking backed by research inquiry (Jones & Jackson, 2010). When this is addressed with suitable methods like PBL, it will lead to Deep Learning (DL) as characterized by understanding, questioning, testing, and finally applying the knowledge in problem solving. (Kloes-Corwin, 2018)(Young et al., 2020). With the current conundrum that architecture education is situated in, it is necessary to adapt to change and usher in new and effective methods of studio engagement. (Shareef & Farivarsadri, 2020). When students become active participants in issue identification and arrive at the project brief by using a process of inquiry, it brings an understanding of contextual issues and human behaviour in a space. (Shanthi Priya et al., 2020). Further, assessment tools in traditional studio pedagogy do not find relevance with current-day practices, which the research brings forward in terms of students' perspectives (Schuwirth & Van der Vleuten, 2011).

Although various studio methods have been adopted in India and around the Globe in the last decade (Kılıçaslan & Kalaycı, 2021; Soliman, 2017), there are limitations in meeting the current requirement. The outcomes defined in the Canberra Accord mandate that graduates apply the acquired knowledge for the design, operation, and improvement of systems, processes, and environments (Pavai Madheswari & Uma Mageswari, 2020). There is an identified need to reform and restructure higher education models in India to achieve desired graduate attributes that help them thrive in local and global professional domains in an increasingly interconnected world (Mittal et al., 2020).

There have been various approaches in restructuring the architecture studio to make it appealing to the present-day student (Aldabbus, 2018). An important consensus was that the studio must bring in the right blend of knowledge and design experience as close to the real world as possible (Schön & D.A., 1983). Recent research on studio themes and practices collated from 1999 to 2020 of the periodical Journal of Architectural Education, in the form of a studio manifesto (Kılıçaslan & Kalaycı, 2021), is included in Appendix A. This indicates that studio pedagogy is dynamic and evolving in nature, and Project-Based Learning can bridge this gap between theory and practice.

The rationale for this research is to study the effects of applying PBL methodology in the Design Studio for architecture education, to assess whether PBL leads to Deep Learning. The researchers chose to design and implement a bottom-up model of PBL (Shinde, 2014), referred to as the Course Level PBL (CLPBL), at a private university in Bengaluru, India. This approach offers a canvas to embed deeper cognitive learning, essential for architects to help bridge the ever-widening chasm between educational environments and practice. Since the primary researcher and guide were already employed at the said university for several years and were aware of the ecosystem, the feasibility of implementing the method was high. At the chosen university, the architecture program was introduced in the year 2015, and the first batch was to graduate in 2020. The curriculum followed was dynamic and innovative, approved by an independent Board of Studies, with revisions and changes incorporated every year. This made it receptive to try a new pedagogical approach at the third year level, since technical courses like building construction, structures, building services, and climatology are already reinforced as content, and applying the learning at the third year level will be feasible for the students. The first two cycles of CLPBL were completed in the academic year 2020-21, for semesters 5 and 6 with the same cohorts.

2. Review of Literature and drivers of change

This research examines Project-Based Learning (PBL) as a pedagogical approach within the context of architectural education, taking cues from the first utilization of Problem-Based Learning in medical education due to its emphasis on problem-solving(De Graaf E & Kolmos A, 2003; Hmelo-Silver, 2004). PBL was successfully implemented at the University of Delft, Netherlands, in the School of Architecture (Banerjee & Graaff, 1996). PBL focuses mainly on 3 domains of learning. Cognitive, using the intellect to learn by critically reflecting on a given problem. Content, where the theory or content is provided by the faculty. Essentially, it provides an interrelation between theory and problem to be solved or design to be created. The third being Social, where learning happens due to the sharing of ideas and tasks involved in teamwork. PBL problems are required to be complex, open-ended, and must start with research and inquiry. The choice of problems in PBL is key to enhancing deep cognitive learning. The problems chosen must be contextualized to suit course learning objectives (CLOs) and timelines of professional education. Since the PBL problems are multifaceted, challenging, and complex, a social or team-based approach is required to solve the problem (Sockalingam & Schmidt, 2011). The social principle in PBL provides the opportunity for peer-to-peer learning through cooperative and collaborative learning principles (De Graaf E & Kolmos A, 2003). The efficacy of Project-Based Learning (PBL) within architectural education is anchored in its ability to foster deep learning (Weng et al., 2023). Deep learning in PBL is characterized by the integration of knowledge, critical thinking, and the application of concepts to new situations. (He et al., 2021)

The parameters of deep learning outcomes in PBL are derived from a synthesis of the literature, which clearly emphasizes the need for students to engage with content at a level that allows for understanding and application rather than mere reproduction (Trigwell K et al.,

1999). Research further shows that architectural design studio follows a collaborative learning method, wherein rapid iterations, time-based design solutions, critiquing methods through peers and instructors, dealing with heterogeneous elements, and finding a commonality are all applied to arrive at the end product (Kuhn, 2001), thus linking it to Vygotsky's theory of social interaction.

A recent report by CoA has proposed further improvements in the structure of the curriculum of architectural education to align with the National Education Policy (NEP) 2020. The NEP advocates a problem-solving approach to learning in various professional disciplines, including architecture. In the Indian context, there is a need for a reimagined approach to studio pedagogy that emphasizes the process rather than the outcome. (Chakrabarty & Singh, 2023). The shift is necessitated by the rapidly evolving knowledge-driven economy and the directives of the NEP. (Gupta, 2021).

In summary, the following reasons underscore the need for change.

1. *Need for transformative shift:* Architecture studio pedagogy in India must evolve towards real-world problem solving, enhancing graduates with better employability skills and competencies.

2. *Misalignment with NEP 2020:* The existing teacher-centric studio approach, coupled with the critiquing method of pedagogy, fails to align with NEP 2020, which recommends diverse assessment methods in terms of PARAKH (Performance Assessment Review Analysis of Knowledge towards Holistic development) and developing multiple competencies.

3. *Peer Learning and collaboration*: Research indicates that peer learning and collaborative work foster holistic learning and nuanced design solutions, an effective outcome of Project-based learning.

3. Hypothesis, Research Aim, and Methodology

Adopting the Project-Based Learning method (PBL) in a third-year level for the architecture design studio will lead to Deep Learning" is assumed as the alternative hypothesis (H1). The research aims to establish the efficacy of project-based learning (PBL) over other non-PBL methods through an empirical validation of two indicators of Deep Learning, scores and student satisfaction with learning, thereby guiding future curriculum and pedagogical changes in architecture education in India. This is achieved through the following methodology.

1) By adopting action research, plan and implement the Course level PBL model (CLPBL) at the host institution for Cycle 1 at the 5th semester level and collect the data on scores achieved, student satisfaction, and learning outcomes.

2) Repeat the implementation for a consecutive studio Cycle 2 at the 6th semester level and collect the data, by incorporating the reflections from Cycle 1

3) Using statistical tools, analyse the data for significance in terms of similarity or differences to establish the empirical relation between PBL and non-PBL studios

4) Derive Deep Learning indices relevant to the architecture studio from the CLPBL implementation that can lead to a new taxonomy for studio-based learning

3.1. Methodology of the Action Research

The choice to utilize action research for evaluating Project-Based Learning (PBL) methodologies was intentional, aiming not only to assess the effectiveness of PBL but also to engage educators and learners in a process of continuous improvement, mirroring the learner-centered ethos of PBL itself. Action research is a participatory and democratic form of inquiry that is particularly well-suited for educational settings (Constantia & Christos, 2019). It is characterized by its cyclical nature, which enables researchers to iteratively investigate a problem through a series of actions and reflections. This approach is grounded in the belief that complex educational phenomena can be best understood by actively engaging with them and that practitioners themselves can produce valuable insights through reflective practice. The methodology of this study was anchored in the iterative cycles of action research, consisting of four stages: planning, action, observation, and reflection (Kemmis, 2009).

Figure 1 below represents the process followed for the Action Research designed for CLPBL Cycles 1 and 2

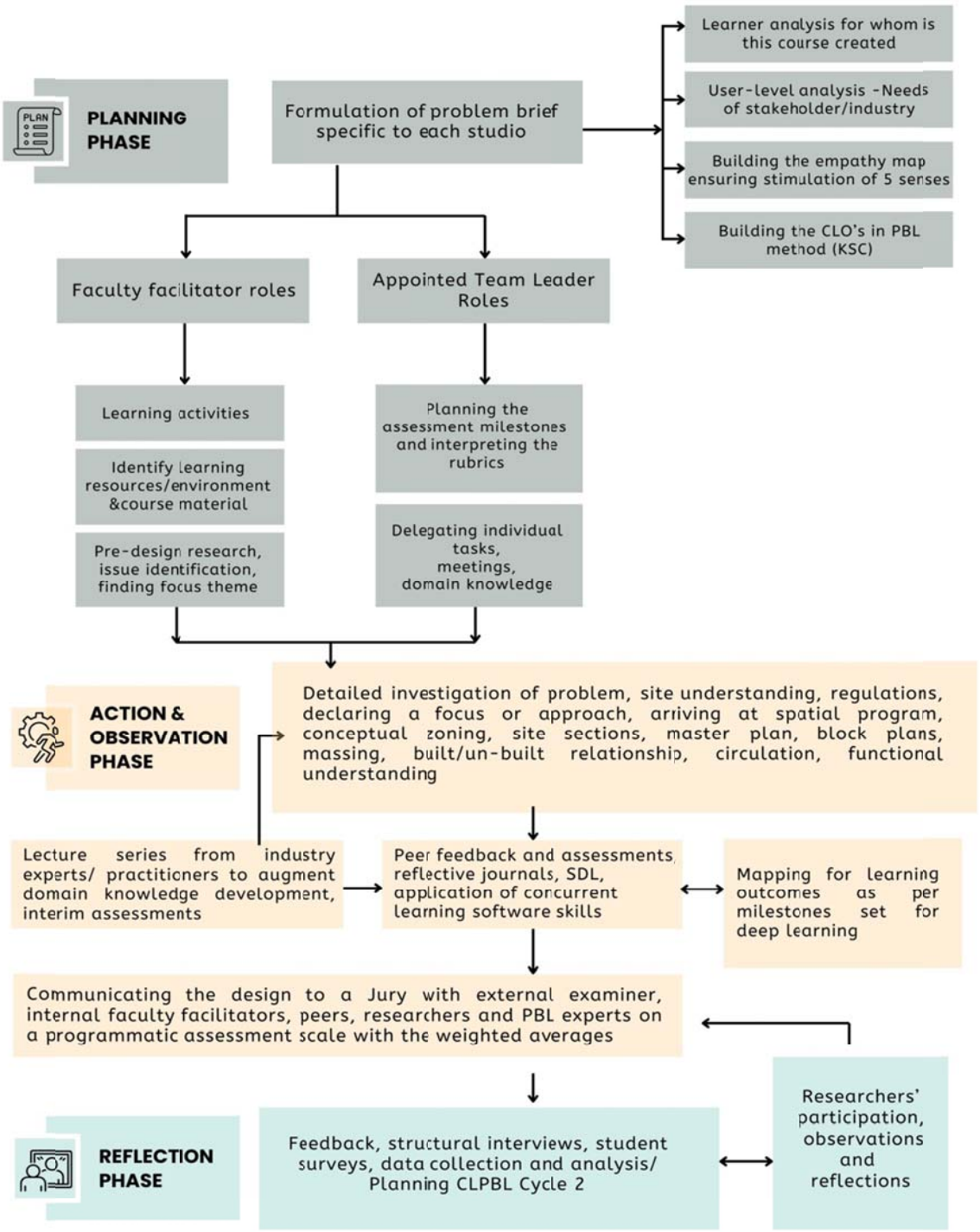


Figure 1. Process Flow Chart CLPBL Cycle 1, *Source: authors, 2020*

Each CLPBL cycle began with the planning phase, where objectives and strategies for implementing PBL were delineated in consultation with stakeholders. This was followed by the action phase, during which PBL and non-PBL strategies were enacted within the architectural design studio course. Observations were systematically recorded throughout the semesters to capture data on student engagement, learning outcomes, and the overall efficacy of the teaching methodologies of CLPBL cycle 1. The subsequent reflection phase involved a thorough analysis of the collected data, drawing on both quantitative assessments and qualitative feedback from students and faculty (Nijhawan, 2017). These reflections were then used to refine the approach for the subsequent cycle of CLPBL 2, thus embodying the dynamic and responsive nature of action research. To conduct a comprehensive evaluation of the efficacy of the implemented Course Level Project-Based Learning format (CLPBL), the comparison involved scrutinizing the earlier implemented non-Project-based learning (non-PBL) methodology against the current PBL approach, in the architectural design studio course at a private university in Bengaluru, India

3.2 Process-driven approach

The PBL Methodology, adapted from engineering streams to suit architecture studio pedagogy, is based on the following principles, namely real-world relevance, collaborative process of problem solving and learning, user-centric approach, issue identification using an inquiry approach, reflection, and finally, using an empathetic approach in reaching the design solution.

The cohort size of 80 students was spread across two sections of the 5th semester. The Learning outcomes defined in the curriculum were mapped to the scope of the PBL project, and groups were formed with one chosen group leader. The table below presents the adopted process-oriented approach, with various milestones defined and innovative assessment models incorporated into the CLPBL cycle 1. Action research is a reflective method in which learning from the first cycle becomes feedback for the next cycle. Hence, the CLPBL cycle 2 followed broadly the same process, albeit with new cohorts.

Table 1. Process-driven pedagogy, milestones, and assessment methods of CLPBL

Peer /collaborative learning	Nature of Activity	Timeline for the semester	Assessment
4 to 6 students per group- 16 groups in total among 80 cohorts	Secondary study using the internet on user group, anthropometrics & ergonomics, flexible furniture, building services, serviced community living, vertical core, and circulation	Before the commencement of the semester. Duration of work: -1 week	05 marks – common marking
	Secondary Precedent Study (National & International examples) of Student Living and Senior Living using	First task at the start of the semester. Duration of work-1 week	20 marks – Based on individual

	the internet		contributions
	Primary stakeholder feedback survey among 150 undergraduate University students	The second task is at the start of the semester. Duration of work-1 week	within the group
5 per group, with one chosen group leader	Researching the Focus theme emerging from meeting CLOs and stakeholder feedback to arrive at the unique project brief for each group- Affordable housing, flexible housing, universal design, facility management, Energy efficiency, modular housing, technology, and IOT	Duration of work- 2 weeks	10 marks- peer grading among groups of presentations
Expert talks- developing domain knowledge	Studio Facilitators and Industry experts delivered content on chosen focus themes	1 expert talk per week, lasting a total of 6 weeks	Learnings from talks observed in reflective journal entries
Group	Area statement and project brief formulation with requirements, and developing the Master Plan	Duration of work- 3 weeks	15 marks- individual contributions within the group
Internal Assessment Viva Voce – Stage 1 completed 50 marks – scaled to 25			
Individual	Detailed design of each block within the Master Plan- living units, common facilities like sports, canteen, multi-purpose hall	Duration of work- 2 to 4 weeks	10 marks
Group	Integration of focus theme, furniture layout, services, circulation, parking, unbuilt spaces, energy simulation models		10marks
Individual	Time problem- Applying concurrent learning of SSBC to create innovative roof spans for interaction zones	1 day	10 marks
Group	Go to Market- creating the brochure for the project as a commercially viable idea	1 week – ideation of name for the project, drawings, detailing, pricing, and USP	10 marks
Individual	Peer assessment survey form- assessing the group leader and group member contribution in the design process	1 day	10 marks
Internal Assessment Viva Voce – Stage 2 completed, validation by a juror from academia 50 marks – scaled to 25			

Group & Individual	Developing the portfolio – Preliminary research, Masterplan, Zoning, Detailed design, project costing, Integration of concurrent learning, brochure design, 3D models, reflective journals, walkthrough simulation	2 weeks	100 marks
End Examination Assessment Viva Voce by an External Juror from Industry			
100 marks – scaled to 50			

Source: Authors, 2020

3.3 Studio Outcomes

The PBL method is a learner-centric, participant-directed approach in which considerable autonomy of decision-making and choices is given to the learner. Thus, the CLPBL studio format designed for this research, applied with the 2018 cohort, embraced a learner-centric paradigm. In the conventional method, the project is defined by faculty coordinators. (Hardman & Hardman, 2017). However, in the designed CLPBL format, the faculty was a facilitator, and the student had control and ownership in the project formulation to ensure active learning. In the conventional method, stakeholder feedback in issue identification had never been collected. (Jones & Jackson, 2010)Nor incorporated into the design formulation. In the CLPBL method, students identified issues through a primary survey and stakeholder feedback, thereby giving credibility to the project. The differences in the project brief between non-PBL and PBL studios can be seen in Appendix B.

In the conventional method, there is a limited scope of knowledge development through self-study (Stewart, 2007). Whereas in the CLPBL format, self-directed learning had been incorporated into the weekly schedule with curated domain knowledge lectures to help fill the learning gaps. In the conventional method, the scale of the project limits peer learning (Mahendra Sonawane & Gokhale, 2016). However, in the CLPBL format, care was taken to advance peer learning by adding complexity to the project designs, thus allowing students to work in teams for a considerable period.

In the conventional method, communication of the design solution was only through drawings and models (Stanimirovic et al., 2023). However, in the CLPBL format, care was taken to include market trends and innovations in communicating the design. This process entailed engaging with stakeholders to discern design challenges, emphasizing collaborative endeavors in small groups, promoting independent study on specialized subjects, and evaluating practical applications. This modality was anticipated to foster a plethora of unique and diverse design solutions (McCrum, 2017). Figures below are a representation of the diversity in design solutions achieved by the PBL cohorts.

Figures 2 and 3. Sample panel composition & brochure by a group with a focus on affordable housing, *Source: Authors, 2020*

Figures 4 and 5. Time-based problem for innovative seating in open areas, individual designs, *Source: Authors, 2020*

Figures 6 and 7: Students presenting the work to the external examiner, *Source: Authors, 2020*

3.4 Assessment and Evaluation

An assessment rubric is a scoring tool used to evaluate and assess the quality of student work based on predetermined criteria and performance levels. In a course like architecture design, which is subjective, designing a rubric and sharing it ahead with students helped to prepare the output to match the assessment criterion better, and ensure transparency in grading. In non-PBL studios, a rubric of assessment had never been used in the grading. Marks were

awarded on standardized parameters like literature study, case study, site analysis, concept, design development, and model. For the CLPBL, the researchers adopted diverse criteria for formulating the assessment rubric based on the literature studied. The rubric weighed in parameters like the process of design rather than the final product, design methodology, and technical resolution by incorporating learning in concurrent courses, spatial organization, and written, oral, and visual communication. The assessment rubric was designed for the first formative evaluation stage based on preliminary research, precedent study, and concept, arriving at the area program, focus study, site study, and analysis, and arriving at zoning. A similar rubric was designed for the second formative assessment towards the end of the semester, and again for the external viva assessments for the portfolio. The rubric was shared ahead so that students could plan their presentations to focus on all requirements of the rubric and as a form of self-assessment to gauge the quality and quantity of the work completed. The rubric samples can be seen in Appendix C.

3.5 Reflections and changes to the CLPBL for Cycle 2

The last stage of the action research of the CLPBL cycle 1 is the reflection phase, where the planning, process, and results are reflected upon by the researchers. Adequate opportunities were created for peer learning, collaborative learning, and critical thinking using innovative pedagogical tools through online mode in the formative assessment stages and transitioning the output to offline mode before the summative assessments. Further, by creating smaller groups with specific focus themes to facilitate deeper understanding with three faculty facilitators per studio, efficient discussion and learning were ensured in the predesign and design development stages.

Studio facilitators and the PBL cohorts discovered diverse and effective assessment methods that aligned with differentiated learning for group work, including mid-semester peer feedback among group members and the group leader using Microsoft Forms. Group work and peer learning, which is the overarching premise of the PBL method, were not the norm in the Architectural Design studio of earlier semesters. This posed a few issues initially with group heads delegating and not receiving the work. Due to the group work, considerable skills were developed over AutoCAD and 3D tools like SketchUp by students, thereby improving software competencies. The following changes were made to the model for CLPBL Cycle 2 for the 6th semester.

1. Treatment and Control Groups were planned within the 2018 cohorts for the subsequent CLPBL cycle 2, at the 6th semester, at the host institution

2. New groups and group leaders were to be formed in the PBL cohorts (Treatment group) to equalize and create an unbiased ecosystem of collaborative and peer learning

3. Non-PBL cohorts of 2015, 2016, and 2017 would be evaluated in retrospect on learning outcomes through questionnaire surveys and scores obtained from previously published University results

4. Increased individual design challenges were to be assigned within the group work for each member, such that the creative potential was not compromised. Group assessment rubrics were to be revisited to address any gaps.

4. Results & Discussion

The data collected by various instruments from CLPBL Cycle 1 and 2 discussed in the methodology section, are analyzed and presented here. The focus of the results presented here is on intended deep learning outcomes, which are described in section 4.2. The qualitative component, grounded in the data from the questionnaire, provided deeper insights into the students' satisfaction and contributed to achieving the deep learning indices previously defined. The statistical tools selected and modes of data visualization are represented in Figure 8 below.

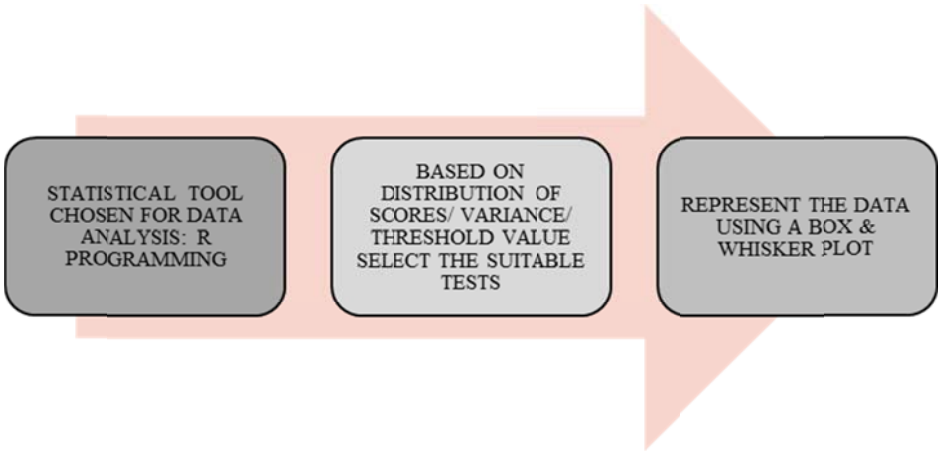


Figure 8. Method of Data Analysis for quantitative data of scores, *Source: Authors, 2021*

4.1 Indicator I: Absolute scores

Cycle 1 Data Analysis

The First cycle of CLPBL was an exploratory Pilot study, and hence the Confidence Interval assumed was 90% (alpha=0.1). Since the difference in the mean total marks between the non-PBL batches was non-significant ($P \geq 0.1$), they were grouped and compared with the mean total marks of the PBL batch in 2018. Since the sample sizes were vastly different, a Wilcoxon rank sum test (also known as the Mann–Whitney U test) was conducted to account for differences in the variance of the two groups. A one-sided Wilcoxon rank-sum test with continuity correction was performed to evaluate whether total marks in the PBL group ($n = 75$) were significantly greater than in the non-PBL group ($n = 157$). Table 2 below represents the findings of the ANOVA test. The data visualization using R programming is represented through a box and whisker plot of Cycle 1 (Figure 9), demonstrating the significant disparities, emphasizing the potential influence of PBL on student learning in the design studio.

Table 2. ANOVA Test for Significance: Cycle 1

Comparison of cohorts	Difference in Group Means	Lower Bound	Upper Bound	Adjusted P value
2016 to 2015	-1.8173077	-9.0105892	5.37597378	0.91411618
2017 to 2015	-4.5565068	-11.344202	2.23118789	0.30679489
2017 to 2016	-2.7391992	-8.5489295	3.07053121	0.61464065
2018(PBL) to 2015	-1.0516667	-7.8117234	5.70839007	0.97787507
2018(PBL) to 2016	0.76564103	-5.0117748	6.54305689	0.9860933
2018(PBL) to 2017	3.50484018	-1.7590021	8.76868247	0.31399813

Source: Authors, 2021

The result was statistically significant, W = 6559.5, p = 0.080, with alpha = 0.1 to account for the exploratory and early phase of the experiments. This points to a favorable change when compared to trends that did not involve PBL.

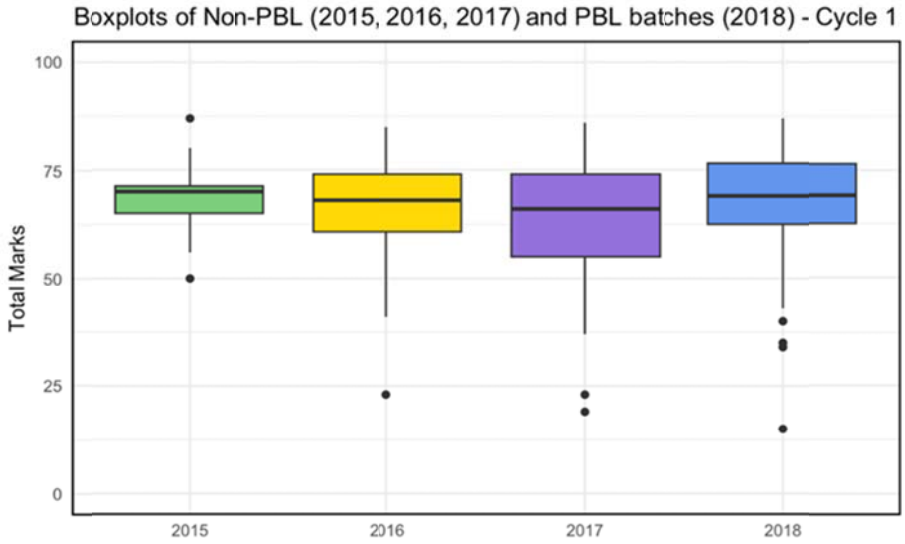


Figure 9. PBL studios vs. Non-PBL cycle 1 scores of different cohorts, *Source: University results data, visualized through R programming, authors, 2021*

2015 non-PBL (in Green), we observe that the whiskers are short, thus representing a sharp bell curve, with scores ranging between 56 and 80, while the lower quartile was 65 and the upper quartile at 71. The median value was high at 70. For 2016 non-PBL (in yellow), whiskers were uneven, maximum students scored between 60 to 74, the lower quartile was at 60 and upper at 74, but the median value dropped to 68; the performance range was between 41 to 85. For 2017 non-PB (in Purple), it performed poorly in comparison, with uneven whiskers, a low median value of 65, *In 2018 PBL (In Blue) - the maximum scores are pushed upward towards the higher quartile, with a median value at 70 and upper quartile reaching 78, lower quartile at 63 thus indicating a better performance for the class as a whole in terms of scores. Lower quartile at 58, and upper at 74.*

Cycle 2 Data Analysis:

Since several reflections from Cycle 1 had been incorporated before commencing Cycle 2, and the implementation has passed through a few iterations, the Confidence Interval (CI) was set at 95% (alpha=0.05) to test for significance in Cycle 2. A Wilcoxon rank sum test was conducted to compare the means of total marks of the Non-PBL batches and the 2018 Control. The total marks in the 2018 Control group (n = 39) were significantly greater than the total marks in the non-PBL group (n = 156). The result was statistically significant, $W = 4337.5$, $p < 0.001$, with alpha = 0.05 at 95% Confidence Interval. A Wilcoxon rank sum test was conducted to compare the means of total marks of the Non-PBL batches and the 2018 Treatment. The total marks in the 2018 Treatment group (n = 39) were significantly greater than the total marks in the Non-PBL group (n = 156). The result was statistically significant, $W = 4337.5$, $p < 0.001$, with alpha = 0.05. Table 3 below represents the values of the ANOVA test for significance. Figure 10 represents graphically the data through a Box and whisker plot.

Table 3. ANOVA Test for Significance: Cycle 2

Comparison of cohorts	Difference in Group Means	Lower Bound	Upper Bound	Adjusted P value
2016-2015	2.91973039	-3.3667495	9.20621025	0.70558363
2017-2015	1.71532534	-4.1946653	7.62531594	0.93096519
2017-2016	-1.204405	-6.2917699	3.88295979	0.96632841
2018 Control-2015	6.54567308	-0.1032367	13.1945829	0.05599229
2018 Control-2016	3.62594268	-2.3037532	9.5556386	0.44751301
2018 Control-2017	4.83034773	-0.6986172	10.3593127	0.11840395
2018Treatment-2015	9.5713141	2.9224043	16.2202239	0.00094932
2018Treatment-2016	6.65158371	0.72188779	12.5812796	0.01924559
2018Treatment-2017	7.85598876	2.3270238	13.3849537	0.0011546
2018Treatment-2018Control	3.02564103	-3.2870023	9.33828438	0.68037028

Source: Authors, 2021

Since the achieved value of p is less than the assumed alpha value of 0.05, we accept the alternative hypothesis (H1), that PBL (Treatment) results in better scores than all other non-PBL.

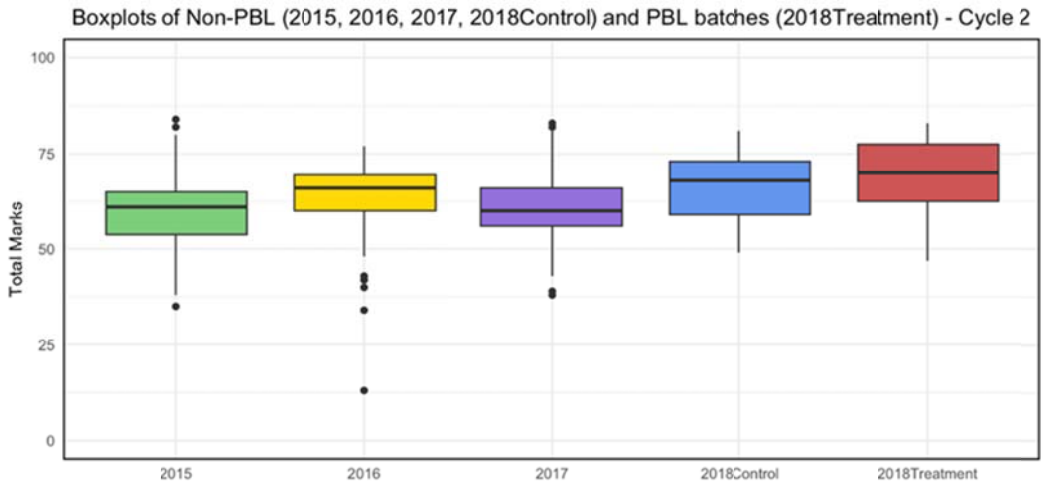


Figure 10. PBL vs. Non-PBL cycle 2 studio scores of different cohorts, *Source: University results data, visualized through R programming, authors, 2021*

The non-PBL scores in 2015, 2016, and 2017 for Cycle 2 exhibited balanced distributions, characterized by different medians and quartiles. The control group of 2018 cohorts consisted of a section of the students who participated in the PBL method for cycle 1 but reverted to the conventional (non-PBL) approach for cycle 2. This control group demonstrated higher median and quartile scores, indicating an improved class average. Nevertheless, the PBL group (treatment group) in 2018 outperformed both the control group and prior non-PBL cohorts, with a significant rise even in the third quartile.

Thus, after the two CLPBL cycles, we validate empirically the first indicator that PBL results in better scores in terms of students' performance and thereby leads to Deep Learning. The p-value in both Cycle 1 and Cycle 2 is less than the assumed alpha value, we accept the alternate hypothesis (H1) that there is a significant difference between PBL and non-PBL scores.

4.2 Indicator-II: Student Learning Outcomes and Satisfaction

To assess Learning outcomes in terms of depth of learning, level of concurrent learning, autonomy over the project brief, and development of the design, collaborative learning, self-learning, and satisfaction level on completion of the studio, a detailed survey questionnaire with over 20 parameters was circulated. 77 responses from the non-PBL cohorts and 50 responses from the PBL cohort were sought in cycle 1, and 107 responses and 54 responses in cycle 2. The nature of questions planned in the survey questionnaire is explained in Figure 11 below

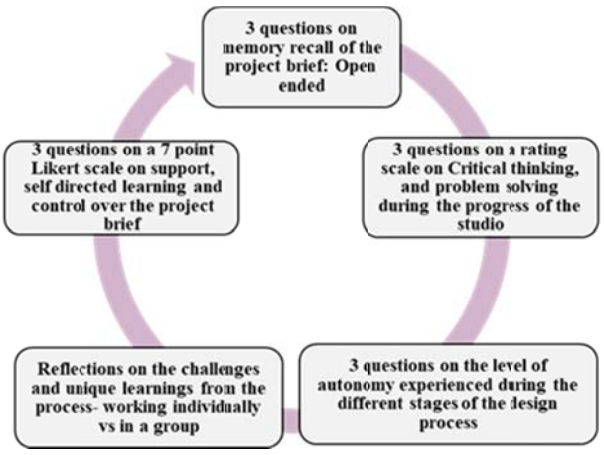
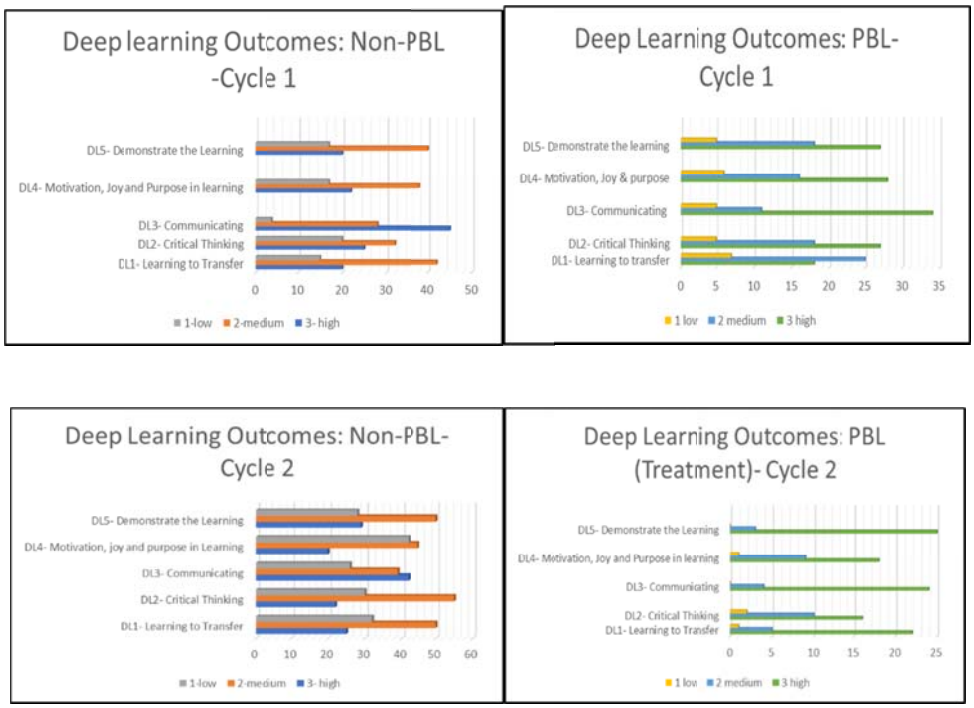


Figure 11. Structuring the instrument of measure: Student Questionnaire survey,

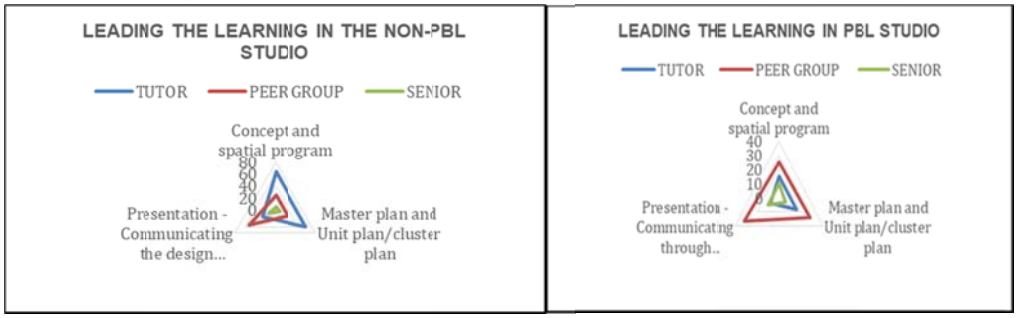
Source: authors, 2021

Questions were on a 3-point or 7-point Likert scale, and some were open-ended. A few samples from the qualitative data collected through the questionnaires are found below. Responses from the non-PBL batches indicated that Deep learning indices were average, the studio facilitator guided learning, and the level of satisfaction was neutral. In contrast, the response from the PBL cohort on achieving deep learning ranged between excellent and average for DL 1 to 5. Figures below depict the data visualization of responses of the non-PBL and PBL cohorts



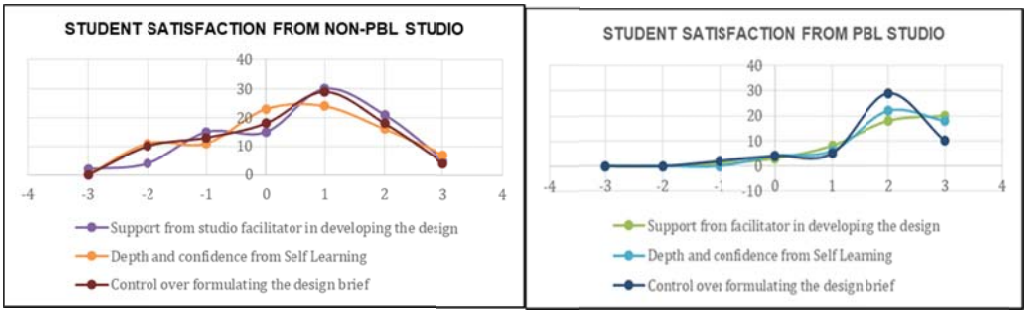
Figures 12, 13, 14, and 15. Level of Deep learning through questionnaire survey from non-PBL cohorts and PBL cohorts, *Source: Questionnaire response, 2021*

Non-PBL cohorts responded that facilitators led the learning at all stages of the studio, except during presentations, when they learned from peers or seniors. PBL cohorts rated peer learning higher than learning from the facilitators at all stages of the studio. The questionnaire is added in Appendix D for reference.



Figures 16 and 17. Response from PBL and non-PBL cohorts -cycle 1 on "who led the learning in the studio"?

Another important indicator of learning outcomes was the level of satisfaction experienced by the students with the support from studio facilitators, depth and confidence from self-learning, and control over the project brief. As can be expected, the PBL cohort expressed a higher level of satisfaction on a five-point scale against each of the parameters.



Figures 18 and 19. Student satisfaction of non-PBL studio cohorts and PBL studio cohorts-Cycle 1

The maximum response from non-PBL cohorts ranged between -2 to +2 in terms of satisfaction, with many on the negative side of the scale. In contrast, the response from the PBL cohort ranged between +2 to +3 in terms of satisfaction across 3 important learning parameters, with negligible negative responses. Similar questionnaire responses were collated and analyzed, and the table below indicates the learning outcome.

A Student's t-test was conducted to compare the proportion of students who had scored high across the Deep Learning outcomes in PBL and Non-PBL batches. The results are plotted in Figure 20 below.

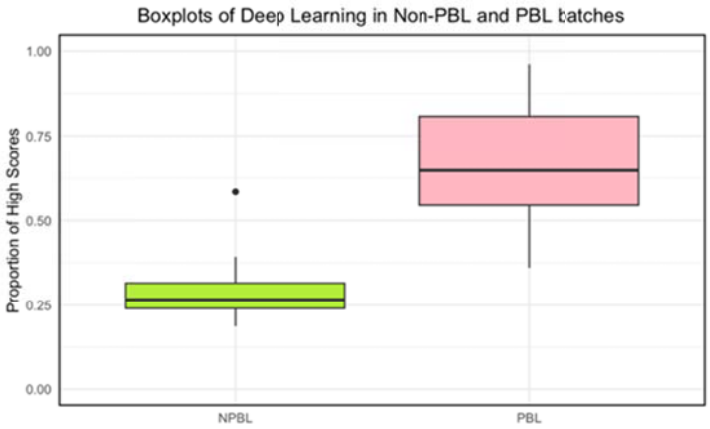


Figure 20. Deep learning synthesized for PBL vs. Non-PBL, *Source: Authors, 2023*

The difference in means was statistically significant, $t(16.16) = 5.39$, $p < 0.001$. The 95% confidence interval for the difference ranged from 0.21 to 0.48, indicating a meaningful difference.

A Student's t-test was conducted to compare a calculated satisfaction score given by students in PBL and non-PBL batches. The results are plotted in Figure 21 below.

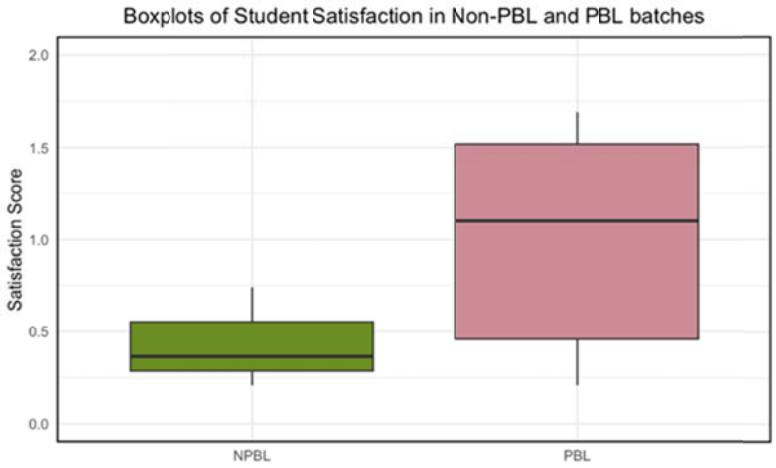


Figure 21. Student Satisfaction from the studio experience synthesized for PBL vs. Non-PBL, *Source: Authors, 2023*

The results showed a statistically significant difference, t (9.75) = 2.78, p = 0.010. The 95% confidence interval for the difference in means was [0.39, ∞), supporting the conclusion that the PBL group had higher student satisfaction. Since the p-value was less than 0.05, we accept the alternate hypothesis (H1) that there is a significant difference between PBL and non-PBL responses.

In conclusion, the responses from the student questionnaire surveys, the 5 indices of Deep Learning are derived, as applicable to the PBL studio pedagogy, by drawing its relevance from the defined PBL principles applicable in Engineering education and the interpretation of Deep Learning from literature. These are learning to transfer (DL1), Critical thinking (DL2), Communicating (DL3), Motivation, joy, and purpose in learning (DL4), and Demonstrating the learning (DL5). These outcomes are mapped to core principles of PBL in engineering education and matched to the indices of Deep Learning drawn from the implementation of CLPBL in the Architecture studio. This is described in Table 4 below.

Table 4. Mapping of Deep Learning Indices from CLPBL implementation

Core Principles of PBL in Engineering Education		Defined Deep Learning Indices from Literature	Deep Learning Indices Drawn from CLPBL Implementation
Cognitive	Critical thinking	DL2: Critical Thinking DL4: Motivation, Joy, and Purpose in Learning	Pre-Design Phase: DL2&4- Cognitive learning: Form generation, Concept, Spatial program, Zoning and fitting functions, issue Identification from primary research
	Problem identification		Design Development/ Application Phase: DL2 &4 -Process of iteration, developing the detailed design, and application to reflect real-world solutions, patents, and processes
Content	Self-Directed Learning	DL1: Learning to Transfer	Pre-Design Phase: DL1 from Content learning- Concurrent courses and previous learning, Special lectures, Byelaws and regulations, Site features
	Theoretical learning & from domain experts		Design Development/ Application Phase: Application of BCM, Structures, and Services in the detailed plans toward real-world solutions
Social	Learning from peers	DL2: Critical Thinking DL3: Communicating	Pre-Design Phase: DL2&3 from social learning- Listening, brainstorming, debates and discussion, primary survey analysis, stakeholder feedback, precedent studies, formulating a unique project brief as a group
	Problem-solving in a group	DL5: Demonstrate the Learning	Design Development/ Application Phase: DL3 Use of skills and tools to communicate the Design. DL5- Differentiated learning output demonstrated by individuals within the group

Source: Authors, 2022

4.3 Discussion

The synthesis of quantitative and qualitative data from this study presents compelling evidence of the efficacy of PBL in educational settings. The quantifiable improvement in student performance, as captured by the box and whisker plots and the qualitative feedback obtained from questionnaires, establishes the enhanced learning outcomes attributable to the PBL approach. Through the interpretation of the outcomes from a year-long program of the CLPBL approach in the architectural design studio, the following inferences can be drawn.

1. Based on the comparison of absolute scores of both cycles of the experiment, it is evident that PBL pedagogy helps to achieve higher scores, a culmination of the formative assessment of 50% through an internal jury and the summative assessment of 50% in the presence of an external jury. Since the other parameters like duration of the semester, complexity of the problem, typology of design, area of the site, and number of studio facilitators per cohort were all constant in both PBL and non-PBL approaches, the enhanced performance in terms of scores is decidedly a result of the PBL pedagogy and process, validating Deep learning.

2. The findings above need to be further validated through a reliability study by varying the studio settings, context, and cohorts to establish the hypothesis that the PBL approach will lead to Deep Learning, irrespective of contextual variations.

3. The treatment group that went in for the second consecutive cycle of PBL in the 6th semester scored more than the control group that reverted to the non-PBL approach in cycle 2. This leads to validation that if PBL pedagogy is continued, it elevates the performance to a higher level and encourages self-directed learning.

4. The qualitative data responses suggest that the learning from PBL studios is evaluated higher by the students, and the sense of student satisfaction achieved in delivering a design solution is enhanced on multiple parameters, which validates the interpretations of Deep Learning.

5. The upward shift in student scores in PBL cohorts demonstrates that active, problem-based learning can significantly impact educational attainment. The value of experiential and applied learning in improving student competencies in technical knowledge and problem-solving is evident. The sustained implementation of PBL methods across successive semesters has also shown a compounding effect on student performance and self-directed learning.

6. The stakeholder engagement integral to the PBL approach mirrors the user-centric design processes vital in projects, promoting a comprehensive understanding of the project lifecycle from conception to implementation, preparing students for real-world challenges.

7. Furthermore, the PBL approach's emphasis on collaborative learning and its success in an architectural studio provides a pedagogical initiative to cultivate teamwork and interdisciplinary cooperation.

8. The sliding scale rubric, found to be effective in evaluating complex architectural projects, could serve as a framework for assessing students' design projects, research initiatives, and group work. This can be considered a contribution to the multi-faceted assessment method promoted by NEP 2020.

5. Conclusions and implications of research

This research substantiates the transformative potential of Project-Based Learning (PBL) within architectural education, reinforcing its status as an impactful, process-oriented pedagogy in design studios. Mirroring the emergent trends in pedagogical exploration (Sinfield & Cochrane, 2021), the study posits PBL not merely as an alternative instructional strategy but as a keystone for progressive educational models in architecture. The empirical evidence gathered through this study lends credence to the assertion that adopting PBL within the architecture curriculum can enrich the educational journey of aspiring architects, making the learning process more engaging, practical, and relevant. Furthermore, the introduction of course-level project-based learning (CLPBL) in architectural design studios has laid down a scalable and adaptable framework that can extend beyond design practice to incorporate theoretical domains. There is a need to foster a learning environment that values student autonomy, encourages engagement with real-world problems, and promotes a culture of self-directed inquiry. For architecture education in India and beyond, this entails a holistic reimagining of the curriculum to emphasize hands-on, project-based activities that reflect the dynamic and evolving demands of the architectural profession. It is positioned to drive future curriculum development and enhance teaching methodologies, steering architectural education towards a more integrated, practice-oriented, and student-centered approach.

Acknowledgements

This paper is part of a larger Doctoral research based on project-based learning in the domain of Architecture education in India as a tool to achieve Deep learning. This research has been ongoing since 2019 at a Private University and a state-affiliated University in Bangalore, India. The researchers acknowledge the contributions of students of the 2015, 2016, 2017, 2018, and 2020 cohorts for supporting the research. The researchers are also indebted to the faculty members from different Universities who supported and were trained in the PBL method to conduct the experimental studios. The research does not receive any funding and is self-sponsored.

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Appendices

Appendix A

Table 5: Contemporary Studio Approaches in Architecture Education

Type of Studio	Description	Reference
Weather Register	Generating small programs and designing them according to specific geographical conditions, designs, and analyses through which solutions for different geography, climate, and ground features are produced, is given a place.	Liu et al., 1999
Boundary Studies	Studio exercises target the current habituated environments and search how to reconsider the place and configuration according to the circumstances of coexistence.	Chi, 1999
Design Build	Build dwellings that necessitate the design-production process to maintain the quality from diagram to construction.	Archer-Barnstone, 2002

Rapid Response and Compassionism	pedagogy sense that concentrates on generating architectural identity and establishing a connection again with social and moral imperatives	Verderber, 2003
Studio South	Adds an intellectual depth to the design-build process of theoretical problems and community interaction. It allows the investigation of a historic site and to learn about the politics and community that created it, as well as the architectural implications.	Erdman, 2006
North Studio	Modern version of the traditional Beaux-Arts atelier model, projects with notional content aiming to develop and produce research are given a place. In every project, traditional ideas concerning the relationship between landscape and architecture are interrogated, and concepts and design ideas are generated. The studio collaborates with students and customers to design and apply projects that will be built.	Huge, 2009
Remote Studio	Coupling architectural works with patterns of action. Arranged area/trip works encourage students to think of and redefine their priorities when they are away from the studio. A studio combining practices of architecture with settled conceptions and material features of regional context provides a mechanism to learn coexistence and cooperation.	Taylor, 2010
Design Games	Discovering the boundaries of the design-studio context. Scenarios, diagrams, and place/time games benefit in learning urban informality processes. Student-centered pedagogic techniques are formalized by spatial and formal solution-seeking	Owen et al, 2013
8 Mile Baseline Studio	Formulates a politic-aesthetic project that handles urban inequality by considering the border between a city and its suburbs. It takes advantage of pedagogic means that make the intangible urban dynamics of thinking and visualization visible.	Ghosn, 2015
transLAB / transSTUDIO	Movement pedagogy in a studio setting aims to develop new transformable-based designs through the cumulative substantiality of theory and practice. Getting involved in an intangible mechanism, including a transformable shading device, makes it possible to heighten awareness of interactions between mechanical limitations and environmental requirements.	Kalantar and Borhani, 2016
Design by Decoding	Code-based research relating to the definition of architecture and the borders of a designer's role. Case studies describe the creation process of digital architectural discourses/spatial production utilizing cultural software and plays.	Pearson, 2017
Social	Generating specific and significant programmatic content for social, cultural, and	Fullaondo and Gauci

Condenser Studio	technological contexts based on the present condition. The pedagogic framework and methodology of the studio do not separate diagram from design. As part of the design, diagrams pertain to the informative and definitive level of the architectural object.	Seddon, 2018
Un-Working Studio	Workshop format to enact new pedagogical paradigms within design education. The workshop serves as an experimental platform outside curricular credit models. In ateliers, where architectural production is centered, assumptions are problematized through conversations among architects, educators, historians, and, most importantly, students.	Jacobs and Utting, 2019
Alternate Endings Studio	Inventory practices of the modern demolition industry. In studios, material strategies and material management focus on urban networks, from environmental policy to spatial order.	Li, 2019
The virtual Other Studio	Three prominent technologies, such as design users (or digital human figures), software users, and user avatars, have become prominent. Various virtual applications corroborate the opinion that design information is a techno-social action in architectural practice and education.	Canizares, 2020

Adapted by authors from "A Joint Manifesto for Design Studios based on Residuals and Experiences", Kılıçaslan, H., Kalaycı, P. D. (2021)

Appendix B: Comparison of Project Brief of Non-PBL and PBL Cohorts

5th Semester Architectural Design Studio- Non-PBL pedagogy adopted

2015 COHORTS CLASS SIZE 32	HIGH-RISE APARTMENT HOUSING Teacher-driven approach. Area statement and amenities, F.A.R to be achieved common to all students
2016 COHORTS CLASS SIZE 55	INSTITUTIONAL CAMPUS HOUSING-MID-RISE Teacher-driven approach, partial control is given to students to define requirements & clusters. Some attempts at integration of concurrent courses, like building services, and building construction
2017 COHORTS CLASS SIZE 78	LOW-RISE, WALK-UP HOUSING FOR POTTERS COMMUNITY Teacher-driven approach, number of housing units, and typology are common to the class. Focus on occupation/user-centric solutions.

5th Semester level CLPBL, cycle 1 for Architectural Design Studio- PBL Pedagogy Adopted

2018 COHORTS: CLASS SIZE 80 STUDENT-DRIVEN APPROACH	PROJECT BRIEF: STUDENT HOUSING (SECTION B) & SENIOR LIVING (SECTION A) Diversity in real-world problems Diversity in site location Formulation of detailed project briefs by students & identification of issues through primary survey, ensuring a high level of student engagement Development of detailed area statements and requirements by students, working in groups as per PBL norms. A deeper understanding of chosen focus themes & application into the design due to working in groups. CLOs determined as per curriculum-balance of domain knowledge, competencies & skills. Assessment – peer evaluation was introduced at the mid-semester level to assess group work. Sliding scale Rubric designed and shared ahead with students for group assessments

6th Semester level Architectural Design Studio- Non-PBL pedagogy adopted

2015 COHORTS CLASS SIZE 32	ENGINEERING INSTITUTE CAMPUS Teacher-driven approach. Area statement and amenities, F.A.R to be achieved common to all students. A contoured Site was chosen as per the curriculum requirement.
2016 COHORTS CLASS SIZE 55	INSTITUTIONAL CAMPUS Teacher-driven approach. Area statement and amenities, F.A.R to be achieved common to all students. A contoured Site was chosen as per the curriculum requirement.
2017 COHORTS CLASS SIZE 77	MIXED-USE DEVELOPMENT- COMMERCIAL AND RECREATIONAL USE- COMPETITION DESIGN. BRIEF DRAWN FROM COMPETITION BRIEF Group work. A collaborative studio model with a partner institution was attempted during initial concept generation and ideation.

6TH Semester level CLPBL, cycle 2 for Architectural Design Studio- PBL Pedagogy
Treatment & Control Groups

2018 COHORTS: CLASS SIZE 40	INSTITUTIONAL CAMPUS FOR DESIGN DISCIPLINES Diversity in the area program & in identifying selected zones for development within a larger site ensures each design develops uniquely.

		Formulation of the design brief is defined by students, giving greater control and ownership over the design. Stakeholder feedback is feeding into research on the area program and concept. Group work fosters a Deeper understanding of chosen focus themes and applications in design. CLOs determined as per curriculum-balance of domain knowledge, competencies & skills. Assessment- Individual deliverables are determined within the group due to the larger scope of work, with a detailed rubric
2018 COHORTS: CLASS SIZE 39	CONTROL GROUP	RESORT DESIGN The common area program for all students is formulated by the faculty. A contoured common site was chosen for all students. Design solutions were in groups of 3 or 4 per group. Students formulated the groups. Traditional assessment methods were adopted.

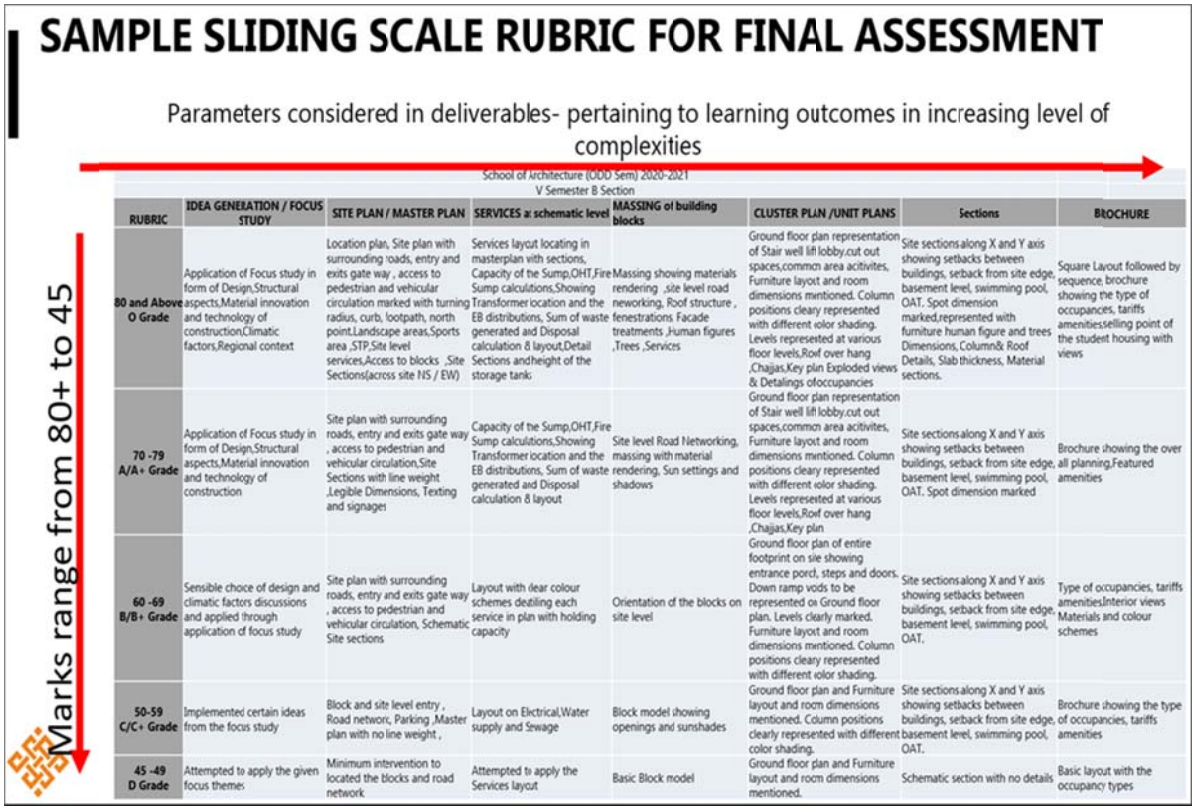
Appendix C: Sliding Scale Rubrics for Assessments

SAMPLE SLIDING SCALE RUBRIC – MID SEMESTER EVALUATION

Marks range from 9+ to 5 and below

Parameters considered in deliverables with varying complexities

RUBRIC	9-10 marks	7-8 marks	6-7 marks	Below 5 marks
Master plan	Location plan, Site plan with surrounding roads, entry and exits gate way , acess to pedestrian and vehucular circulation marked with turning radius, curb, footpath, north point.Landscape areas,Sports area ,STP,Site level services,Access to blocks	Siteplan with surrounding roads, entry and exit gate way , acess to pedestrian and vehucular circulation marked with turning radius, curb, footpath, north point.Landscape areas,Sports area and other common areas	Site plan with surrounding roads, entry and exits gate way , acess to pedestrian and vehucular circulation north point.Landscape areas,Sports area and other common areas	Block and site level entry , Road netwook, Parking ,Master plan with no line weight ,
Building plans with furniture layout	Ground floor plan representation of Stair well lift lobby.cut out space,common area acitivites, Furniture layout and room dimensions mentioned. Column positons clearly represented with different color shading. Levels represented at various floor levels,Roof over hang ,Chajjas,Key plan	Ground floor plan of entire footprint on site showing entrance porch, steps anddoors. Down ramp voids to be represented on Ground floor plan. Levels clearly marked. Furniture layout and room dimensions mentioned. Column positions clearly represented with different color shading.	Ground floor plan and Furniture layout and room dimensions mentioned. Column positions clearly represented with different color shading.	Ground floor plan and Furniture layout and room dimensions mentioned.
ections (across site NS / EW)	Site sections along X and Y axis showing setbacks between buildings, setback from site edge, basement level, swimming pool, OAT. Spot dimension marked,represented with furniture humas figure and trees	Sitesections along X and Y axis showing setbacks between buildings, setback from site edge, basement level, swimming pool, OAT. Spot dimension marked	Site sections along X and Y axis showing setbacks between buildings, setback from site edge, basement level, swimming pool, OAT.	Schematic section with no details
idea of Focus Study in design	Application of Focus study in form of Design,Structural aspects,Material innovation and techology of construction,Climatic factors,Regiona context	Application of Focus study in form of Design,Structural aspects,Material innovation andtechnology of construction	sensible choice of design and climatic factors discussions and applied through application of focus study	Implemented certain ideas from the focus study
Services at schematic level (Electrical /water supply/Sewage)	Water supply,Electrical.Drainage Service lines in Master plan showing slope arrows and spot dimension, Detail section of ground level piping, Storm water management and sewer channels	Water supply,Electrical.Drainage Service lines in Naster plan, Detail section of ground level piping, Storm water management and sewer channels	Water supply,Electsical.Drainage Service lines in Master plan, Storm water management and sewer channels	Basic services line represented with legends
Massing analysis of building blocks	Massing showing materials rendering ,site level road newoking, Roof structure , fenestrations, Facade treatments ,Human figures ,Trees ,Services	Sitelevel Road Networking, massing with material rendering	Block model showing openings and sunshades	Basic Block model



SAMPLE SLIDING SCALE RUBRIC FOR FINAL ASSESSMENT

Parameters considered in deliverables- pertaining to learning outcomes in increasing level of complexities

Marks range from 80+ to 45

School of Architecture (ODD Sem) 2020-2021
V Semester B Section

RUBRIC	IDEA GENERATION / FOCUS STUDY	SITE PLAN / MASTER PLAN	SERVICES at schematic level	MASSING of building blocks	CLUSTER PLAN /UNIT PLANS	Sections	BROCHURE
80 and Above O Grade	Application of Focus study in form of Design,Structural aspects,Material innovation and technology of construction,Climatic factors,Regional context	Location plan, Site plan with surrounding roads, entry and exits gate way , access to pedestrian and vehicular circulation marked with turning radius, curb, footpath, north point,Landscape areas,Sports area ,STP,Site level services,Access to blocks ,Site Sections(across site NS / EW)	Services layout locating in masterplan with sections, Capacity of the Sump,OHT,Fire Sump calculations,Showing Transformer location and the EB distributions, Sum of waste generated and Disposal calculation & layout,Detail Sections andheight of the storage tanks	Massing showing materials rendering ,site level road networking, Roof structure , fenestrations Facade treatments ,Human figures ,Trees ,Services	Ground floor plan representation of Stair well lift lobby.cut out spaces,common area acitivites, Furniture layout and room dimensions mentioned. Column positions cleary represented with different color shading. Levels represented at various floor levels,Roof over hang ,Chajjas,Key plan Exploded views & Detalings ofoccupancies	Site sections along X and Y axis showing setbacks between buildings, setback from site edge, basement level, swimming pool, OAT. Spot dimension marked,represented with furniture human figure and trees Dimensions, Column& Roof Details, Slab thickness, Material sections.	Square Layout followed by sequence, brochure showing the type of occupances, tariffs amenitiesselling point of the student housing with views
70 -79 A/A+ Grade	Application of Focus study in form of Design,Structural aspects,Material innovation and technology of construction	Site plan with surrounding roads, entry and exits gate way , access to pedestrian and vehicular circulation,Site Sections with line weight ,Legible Dimensions, Texting and signages	Capacity of the Sump,OHT,Fire Sump calculations,Showing Transformer location and the EB distributions, Sum of waste generated and Disposal calculation & layout	Site level Road Networking, massing with material rendering, Sun settings and shadows	Ground floor plan representation of Stair well lift lobby.cut out spaces,common area acitivites, Furniture layout and room dimensions mentioned. Column positions cleary represented with different color shading. Levels represented at various floor levels,Roof over hang ,Chajjas,Key plan	Site sections along X and Y axis showing setbacks between buildings, setback from site edge, basement level, swimming pool, OAT. Spot dimension marked	Brochure showing the over all planning,Featured amenities
60 -69 B/B+ Grade	Sensible choce of design and climatic factors discussions and applied through application of focus study	Site plan with surrounding roads, entry and exits gate way , access to pedestrian and vehicular circulation, Schematic Site sections	Layout with clear colour schemes detailing each service in plan with holding capacity	Orientation of the blocks on site level	Ground floor plan of entire footprint on site showing entrance porch, steps and doors. Down ramp vods to be represented on Ground floor plan. Levels clearly marked. Furniture layout and room dimensions mentioned. Column positions cleary represented with different color shading.	Site sections along X and Y axis showing setbacks between buildings, setback from site edge, basement level, swimming pool, OAT.	Type of occupancies, tariffs amenities,Interior views Materials and colour schemes
50-59 C/C+ Grade	Implemented certain ideas from the focus study	Block and site level entry , Road network, Parking ,Master plan with no line weight ,	Layout on Electrical,Water supply and Sewage	Block model showing openings and sunshades	Ground floor plan and Furniture layout and room dimensions mentioned. Column positions clearly represented with different color shading.	Site sections along X and Y axis showing setbacks between buildings, setback from site edge, basement level, swimming pool, OAT.	Brochure showing the type of occupancies, tariffs amenities
45 -49 D Grade	Attempted to apply the given focus themes	Minimum intervention to located the blocks and road network	Attempted to apply the Services layout	Basic Block model	Ground floor plan and Furniture layout and room dimensions mentioned.	Schematic section with no details	Basic layout with the occupancy types

Appendix D: Assessing the 5th Semester Housing Studio NON-PBL and PBL Questionnaire Survey

Open Ended:

1. Describe the design brief of your housing studio and indicate the Site location and case studies done towards initial research

2. Elaborate from memory on the Site area, FSI/FAR achieved, ground coverage, typology mix, and any other regulations considered

3. Describe your concept and planning philosophy applied

Sliding scale:

4. Choose from below the milestone you reached at the end of the studio as per your learning speed and tempo on a scale of 1 being lowest to 3 highest- i) I resolved horizontal and vertical circulation in my block plans to the level of

- Unable to arrange my vertical core and corridors to the optimum level (1)
- Somewhat resolved the circulation to a satisfactory level (2)
- Achieved desirable vertical core for services and circulation, and optimized corridors (3)

5. Choose from below the milestone you reached at the end of the studio as per your learning speed and tempo on a scale of

1 being lowest to 3 highest- ii) Ability to resolve requisite parking, at grade and basement level

- Avoided Basement parking as I could not resolve (1)
- Mostly resolved Parking at Grade, but accommodated under a few blocks (2)
- Achieved Basement parking with ramps, requisite 4W and 2 W parking (3)

6. Choose from below the milestone you reached at the end of the studio as per your learning speed and tempo on a scale of 1 to 3: iii) Ability to integrate social interaction and community spaces into the design

- My social spaces were not deeply embedded into the design within blocks and between blocks (1)
- My Interaction spaces were somewhat embedded within blocks as courtyards (2)
- My social interaction spaces had a hierarchy, were desirable in scale and volume, and community activities were well integrated (3)

7. Choose from below the milestone you reached at the end of the studio as per your learning speed and tempo on a scale 1 to 3: iv) Applied concurrent learning from Structures, building construction, Building services into the masterplan and block plans

- only applied knowledge of one domain (1)
- Applied knowledge of more than one domain (2)
- Applied knowledge of all 3 domains to a satisfactory level (3)

8. Choose from below the milestone you reached at the end of the studio, as per your learning speed and tempo on a scale of 1 to 3: I communicated the design through a presentation to the juror

- Used Manual drawings (1)
- Attempted software but gave up as I could not grasp it (2)
- Used Software and blended with manual work, 3D models (3)

9. Elaborate on the most challenging and confusing part for you in the design development during the progress of the studio *

10. During the concept stage and spatial program, most support in my design process was received from

- Studio in charge
- Friend/Peer
- Seniors

11. During the master plan and clustering of units, most support was received from

- Studio in charge
- Friend /Peer

- Senior student

12. During the presentation stage, most support was received from
    - Studio in charge
    - Friend/Peer
    - Seniors

13. Was there any point when you would have liked to resolve the design in a group in collaboration with peers?
    - Yes
    - No

14. State 3 unique/special learning from the Housing studio from your perspective

15. Mark the level of satisfaction from the Housing studio on a scale of -3, -2, -1,0, +1, +2, +3 on -i) support from Studio In-charge
    - ❖ -3: The Studio in charge did not even know I existed, and I rarely attended
    - ❖ -2: Studio in-charge confused me, and I struggled with resolving the design
    - ❖ -1: Studio in charge guided me initially, and after that, lost interest as I was struggling
    - ❖ 0: The Studio in charge did the design for me
    - ❖ +1: Studio-in-charge supported and guided me to think critically
    - ❖ +2: Studio in-charge gave me useful input, but let me develop my design
    - ❖ +3: Studio in-charge challenged me to think out of the box and come up with multiple iterations

16. Mark the level of satisfaction from the Housing studio on a scale of -3, -2, -1, 0, +1, +2,+3 on -ii) Quantum of Self-directed learning (SDL)
    - ❖ -3: Self-learning was not encouraged
    - ❖ -2: Self learning stopped with the literature review and case study
    - ❖ -1: Self learning continued with visiting the Site and inferring site conditions
    - ❖ 0: Self learning continued with referring to standard books in the library
    - ❖ +1: Self learning continued by watching other students resolve their design
    - ❖ +2: Self learning continued by applying domain knowledge from previous semester courses like BCM, Services, Theory, and Structures
    - ❖ +3: Self learning reached teaching myself software skills and applying them in presentation drawings

17. Mark the level of satisfaction from the Housing studio on a scale of -3, -2,-1,0,+1,+2,+3 on -iii) Level of control and

decision-making power experienced in the Design process

- -3: The Brief was too structured, and I did not get any choice
- -2: Some class opinion was accepted for Site selection
- -1: Some freedom given in clustering of units and achieving requisite units
- 0: Freedom to develop the Master plan but no freedom in regulations, number of floors, clustering
- +1: Freedom to choose alternate building technology, finishes, planning principles
- +2: Complete freedom to develop the Masterplan, no of units, floor heights, technology, and design philosophy
- +3: We developed our unique design brief, and every student's approach was different

18. Lastly, in the years gone by, have you reflected positively on your Housing studio experience

- Yes
- No

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