

## **Comprehensive Evaluative Perspective of PBL on the Learning-Teaching Process of Architecture in the Universidad Simón Bolívar**

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### **ABSTRACT**

*The learning process in architecture at Universidad Simon Bolivar is based on confronting students with practical or theoretical situations to let them acquire knowledge about the discipline. The core of this process is on design studio courses, and from the early stages of the program they have to discover for themselves the role of architecture in the creation of spaces. Alongside this design methodology, students are exposed to theoretical, historical, and technical knowledge that aims to complement their skills for their professional future. This paper evaluates the general efficiency of the learning process based on solving problems. The first part describes the application of a problem-based situation in a sustainable urban environment for the Architectural professional. The second part explores similarities and differences among Design Studio Learning(DSL), as it is generally applied, and Problem-Based Learning (PBL). Data about methodology, level of student participation, and results were compared using the syllabus. The comparison between title, competences and objectives shows that these aspects should be addressed differently if using PBL.*

**Keywords:** Universidad Simon Bolivar, Architecture, Syllabus, Design Studio, PBL Learning Process Efficiency, Sustainable Cities

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## **INTRODUCTION**

The learning process of architecture at Universidad Simon Bolivar is developed confronting students with practical or theoretical situations to let them achieve elementary knowledge of the discipline. The core of this process is based on design studios, and from early stages they must discover for themselves, with the guide of professors, what elements conform a space. They also explore how those elements could be combined in such manners to distinguish architecture beyond individual preferences. The students are also taught other theoretical, historical, and technical knowledge that aims to complement and complete the spectrum of the desired skills for the future professional. As students progress through their career, problems gain complexity, requiring a deeper level of interpretation. The degree of success of this methodology could be more efficiently assessed in senior years, when students are exposed to different situations and have gained problem-solving experience.

This paper evaluates general efficiency of the learning process through the application of a problem-based situation in a sustainable urban environment. This includes the comparison of the advantages of the methodology in accordance with the curricular design of the program, particular characteristics of the institution, and specific content of each subject.

The paper is organized in two sections. The first part describes the application of a problem-based situation in the scenario of the City Lab Project. The second part explores similarities and differences between Design Studio (DSL) and Problem-Based Learning (PBL).

Both parts deal with a one-year sequence that included three parts. First, a preparation term related to the overall planning conditions of the municipality and the limits between the informal settlement of Petare and La Urbina. Second, a term related to the specific border between the two communities. The last term only targeted Petare.

## **A CITYLAB MODULE**

The topic of this module was the issue of informal city, which allow us to evaluate the integration of different disciplines in a very complex situation, and to achieve a sustainable approach. These spontaneous settlements were developed as part of urban process of large metropolitan areas in Latin American cities like Caracas. Students were

given basic information about the growth process and the potential transformation of these areas into regular city districts.

This experience was implemented through a participative design process between undergraduate students and communities from the sector of Petare Sur. Students were organized in teams and assigned a sector. Each sector had leaders chosen and recognized by its inhabitants.

### **The case study: Petare Sur, Caracas, Venezuela**

Petare Sur is a collection of different neighborhoods or barrios, some of them established in the 1950's. These communities began to settle in the hills around the colonial town of Petare, in the east side of the Caracas's Valley. There was no planning involved in the process of organization except for previous infrastructure and roads that connected the town with the outskirts of Caracas.

The methodology applied began with specific activities in order to understand site conditions as well as community organization, municipal authorities, and professional urban plans or academic studies that were previously developed for the area.

### **Definition of the problem**

Spontaneous settlements in Caracas are characterized by of the geographical conditions in which they are developed, the pattern of occupation of the land, the infrastructure, the architectural solution for housing types, and its community organizations.

Critical urban problems of Caracas' barrios are associated with the density, the lack of appropriate infrastructure and services, poor quality of public spaces and institutional facilities, and severe environmental issues related with water and garbage disposal. Specific social issues are typical for this kind of urban areas where crime and violence have created a sensation of fear for their inhabitants, historically neglected by the state and its institutions. From the economic point of view, they are not integrated into the formal city and therefore there are scarce opportunities for employment or commercial services. Legally, tenure rights are not fully recognized. In some cases, these houses are multifamily residences in which families have invested most of their savings, becoming their only real capital.

### **Identification of most important urban issues**

Based on direct contact with the communities, visits to the site and extensive bibliographical information, students were able to establish the problems requiring technical or institutional solutions. The main problems identified in the first stage of the studio were:

### *Accessibility and mobility*

Due to the steep hills, accessibility and mobility are critical for the inhabitants. In general, the area has been developed intensively since it is located close to the subway, Metro de Caracas, with proximity to two stations, and some other mass transit solutions. The real problem is the interchange from the metro system to regular transportation including formal buses and the intensely used informal jeeps and moto-taxis.

### *Lack of public spaces*

One of the most frequent problems is the lack of public spaces for different age groups. The urban pattern leaves, however, multiple open spaces that are undefined both publicly and privately.

### *Community organization*

The undefined space become a safety problem that communities try to control by incorporating security devices such as gates and fences, establishing clear limits. This tendency helps the organization of the community, conforming condominium blocks—a concept taken from the formal city residential complexes.

### *Infrastructure and services*

The lack of proper infrastructure and services—water supply, poor sewage, bad drainage system, meager public lighting—are typical conditions in barrios. Problems associated with those services are difficult to solve because they depend on a complex institutional structure that communities cannot manage. Alternative community solutions became the basis for some students' projects.

### *Public facilities*

When establishing the conditions for the infrastructure of services such as education, health, sports, recreation, and culture, one of the first conclusions was that some of the facilities were in good condition but not interconnected as a network. Some others were in very poor form or not big enough. Students were asked to evaluate standards for these kinds of services for each sector and to determine needs and possible ways to compensate them.

### *Risks*

One of the most serious problems were risks related with geological and hydrological conditions. Traces of previous disasters are visible and constantly referred as tragedies that could repeat. Most of the vulnerable areas have been indicated in maps and official documents but they were not clearly protected as a sensitive space in which constructions should not occur.

### *Environmental issues*

Some critical environmental issues were detected in many places such as the presence of garbage in areas of easy access and related to the recollection route. Often, areas with potential as green spaces or water courses have become the back of the houses and get polluted by the presence of important amounts of garbage.

### *Institutional fragmentation*

One of the most critical issues is the institutional fragmentation that has an impact on urban management. Not only because there is an inappropriate distribution of responsibilities between local, regional, and national government, but also for political reasons as authorities elected at each level are not ideologically aligned. Therefore, there is an absence of institutional presence or bad coordination undertaking urban plans, actions, and functions.

### **Analysis process**

Once problems were clearly identified, teams had to develop specific site analyses. They had to work simultaneously as a class and as a team, in relationship with their communities. As a class they had to get data from different sources such as academic studies, urban plans, or official projects. The teams had constant meetings with the community and site visits to create proper documentation for the project: drawings, photographs, and models. This allowed them to have a direct perspective of the situation and get familiar with site conditions.

The experience helped students understand the real purpose of an analytical process for specific urban conditions and to look for questions before providing anticipated answers.

### **Design strategies**

The studio proposed several scales of intervention: as a general district; as a collection of neighborhoods, and also as particular places with local identity. Each team developed urban proposals and architecture projects operating at the three different scales.

### **First scale of intervention**

The first scale was an architectural intervention on a small public space under precarious conditions. It was a sort of tactical urbanism strategy, with a place identified by the community and selected with the participation of the students, based on its potential and real problems. Students developed their preliminary ideas that were constantly reviewed by the community, the studio professors, and several consultants. The resulting fourteen projects were presented in a private competition, in front a jury of multidisciplinary experts to select the best five proposals.

Students were able to produce feasible projects based on real needs and opportunities in terms of available materials, human resources, and capacities for their implementation. The projects were presented with videos, images, descriptions, budgets, and schedules. Most of the winning projects were dealing with abandoned areas that became an opportunity to create places for congregation or social interaction.

Jury evaluation was based on the clarity of the design proposals and their feasibility. One of the most important lessons provided by this part of the experience is related to the scale of the problem as something important to be established from the very beginning. The smaller the problem, the easier it would be to determine a solution and guarantee its participative implementation.

### **Second scale of intervention**

The second scale was related to the development of an urban plan for the specific sector assigned to each team and community. This included the identification of some specific architectural projects combining strategies for improvements of the urban facilities, as well as the integration of a network of public spaces, connectivity and mobility and environmental issues. The architectural solutions were designed preliminarily.

These urban plans stimulated students to work in teams not only in a specific area but also with other groups representing neighboring communities. Negotiation was a key tool for the coordination of several adjacent proposals, obligating students to consider different points of view about specific problems. One of the main aspects at this scale was the organization of houses into condominium to guarantee a reasonable social structure. The learning process was clear by relating the problem at the first scale as an instrument for understanding the overall area and the complexity of situations at an urban level.

### **Third scale of intervention**

The third scale was related to the urban organization of all sectors of Petare Sur in relationship with the city in order to determine ways to integrate effectively its physical, economic, and social conditions. It included a series of strategies for the intervention of public spaces, solutions to improve the conditions of mobility and transportation, and a network of public facilities for education, health, culture, and recreation.

This scale of the project allowed students to develop full architecture projects for specific sectors of a general plan. These projects were based on the established priorities and related to the previous scale. The notion of phasing became very important for the general plan but also for the specific architecture solutions that were developed as a first phase of the urban strategy.

## Objectives for Sustainable Development

Problems identified in the studio were related to the Objectives for Sustainable Development, in particular with objective 11 which intended to achieve cities and human settlements that are inclusive, safe, resilient, and sustainable. The goals and actions are shown in Table 1.

	<i>Objective by 2030</i>	<i>Actions proposed</i>
11.1	<i>Ensure access for all people to their homes and basic adequate, secure and accesible services and improve the conditions of marginal settlements.</i>	This objective became critical in order to establish the problem, develop a complete analysis, define an urban and architectural strategy and design some of the projects.
11.2	<i>Provide access to transportation systems that are safe, accesible and sustainable for everyone and improve the security in transit, particularly by expanding the section of roads for public transportation, with special attention to the needs of people that are vulnerable, women, children, people with disabilities and senior citizens.</i>	Community indicated accessibility and mobility as the most important problems. The main road system could be improved by organizaing of public transportation and its linkage with the pedestrian network, but many pedestrian paths and stairways are not appropriate for senior citizens and people with disabilities.
11.3	<i>Increase the inclusive and sustainable urbanization process and the capacity for a participatory planning and management process, integrated and sustaible of human settlements in all countries.</i>	This became a fundamental goal since community participation was the key element. It would be almost impossible to plan any urban strategy in a spontaneous settlement without the incorporation of the community in all phases of the process.
11.4	<i>Double the efforts to protect and preserve the cultural and national heritage of the world.</i>	For the students the notion of cultural heritage was inherent to the community and their cultural, musical or religious traditions. Some of those traditions became an excuse for the development of proposals with impact on the physical conditions.
11.5	<i>Reduce in a significant manner the number of deaths and affected people by disasters, including the ones related with water and reduce sustancially the direct economic losses related to the internal gross product of the world caused by disasters, with particular emphaiss on the protections of the poor and people in vulnerable conditions.</i>	This goal was relevant because of the necessary relocation of an important number of houses to prevent the consequences of natural disasters. Additionally Caracas is located in a tropical country with two main seasons, summer and a very intense rainy winter.
11.6	<i>Reduce the negative environmental impact per capita of cities, paying partiular attention to the quality of air and management of garbage.</i>	Quality of air was not so much a problem because in Caracas Valley the wind running from east to west cleaning the atmosphere constantly. Garbage disposal is a general problem in the city and more intense in spontaneous settlements. Most of the areas for intervention were left over spaces that are used as dumps.
11.7	<i>Provide universal access to green zones and public spaces, safe, inclusive and accesible, in particular for women and children, senior citizens and people with disabilities.</i>	The universal access was considered a fundamental aspect for the designs, particularly at the first scale of the proposals.
11.8	<i>Support the economic, social and environmental positive links between urban, periferal and rural areas by reinforcing development plan for nations and regions.</i>	The projects propose agricultural areas, new urban parks, riverfront public spaces and other activities that would improve economic, social and environmental conditions of the community.
11.9	<i>Increase substantially the number of cities and human settlements that have adopted and implemented politics and integrated plans to promote inclusion, efficient use of resources, mitigation of the climate change and adaptation to it, resilience towards disasters, develope and implement integral management of the risks of disasters at all levels.</i>	Inclusion was one of the most important goals since barrios have been traditionally neglected by urban planning and are not integrated with the formal city. To guarantee equal urban rights projects provide public spaces, infrastructure and services comparable to the ones in the formal city.
11.10	<i>Provide support to less advanced countries, even by finnacial and technical support, so they can build sustainable and resilient buildings by using local materials.</i>	Students were asked to use local materials and solve some of the environmental issues by including recycled elements on their designs.

Table 1: Objectives for sustainable development as were adressed by the projects

**Achievement of Learning Objectives**

Achievement of the learning objectives was measured through practical interactive activities, individual and group questionnaires, final group projects, presentations, multiple group collaboration and by the performance of all activities in the class and particularly in their close interchange with the community. This was also compared with the design quality of all the proposals at the three scales. Projects and plans were also evaluated by their capacity to solve specific problems and their feasibility for execution. Students' projects covered the majority of the case study's area and most of its significant problems. The projects demonstrate that good quality architecture and coherent urban plans can improve the quality of life for people in poor communities where the lack of formal institutional strategy for interventions creates opportunities for a participatory design process that can lead to real transformations of their habitat.

Results show different levels of knowledge integration and the difficulty of a significant number of them for correlating the already acquired skills in a practical and conscious manner. This could need a revision of the level of accomplished objectives of the methodology and its relationship with other subjects which don't apply the PBL methodology. Another relevant aspect was the evolution and progressive changes in the students' perspectives about the integration of skills and about the innovative application of previous knowledge.

One of the key elements of the studio was the regular participation of architect Ana Vargas, who was invited as a visiting professor because of her background working with low income communities. Her team from "Tracing Public Spaces" developed a complete analysis of the area in order to define sectors, community leaders and a full map of local actors, requested by the municipality and City Council of Sucre. This work was fundamental, providing a constant link with community members and organizing the design competition.

**Evaluation**

Evaluation by other professionals took place along the process, including university professors from other departments such as urban planning. Student work was presented on a regular basis to professors of other disciplines to prove their skills in communicating the nature of the problems and ways to approach them to a non-expert audience.

Students also had the chance to interact with experts that have worked in Petare and other informal settlements from both academic and professional points of view. International guests were part of the class structure, giving lectures on previous academic experiences with communities in other countries. The experts also had the chance to visit the site,

meet the community and get to know the projects directly from students that then had the opportunity to explain their problems and solutions in a very analytical and synthetic way. It also allowed students to prove their capacity to express graphically, to identify the most important problems and guarantee appropriate design solutions related to them.

### **IS THE DESIGN STUDIO ALWAYS PROBLEM-BASED LEARNING?**

There are strong similarities among Problem Based Learning (PBL) and Design Studio Learning (DSL) and for some the last is indeed a type of the former (Cennamo, 2011). There is also the contrary position, maintaining that “the design studio is sometimes wrongly assumed as PBL” (Green-Bonollo, 2013). This section explores the similarities and differences of both methods, as they were applied in the Architectural Design Studio at Simon Bolivar University in two consecutive courses, between September 2016 and March 2017. Both courses studied the same site, the limit between the formal and informal city in Petare–La Urbina and shared many students in their fourth year of architectural studies.

The first of these experiences (henceforth DS-1) followed the traditional methodology used at the University. The second (DS-2) was a hybrid proposal based on the Aalborg PBL model. Data about objectives, methodology, level of student participation and results will be compared using both courses’ syllabi and the evaluation acts of design courses between 2013 and 2018.



*Figure 1: DS-2 Vertical Workshop, USB. January-March 2017*

DS-1, with 16 students, corresponds with Design VI; DS-2 was a course with 21 students of various levels, Design VII, VII and IX. Both courses were mandatory as part of the architecture curriculum; in DS-2 the students could choose between two options. Due to conditions not related with PBL, most students preferred the alternative option. As the

students with higher grades can choose first, in DS-2 the average grade (2.88 over 5.00) was lower than average (3.39 over 5.00).

**Title**

In DS-1, the title shows the thematic and a way of approaching the problem, offering a solution from the beginning. In DS-2, the title is inexplicit, opening space for the students’ and local actors’ participation. This space allows students to search by themselves not only the solution, but also the problem to be tackled. Even understanding the title in DS-1 in its more ample meaning, it conditioned both the look over the territory and the possible solutions.

DS-1	Caracas city. Limits and segregation. The bridge project as solution
DS-2	East of Caracas. Inquiries from the fragment towards a sustainable city project

Table 2: Titles of both case studies

**Competences**

The contents are pretty similar, almost identical. Additionally DS-2 sets three clear categories of competences showing the aspects the student is expected to develop. The detailed definition of competences allows for more clarity, establishing the methods to reach them, and guides the evaluation of results, not only related to the project proposed but also relative to the competences. The students are then encouraged to develop their own capabilities rather than accomplish the professor’s established goals.

The contents were mainly related to specific architecture topics, while the competences were more broadly defined

DS-1	DS-2
<ul style="list-style-type: none"> <li>• Introduction to urban design, sustainable architecture, landscape, urban morphology and city.</li> <li>• Principles of architectural composition, typology of the building, the conditions of complex programs, and the consideration of diverse variables such as: climate, context, social and environmental aspects.</li> <li>• Development of research capacity and conceptualization of the urban design project.</li> <li>• Development of research capacity and conceptualization of the architectural project.</li> </ul>	<ol style="list-style-type: none"> <li>1. Creativity and innovation                             <ul style="list-style-type: none"> <li>• Creative thinking</li> <li>• Team work</li> <li>• Innovation</li> </ul> </li> <li>2. Critical thinking and problem solving                             <ul style="list-style-type: none"> <li>• Effective reasoning</li> <li>• Use of systemic thinking</li> <li>• Issuing judgments and decision making</li> <li>• Solution of real problems</li> </ul> </li> <li>3. Communication and Collaboration                             <ul style="list-style-type: none"> <li>• Clear communication</li> <li>• Collaboration with others</li> </ul> </li> </ol>

Table 3: Competences as described in the syllabi

**General and specific objectives**

In both courses the general objective is dictated by the curriculum, and directly related with architecture’s specific skills.

DS-1	DS-2
Introduce the student in the development of urban design projects, understanding the role of architecture and the natural and built environment.	Develop in the students skills to approach the study of architectural problems of different scales of with programs that allow their insertion in complex urban contexts in order to resolve conflicts related to the city and its immediate surroundings.

Table 4: General objective

The main difference is on specific objectives. In DS-1 the more directive approach of the traditional method is evident, with specific operative and theoretical strategies and particular tools for analysis and representation. DS-2 presents two types of objectives: methodological and disciplinary. The first aimed to develop research capabilities in the students, helping them to identify a problem, and the second group is particular to the course.

DS-1	DS-2
<ul style="list-style-type: none"> <li>• Study the concepts of limit and segregation in an urban environment of varied complexity.</li> <li>• Develop a preliminary diagnosis of the conditions of the Petare-La Urbina-El Marqués urban axis mapping the current conditions, problematic situations and potentialities.</li> <li>• Understand basic concepts such as: urban morphology, building typology, public space, mobility, equipment, environment, risk factors, infrastructure elements, social and demographic component, activities, land uses.</li> <li>• Reinforce the capacity to formulate an idea or architectural concept as the generator of a design solution that articulates relationships between building and place, and between place and territory.</li> <li>• Explore graphic and modeling tools according to the concept of a design solution.</li> <li>• Study the concepts of sustainable design, environment and ecology in the urban context.</li> <li>• Interpret an urban environment through mapping, photomontage and collage as tools for analyzing the different geographical, environmental and social variables.</li> </ul>	<p><u>Methodological</u></p> <ul style="list-style-type: none"> <li>• Develop the student critical thinking.</li> <li>• Assist the student in the construction of a theoretical framework to understand the problem.</li> <li>• Develop the ability of students to identify project opportunities.</li> <li>• Expose students to a real work environment</li> <li>• Develop the ability to present proposals to different stakeholders, adapting the discourse, graphic resources and arguments in an appropriate manner.</li> <li>• Generate a series of plausible projects that can be used by the competent agencies.</li> </ul> <p><u>Urban and architectural</u></p> <ul style="list-style-type: none"> <li>• Interpret an urban context of medium complexity.</li> <li>• Develop the concept of habitat.</li> <li>• Study the notions of sustainable design, environmental issues and ecology.</li> </ul>

Table 5: Specific objectives

### Methodology

Both DS-1 and DS-2 use the studio environment for theoretical-practical learning. The difference rests in the role allotted to each actor. In DS-2 it is specifically stated which activities and responsibilities correspond to each group, including the external ones, which although were in fact present in DS-1, had no assigned roles or specific mention.

DS-1	DS-2
<p>The methodological approach of Architectural Design VI is in the workshop where the student develops the design project through complementary activities that include:</p> <ul style="list-style-type: none"> <li>• Theoretical classes and lectures</li> <li>• Group analysis sessions and research exercises</li> <li>• Group and individual workshop practices</li> <li>• Field work and photographic record</li> <li>• Induction in the management of urban design analysis, synthesis and representation tools</li> <li>• Diagnosis of urban phenomena based on the value of pre-existence, the social component and environmental problems.</li> <li>• Development of freehand drawing, advanced expression of computerized drawing and 2D + 3D codes, urban imaginary and iconography, use of references, analysis and urban synthesis in 3D.</li> </ul>	<p><u>Students</u></p> <p>The role of students in the active search for knowledge is prioritized, synthesizing, for this, all the practical and theoretical training acquired in the architecture curriculum.</p> <p>The workshop should provide a place for interaction, discussion and innovation. By working in groups, students can develop individual criteria as well as common agreements to finally generate group proposals for the selected problem.</p> <p>Students will participate in the processes of self-evaluation and evaluation of the teaching experience.</p> <p><u>Teachers</u></p> <p>The role of the teachers will be to assist as facilitators and guide the progress of the course. The participation of professors from other sections and other departments will be arranged, and they may eventually participate as evaluators and external critics of the global experience.</p> <p><u>Local Actors + Community</u></p> <p>They will bring the student closer to the particular needs of a community and explore negotiation strategies to establish agreements between actors with interests that are not always convergent.</p>

Table 6: Methodologies

In DS-2, the proposed six step methodology for the construction of the problem (Table 7) is noticeable, based on this definition: “Understanding problem building as determining through question the topic to be investigated, the course is presented as a turf not limited, but open to multiple perspectives, in which the interrogations that may arise are not predefined, but will be proposed by the students and developed in discussions and negotiations between peers, teachers and external interest groups. Therefore, the design studio will be the appropriate space to define the problem and its scope”.

DS-2
<ol style="list-style-type: none"> <li>1. <u>Problem explanation</u>. From a given context the students approach to the understanding of the structures and the underlying mechanisms for their concretion.</li> <li>2. <u>Problem discussion</u>. In team, the students will debate different points of view on a topic.</li> <li>3. <u>Problem strategy</u>. Outline of the possible strategies and mechanisms of tackling the problem.</li> <li>4. <u>Study of the problem</u>. Being a problem of an open nature, students will be able to approach their object of study from different places, theoretical, referential, analytical, perceptive.</li> <li>5. <u>Application to the problem</u>. The objective is to apply the acquired knowledge to a specific situation within the proposed context.</li> <li>6. <u>Multiple level problem</u>. Similar to the case study, new questions and inputs will arise as students move forward finding the solution.</li> </ol>

Table 7: Problem building process

This aspect was innovative, as DS-1 did not include this approach. More than to guide the students in the problem building process, the emphasis was on the solutions proposed for the students to a given problem, predefined by the professor. DSL tends to make students understand the project not as their own investigation but as an external

commission. This facet has a vital importance in the studio dynamics, as the PBL methodology forces the professor out the center, giving the leading role to the students.

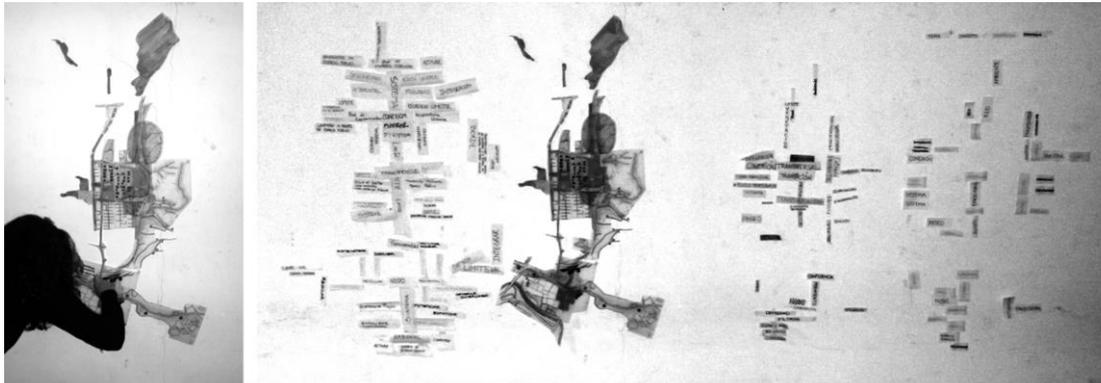


Figure 2: Brainstorming and team dynamic. Problembuilding around the site themes

**Process**

The process and its stages are the more similar aspect between the two syllabi. In both, an agenda is proposed to guide students work, setting a timeframe, and the differences are subtle. The greater number of stages in DS-1 suggests a more meticulous route, more controlled by teachers. The stages are also more detailed.

Professor		Self-assessment	Actors' assessment	Professor vs other actors
Product	Process			
70%	15%	5%	10%	
85%		15%		
70%	30%			Product vs process assessment

Table 8: Evaluation in DS-2

In DS-1 the relevant themes are defined by the teachers. In DS-2 the students search for themes by themselves. It is worth noting that while in DS-1 the themes were the pre-established frame to approach the place, in DS-2 it was assumed that the themes emerged from the place. As DS-1 was the course previous to DS-2, and half the students in DS-2 took both courses, the structured themes in DS-1 certainly had an influence and facilitated the more flexible approach in DS-2.

In DS-1 the material to be produced in each stage is also more detailed, indicating the specific drawings and their desired scales. In DS-2 the scale of drawings (an indicator of the desired level development of the project and its size) is stipulated only in the last stage.

**Dynamics**

The relative participation of each actor was estimated based on the activities stated in the

course's 12 week chronogram, assigning a percentage to each actor. In some activities, like brainstorming, team work, site visits, or interaction with community, the students have the leading role, and were assigned a high percentage (90%-100%) of participation. The critiques or lectures were led by teachers, who got the high portion of participation. The normal activity in the workshop was considered as shared by both actors, with 50% assigned to each one of them. A weekly average was calculated for each group. In DS-2 the participation of other actors was also included, such as community and local government officers.

Activity	Students	Teachers
Workshop	50%-60%	50%-40%
Lectures, critics	10%-20%	80%-90%
Brainstorming, site visits, team work, personal work	80%-100%	0%-20%

Table 9: Estimation of the relative participation of actors in each activity

Weeks	Teachers				Students			
	Monday	Tuesday	Thursday	Weekly average	Monday	Tuesday	Thursday	Weekly average
1	100	60	50	70.00	0	40	50	30.00
2	60	50	50	53.33	40	50	50	46.67
3	50	50	70	56.67	50	50	30	43.33
4	50	90	70	70.00	50	10	30	30.00
5	50	90	50	63.33	50	10	50	36.67
6	50	50	50	50.00	50	50	50	50.00
7	50	50	70	56.67	50	50	30	43.33
8	50	50	40	46.67	50	50	60	53.33
9	50	50	50	50.00	50	50	50	50.00
10	50	60	50	53.33	50	40	50	46.67
11	50	50	50	50.00	50	50	50	50.00
12	0	0	90	30.00	100	100	10	70.00
<b>Total Average</b>	<b>54.17</b>				<b>45.83</b>			

Table 10: DS-1 Participation of actors along the term

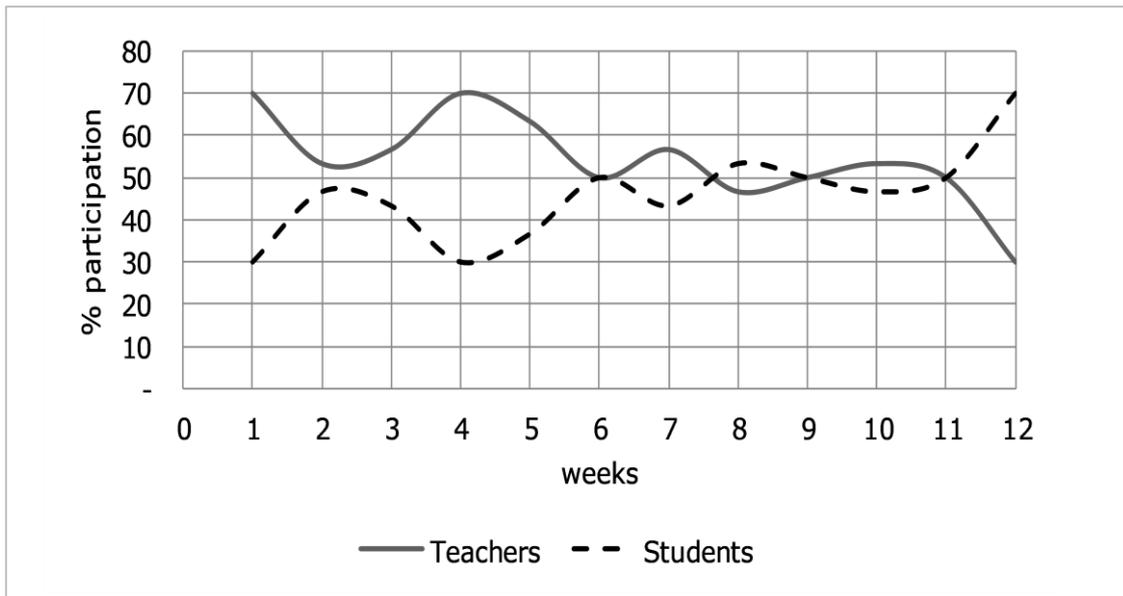


Figure 3: DS-1 Participation of actors along the term, based on data of Table 10

Weeks	Teachers				Students				Others
	Monday	Tuesday	Thursday	Weekly average	Monday	Tuesday	Thursday	Weekly average	Weekly average
1	100	10	10	40.00	0	90	90	60.00	-
2	20	20	0	13.33	80	80	70	76.67	10.00
3	20	10	40	23.33	80	60	60	66.67	10.00
4	30	40	40	36.67	70	60	60	63.33	-
5	30	20	40	30.00	70	20	60	50.00	20.00
6	40	0	40	26.67	60	100	60	73.33	-
7	10	50	50	36.67	90	50	50	63.33	-
8	50	50	20	40.00	50	50	80	60.00	-
9	30	10	50	30.00	70	10	50	43.33	26.67
10	40	20	50	36.67	60	20	50	43.33	20.00
11	10	60	60	43.33	90	40	40	56.67	-
12	0	0	80	26.67	100	100	20	73.33	-
<b>Average</b>				<b>31.94</b>				<b>60.83</b>	<b>7.22</b>

Table 11: DS-2 Participation of actors along the term

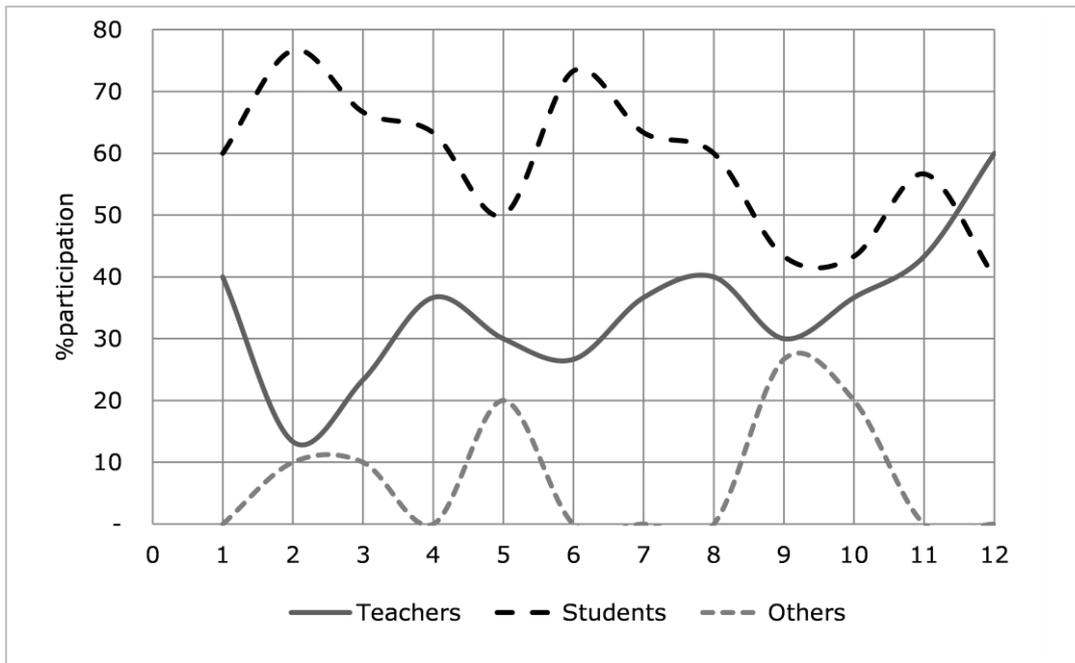


Figure 4: DS-2 Participation of actors along the term, based on data of Table 11

The allocation of participation levels was made based on the time schedule that states the desired dynamics and activities and does not necessarily show actual activities or participation levels during the term. Regular studio sessions, by example, were supposed to be shared by teachers and students, but their relative contribution fluctuated significantly depending on personal attitudes, dedication of students, character of critics and on the moment of the term. Sometimes teachers tend to become more directive near the end of the term if the objectives have not been reached. These subjective differences are difficult to avoid but reaching for goals of higher student involvement and leadership in the chronogram and the syllabus before the course starts, probably help towards a factual decrease of the teachers' participation.

The participation of other actors, such as community and local officers was not permanent, as they shared only in particular activities, such as the site visits and formal arrangement meetings and presentations. However most students went more than once to the site and had a more intense relationship with the community. Even though this participation was documented, it is not easy to measure, and has been dismissed.

### Evaluation

In DS-1 the whole of the grades were established by the teachers. It was not stated how much of the grade corresponded to the product (the project) and how much to the process (participation, team work). In DSL the last criteria is always present, but the product is in general appreciated more. In DS-2, both the external actors and the students participated in the assessments, and an explicit part of the grade corresponded to the process. The

professors' valuation and the quality of project is still the determining aspect (70%), but the inclusion of other opinions and criteria allowed assessing factors apart from the designing skills, such as for example leadership, communication or sensibility to urban and social issues.

The product's high weight in the evaluation has nevertheless advantages. The quantity of material, site analysis, models, and drawings produced during DS-1, and used in both courses, would have been difficult to achieve without a strong directive attitude from teachers prioritizing the product. This is indispensable in the very short terms of only 12 weeks.

In both cases a portion of the grades was individual (70% in DS-1, 65% in DS-2), and the rest was in teams. Although teamwork is normally considered a fundamental aspect in PBL, it is also important in traditional DSL.

**Results**

It was observed that in DS-2 some students, who were weaker designers but strong leaders, demonstrated their abilities and performed better than their personal average. Even if subjective, these observations are valid since in the design studio, teachers and students usually have a very close relationship. The grades of following courses show that for almost every student in DS-2 the improvement was maintained. The DS-2's student with the best improvement, who had among the lowest averages before the course, is highlighted in Figure 5.

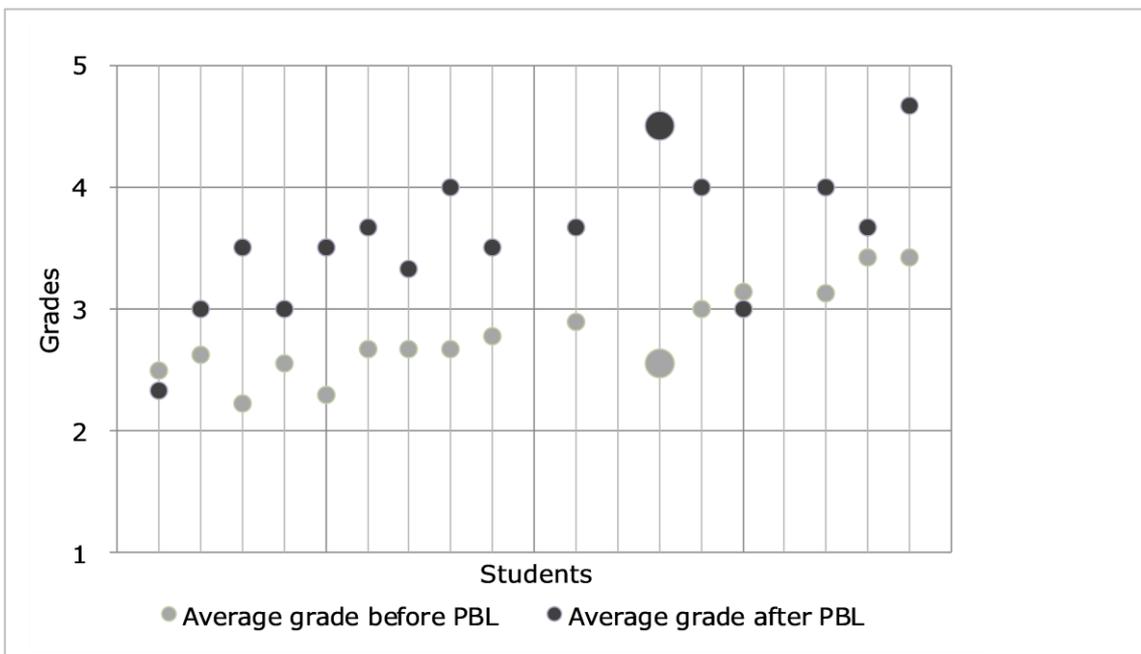


Figure 5: Average grades before and after the PBL courses, by student

In order to validate if there was an actual significant improvement in the grades obtained by the students participating in the PBL model, a brief statistical analysis was conducted. This analysis considered all the grades obtained by the DS-2 students from January 2013 to April 2018; the ones obtained in DS-2, and the grades the same students obtained after.

With this data, a t-test was conducted in order to validate if the differences observed between averages for each stage were statistically significant and could be attributed to

Before	DS-2	After
2.88	3.47	3.64

Table 12: Grades averages for DS-2. Grades over 5 points

the PBL experience. Two-tail T-tests for independent groups were conducted, considering a significance level of 95%.

The statistical analysis suggests that DS-2 students' performance increased significantly after being exposed to this methodology, and that the improvement was maintained after the DS-2 experience.

T-Test	Probability	
1 DS-2 Before Vs. DS-2 After	0.00000	Students from DS-2 experience <b>increased significantly</b> their grades after the experience, compared with their own grades before.
2 DS-2 Before Vs. DS-2	0.00631	Average of grades obtained by the DS-2 students during the PBL experience was <b>significantly higher</b> than their grades before.
3 DS-2 Vs. DS-2 After	0.47317	The grades' increase after the PBL was <b>not significant</b>

Table 13: Analysis of grades average for DS-2 before and after PBL

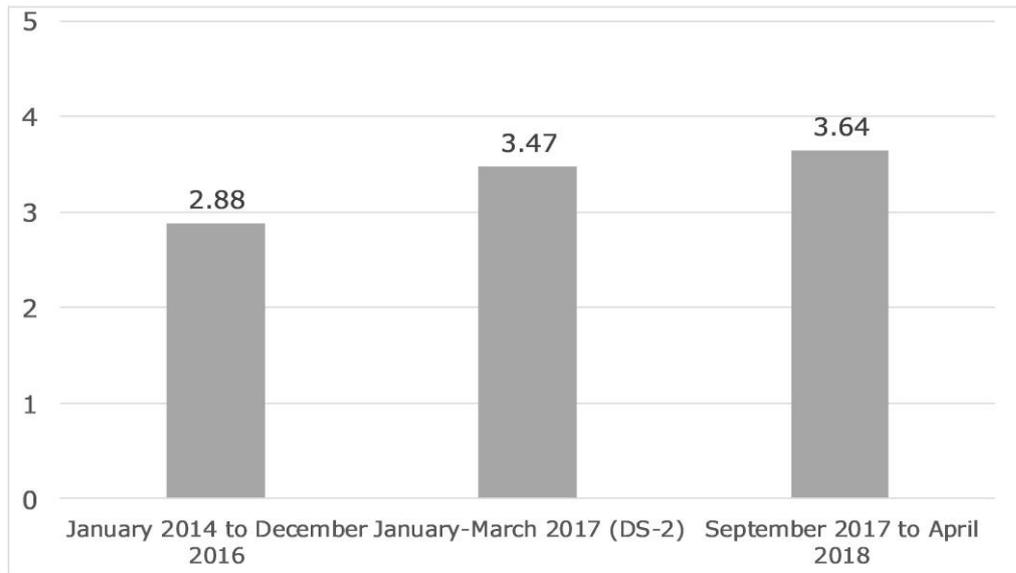


Figure 6: Grade averages for DS-2 (grades over 5 points)

It is also interesting to note the results of the self-assessment, in which each student evaluated their own performance and those of their teammates, in aspects such as initiative, participation, responsibility, creativity and receptivity. For most students the gap between the self-assessment and the view of their team is very small, indicating that, in general, the students were aware of their abilities.

Student	Self-assessment	Team assessment	Final Grade	Difference between self and team assessment	Difference between team assessment and grade
1	3.80	1.80	<b>2</b>	<b>(2.00)</b>	0.20
2	3.80	2.20	<b>2</b>	<b>(1.60)</b>	(0.20)
3	5.00	4.07	4	(0.93)	(0.07)
4	5.00	4.53	5	(0.47)	0.47
5	4.20	3.87	4	(0.33)	0.13
6	5.00	4.80	4	(0.20)	(0.80)
7	4.80	4.73	4	(0.07)	(0.73)
8	4.00	4.00	3	-	(1.00)
9	4.60	4.60	3	-	(1.60)
10	4.60	4.60	3	-	(1.60)
11	5.00	5.00	3	-	(2.00)
12	4.40	4.50	5	0.10	0.50
13	4.80	4.95	3	0.15	(1.95)
14	4.20	4.40	3	0.20	(1.40)
15	4.20	4.40	3	0.20	(1.40)
16	4.60	4.87	4	0.27	(0.87)
17	4.40	4.70	3	0.30	(1.70)
18	4.40	5.00	4	0.60	(1.00)
19	3.00	3.60	3	0.60	(0.60)

Table 14: Self-assessment and grades for DS-2 students

## CONCLUSIONS

### **The projects as the result of interdisciplinary work**

Participation of students from the architecture and urban planning program and the integration of professors from different departments was fundamental for the success of the experience. The institutional structure of programs and departments helped collaboration and constant exchange among students and professors.

Students were able to play roles in order to guarantee objectivity in the process of discussion about problems, strategies and solutions. Architects might have a tendency to control a process as a leader but they should also be trained to incorporate different technical opinions as well as political, social and economic points of view. This is one of the strongest consequences of a learning process based on problems that are real and critical.

### **Development of the project has been guided by the students**

Students were fully responsible for decision making during the courses. They had meetings between teams and also in large numbers up to the whole class. Professors participated as academic advisors with capacity to give orientation to the problem and to help in the decision-making process.

Most of the students were independent in their meetings with the community and visits to the site which required direct coordination. Some of the students developed a very close relationship with community members and representatives.

### **Collaborative process with local partners**

The challenge was defined in collaboration with several authorities from the Municipality of Sucre. The contact was based on previous academic experiences.

Interaction between students and local partners was constant along the process since the community, organized by different sectors or barrios, was related to the municipal authority as well as other levels of government in the area. In that sense, students became links in between institutions but also with other communities that were working with different students.

### **Sustainable Cities challenge**

Project solutions contributed to the fulfillment of the Sustainable Development goals, and in many ways related to some of the most difficult political, economic, social and cultural

situations. Students went beyond the role of an architect, and farther than in other courses, and were capable of understanding the importance of improving the spontaneous settlements as a tool to solve the poverty. It is then possible to say that the PBL methodology helps to stimulate the formation of sensitive professionals for the future vision of our cities.

Although studio environment was appropriate for a PBL approach, the displacement of professors from the center required considerations regarding objectives and methodologies that are not always present in Design Studio.

Inclusion of those considerations on syllabi were needed but not enough; the attention towards keeping the professor's role merely as a guide, and inclusion of other stakeholders should be maintained throughout the course.

Data suggests that using PBL in design studio seems to improve the performance of students and it would be interesting to conduct more extensive statistical analysis among grade averages of students exposed to this methodology and others who did not have the same experience.

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