A Multidisciplinary Design Education Facing Climate Change

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Abstract. To deal with global challenges we face such as climate change, the New European Bauhaus vision depends on educated and empowered citizens. According to this initiative, architecture and urban planning are only effective when a multidisciplinary approach is applied. This is even more important when integrating sustainability into architectural education. This paper presents the results of an experimental study conducted during the first semester of a master's degree program in civil engineering and architecture at the University of Liège and as part of an integrated design process. In this case study, the design studio is not only connected to a Sustainable Architecture and Urban Design course but also, to multidisciplinary interventions provided by different professionals that combine teaching and practice. These interventions include contributions from several fields such as architecture, civil engineering, building envelope, structure, fire safety, heating, ventilation, air-conditioning, and sustainability issues. Students are challenged to work in teams through a collaborative learning process and so to develop in-depth knowledge and understanding of sustainability. Our study is mainly based on examining the whole design process with teaching methods and learning outcomes. Data are collected via questionnaires and interview surveys to figure out students' feedback on this experience. The analysis reveals that professionals 'interventions foster the integration of sustainability criteria through different phases of the design process within an interdisciplinary approach. This paper argues for more transfers between professional practice and teaching for a new generation of conscious architects and engineers aware of current environmental issues.

Keywords: Sustainability · Architecture · Multidisciplinary · Teaching · Practice · Collaboration

1 Introduction: The New European Bauhaus, Bridging the Gap Between Art and Technology in a Global World

One of the defining moments in the history of mankind is the Historical Bauhaus as the ingenious avant-garde movement that shaped the social and economic transition to the twentieth century. From its foundation in 1919 in Weimar to Berlin, and from Walter Gropius to Mies Van der Rohe, the Bauhaus transformed outlooks on innovation by introducing transversality in science, art, design, and architecture [1].

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According to Salama, it was not an isolated phenomenon but a climax and focus of a very complex and multifaceted development. The teaching program taught, by important artists and architects, was holistic aiming at developing the student's personality as well as providing technical skills. The concept behind the Historical Bauhaus was the idea that fine arts and crafts were not fundamentally different activities, but two variables of the same thing [2]. Each industrial revolution has had an impact and shifts on engineering and architecture. The Historical Bauhaus was a response to changing conditions and the same is for the New European Bauhaus.

A hundred years later, we are facing new global challenges. This is bringing new responsibilities for architecture and urban planning since the built environment generates nearly 40% of annual global CO_2 emissions [3].

This alarming situation is emphasized with the earth overshoot day calculated by the international research organization Global Footprint Network, showing the date when humanity's demand for ecological resources and services in a given year exceeds what Earth can regenerate in that year [4]. Therefore, a call for a shifting paradigm is needed for a new generation of conscious architects, engineers, and designers aware of the current environmental issues. This shift means that the way we think our environments has changed, that interdisciplinary thinking is now taking place [5].

It is needed to enhance the implementation of environmental sustainability criteria within the creative design process [6]. To deal with global challenges, the New European Bauhaus vision depends on educated and empowered citizens to face the current era. It is a creative and interdisciplinary initiative where the future of the built environment is situated at the crossroads between art, culture, social inclusion, science and technology [7]. As mentioned by Ursula von der Leyen, President of the European Commission, the New European Bauhaus is intended to be more than just a school of architecture that uses new technologies and techniques. The groundbreaking success of the Bauhaus would not have been conceivable without the bridge to the world of art and culture, or to the social challenges of the time.

The New European Bauhaus should show that the necessary can be beautiful at the same time, that style and sustainability go together [8]. Architecture and urban planning are more effective when interdisciplinarity is applied. This is even more important when dealing with architectural education and research and so integrating sustainability issues. Bridging the gap between professional practice and teaching is needed because without transcending traditional boundaries of disciplines, changes could not be faced [9]. In this context, many universities are committed to improving, understanding and developing skills needed to face these current challenges so students can act and develop solutions to environmental, social, and economic problems.

The University of Liège is no exception with its commitment to contributing to the Sustainable Development Goals adopted by the United Nations. This paper proposes to analyze a pedagogical experience that considers the implementation of sustainability within the whole design decision process, based on collaborative learning and the contribution of different multidisciplinary experts.

2 Method of the Study

2.1 Context and Case Study

Our study took place over four months within the first year of the master's program in civil engineering and architecture within the design studio at the University of Liège and its connection with the course on Sustainable Environmental Design.

In a context similar to an architectural design competition, 21 students are challenged to work together in 6 teams through a collaborative learning process. They are called to design a contemporary building while respecting complex programmatic requirements, form, function, structural systems, spatial qualities…

Sustainability issues in this pedagogical context are represented in terms of the High Environmental Quality initiative for Building (HEQ), based on 14 targets and divided into 4 themes: energy, environment, health, and comfort. For some pedagogical choices made by the teaching staff, only 6 targets are considered in this experience as follows: physical relationship of the buildings with their immediate environment, integrated choice of construction processes and products, energy, water, and waste management, and hydrothermal comfort with its various parameters.

The particularity of this experience is that through this architectural design process, and besides the interconnection between the design studio and the theoretical course on sustainability, students benefit once or twice a month, depending on the evolution of the design process, from the collaboration with different professionals and experts. Therefore, multidisciplinary contributions were provided from several fields including architecture, building envelope, environmental quality, structure, fire safety, accessibility standards, heating, and ventilation to best respond to their architectural choices.

2.2 Methodology and Observation

Throughout the whole design process, the methodology involves qualitative methods that include examining learning activities, teaching methods, professionals' inputs as well as students' outcomes and interviewing them to know their feedback at the end of the design process as shown in Fig. 1.

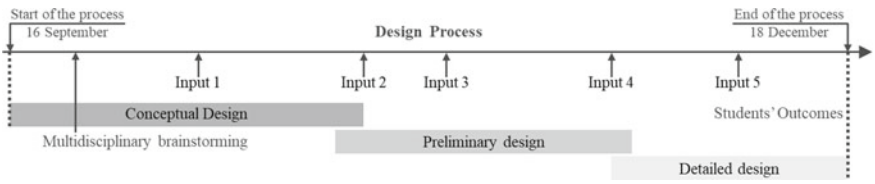
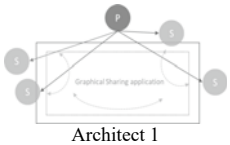
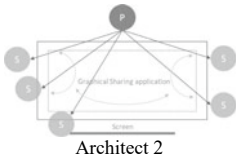
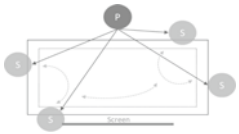


Fig. 1 Professionals' inputs within the design process

3 Multidisciplinary Design Process

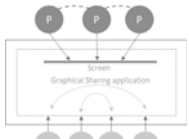
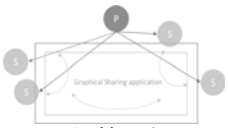
Starting with multidisciplinary brainstorming, the design process becomes more heterogeneous, with several diverse experts involved as it can be seen in Table 1.

Table 1 Multidisciplinary contributions of different professionals

	Time frame	Professionals	Design studio layout	Inputs
Design process (within the design studio)	Multidisciplinary brainstorming starting with all disciplines			
	14 October		 Architect 1	Research phase of architectural choices Functional programming
	24 October		 Architect 2	Architectural composition Formal concept understanding of the urban and architectural context
	6 November		 Engineer (Envelope)	Sustainable materials Envelope Energy efficiency

(*continued*)

Table 1 (*continued*)

	Time frame	Professionals	Design studio layout	Inputs
	21 November		 Engineers (Structure…)	Architectural technology Structural system and regulations
	28 November		 Architect 1	Mastery phase of the design, considering functional, structural and environmental aspects

Collaborative learning and teamwork, Multidisciplinary interactions and inputs

This leads us to develop an integrated approach that combines the different aspects of the building design of the architectural composition, structural engineering, architectural technology, and environmental aspects (HEQ Targets).

4 Results

Through the intervention of different professionals, students acquire and put into practice an interdisciplinary approach using a collaborative, learner-centered approach as opposed to the more traditional teacher-centered approach in the architectural design studio. These contributions lead us to the concept of the integrated design as a teaching method adapted to the pedagogical context. It is defined as an interdisciplinary conceptual approach based on collaborative work. Teaching methods should serve as the bridge to industry, helping students to contextualize their class work in the light of their projections for future roles [10]. Starting from the very beginning of the design process, the goal is to bridge the gap between professional practice and teaching. Their interventions foster the integration of sustainability criteria through different design process phases within an interdisciplinary approach.

The Fig. 2 shows the mobilization of sustainability criteria along the observed design process. It can be concluded that, from the early phases of the conceptual process, most of the sustainability issues are discussed coherently in the various aspects of the design. This paradigm is developed in a holistic way of design thinking that goes hand in hand with all the functional, aesthetic, and technological aspects of the design process while respecting the requirements of the design process.

Based on the concepts of synergies and interconnectedness, this approach is based on the concept of the Whole Building Design and involves two components: an integrated

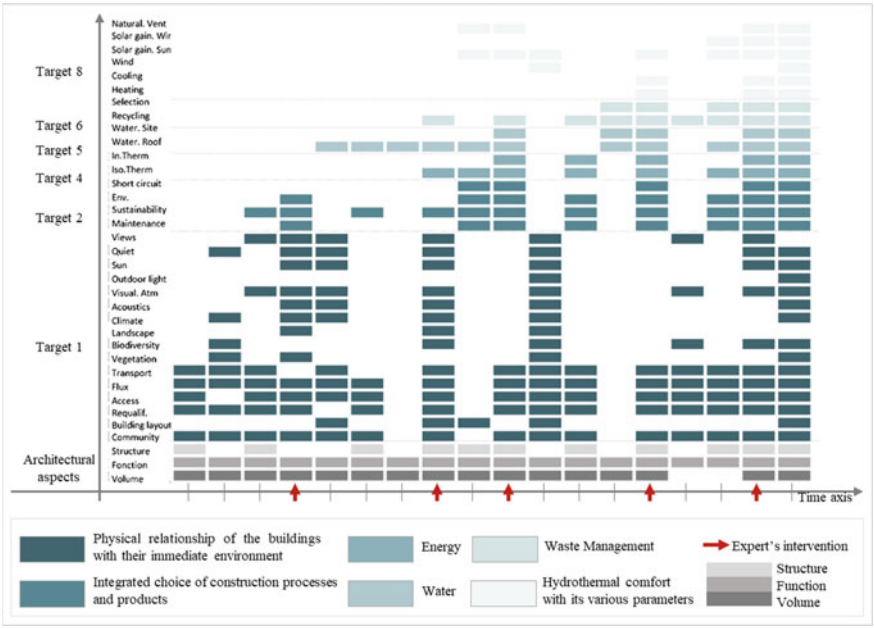


Fig. 2 Visualization of sustainability criteria within the design process (1 team)

design approach and an integrated team process. Through the integrated design approach, all building stakeholders are encouraged to work together throughout project phases and to consider materials, systems, and assemblies from various angles [11]. In contrast to the typical design process, in which specialists with specialized knowledge work isolated from one another, this approach draws on the expertise of a team of specialists who are experienced in their own specialties.

Since the beginning of the design process, students are guided through the conceptual research phase and site analysis to define design solutions that can both optimize natural conditions and create spatial design challenges and opportunities. Then during the preliminary phase and with the intervention of architects and different engineers, students use compositional aspects and volumetric design to propose an architectural choices that can represent a design language for sustainability.

At the end, they have developed construction details and displayed environmental technological solutions as a Mastery phase.

Although results are fully satisfactory, directing students into sustainability criteria turns out relatively difficult, at least at the beginning of the process.

However, with time, it appears that dealing with specific technical environmental and engineering issues in many cases requires corrections to the initial schemes and sketches of the project, with the final benefit for the overall proposal.

This is how the Bottom-Up approach is reached in the design process which is substantially the opposite of the Top-Down approach, where first technical problems are solved and then the architectural composition of the design is created [12].

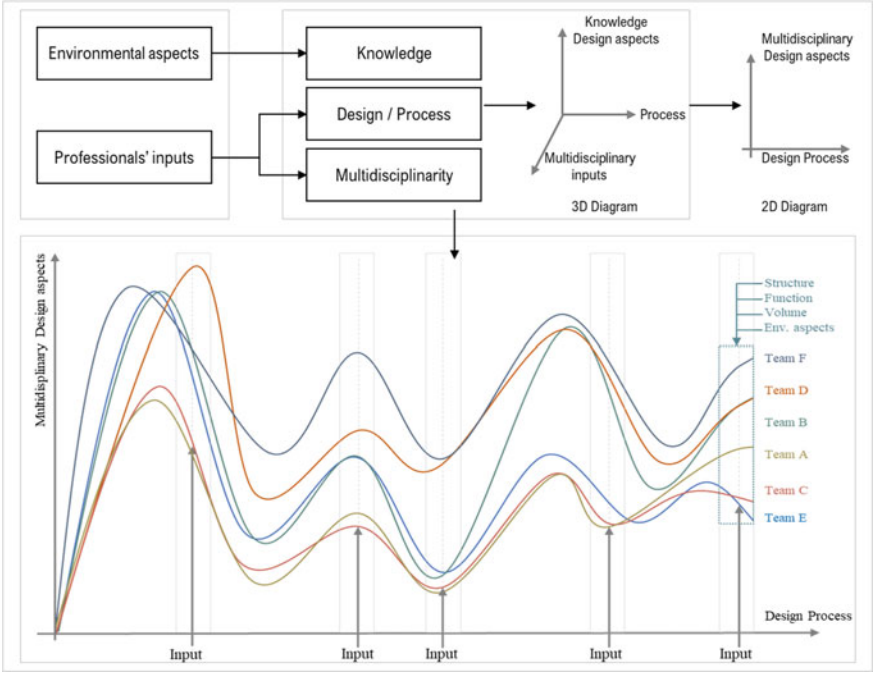


Fig. 3 Illustration of the impact of professionals' inputs

The multidisciplinary aspect of the design starts from the brainstorming stage so that various disciplines intervene from the beginning of the learning process.

Based on the analysis of the data collected during the observation, and on learning outcomes, the study reveals that, after professionals' reviews, each team path is influenced by their mindset and feedback, like shown in Fig. 3.

Their impact differs from one group of students to another. It is the case for all the teams but not with the same level. It depends on different parameters including the complexity of the project, the chosen strategy and the design process.

Dealing with collaboration between students itself needs different levels of knowledge, skills and abilities to acquire to best carry out the design process.

On the other hand, students' answers on different questions show positive feedback towards this experience as we can witness from their comments as follow.

"Sustainable and environmental quality was integrated entirely all along the project and not just at the end of the process" (team B).

"It was an enriching learning experience in terms of the multidisciplinary intervention of several experts from different fields. There was a completely different way of thinking about the design project" (team F).

"The project is more viable than a classic architectural object… Not only have we got an architectural design that is beautiful, inclusive, and sustainable… Beyond the sustainability, but there is also an entire consideration of the architectural design as a whole building design" (team A).

5 Discussion and Conclusion

From the perspective of this study, the projects developed by the students reveal the benefits of professionals' interventions and the collaborative learning that enhance the integration of sustainability within the different phases of the design process.

The biggest challenge faced in this experience is this multidisciplinary character of the profession of architecture but also considering the constraints generated from the early phases of the design process, and the conditions of possible integration of sustainability issues.

In our case, some of the constraints detected are the design process, complexities of the architectural project, the multilayered collaboration, the students' skills (group management skills; inquiry skills; different levels of ability, diverse backgrounds, experiences, and ideas, team strategy…).

Therefore, many learning tools and strategies integrating disciplinary-specific knowledge should be used to achieve an efficient collaborative experience. Formal lectures and theoretical courses are the most common however these teaching approaches are still traditional. We can focus on "hands-on" experiential learning and try more case studies during lectures. Enhancing the collaboration on a macro scale between schools of architecture and engineering may raise awareness among teaching staff and educators. A close architect-engineer collaboration within teaching is also needed with an early consideration of sustainability issues within the design process.

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