



# FINAL REFLECTION

Student: Alvaro Rodriguez Garcia  
Student N°: 4628098  
A.G.RodriguezGarcia1@student.tudelft.nl

Program: Building Technology  
Mentors: Dr. Michela Turrin  
Dr. Wim van der Spoel

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# 1.

## **On the theme graduation lab and the chosen method, topic, outputs of the thesis.**

Despite the fact that the Master does not have a fully computational design educational approach, I always have felt attracted and passionate about this topic. Computational design is each day more necessary and a common practice among all the scientific and professional fields aiming for a better and more efficient way to solve problems, having a huge potential in applying this tools towards energy efficiency and environmental aspects.

While Multidisciplinary design optimization and exploration techniques have been fully developed in industries like automotive and aerospace they are scarcely beginning to be introduced and applied inside the AEC industry especially inside the architectural offices. However, this is still by far not compared with the previous sectors and the application and usage of this cutting edge techniques inside the common architectural and design workflows it is yet being developed and studied. This is in significant part due to the complexity of the problems that a building involves, especially when talking about large scale facilities such as Sports Venues.

The chosen method was first to define the boundaries of the investigation, understanding the background and the current use of this technologies in an educational and professional level by from one side reviewing articles, books, videos and conducting several interviews from another. To later on, defining a methodology to set up a clear workflow for architectural design based on Performance (Qualitative assessment) simulations, exploration and optimization strategies. Finally, this methodology was applied to solve a real case study consisting on the design of a High Performance and energy efficient Sports Hall in Mexico City to conclude in evaluating the applicability of the method to solve a design problem focused on energy and costs efficiency.

## 2.

### On wider social context.

Nowadays buildings are responsible for around 40% of the energy consumption and CO<sub>2</sub> Carbon emissions. It can be said that architects and mechanical engineers are the principals responsible for this considerations. However, are the architects who have the leading role in the most critical decisions that are generally taken during the first stages of the design process which has proven to have the most significant impact for the construction process and the entire life cycle of a building.

Therefore, it is essential to generate a design culture that involves awareness about the consequences of the design decisions towards the environment from the beginning of the design process. This, of course, taking into account as a core aspect the human comfort and well-being, ( as people spend around 90% of their inside buildings according to the European Commission 2003) without compromising economic and aesthetical factors.

The above described can be made with the aid of computational tools that nowadays are more diversified and available. Is with the correct application of these tools, that it is possible to achieve more energy-cost efficient and environmentally friendly buildings. While educating the designers and even the clients and future users towards a culture based on the application of technology to enhance the correct performance of buildings and solve imminent problems such as global warming and the shortage of resources.

Talking in a local context, during the study, I could notice that here in Europe and in principally in several big offices, this technological approach is already being developed (mainly applied to the later stages of the design process). However, in smaller architectural offices and developing countries such as Mexico, these technological and sustainable practices are still not well known yet, which represents an excellent opportunity to start spreading this awareness culture by the use of computational design and technological software among architects and designers.

Nevertheless, now that I have been understanding how computational tools work and how the power of technology is evolving, I am starting to think about some ethical issues and having doubts about what would be the future role of an architect or a designer. With innovations such as Artificial Intelligence and Machine learning, we are heading up to a revolution inside the AEC industry, as happened with the CAD tools during the 80's changing the entire workflows inside architectural offices. Making me reflect that the background of an architect should start being more computer-oriented starting with the educational approach inside architecture schools.

# 3.

## On the relationship between design and research.

I think this thesis is an excellent example of research by design, while the first part consisted in researching an extensive list of topics, being Multidisciplinary design optimization and design exploration holistic and extensive approaches, it was necessary to deep inside diverse topics such as energy, costs, computational design and the specific design of Sports Venues itself.

It was the second section that focused more on the computational part, and it was by using the different existing software to do simulations and understanding how they work that it was possible to come out with a workflow strategy that had sense and could be useful. For this, research needed to be done continuously. For instance, when learning how to use energy simulation software sometimes, it was necessary to still go back to research several required inputs and specific information about the typology, occupancy and use of certain aspects of this kind of buildings, etc... Sometimes, several software and tools needed to be changed because of computational performance limitations and long times, this was specially a great challenge because learning to use new software and understanding how it works is a very difficult and time consuming process. Not to say that another complicated aspect of the entire process, was to deal with the simulation and the optimization procedures, mainly investigating the reasons why these ones sometimes did not work properly.

Talking about the optimization process, it was also necessary to explore diverse techniques and different algorithms while using the available tools, this of course sometimes changed the entire approach of the first parametric model. So in a certain way “designing and doing” helped me to know what to investigate and what to look at, besides a continuous research about the existing different tools that could also be applied, testing them and evaluating them was part of this intermittent process.

Finally, using this specialized software allowed to evaluate the possible design outcomes and it was by having this feedback from the performance of different options, that several relations and dependencies among design decisions were pointed out and some observations about energy and costs performance could be made and analyzed. In this way, it was by a “try and error” strategy which results were continuously compared with benchmarks and databases, that were constructed all along the design process, that the relation between the design and research was a continuous and iterative process.

# 4.

## Evaluation the design process.

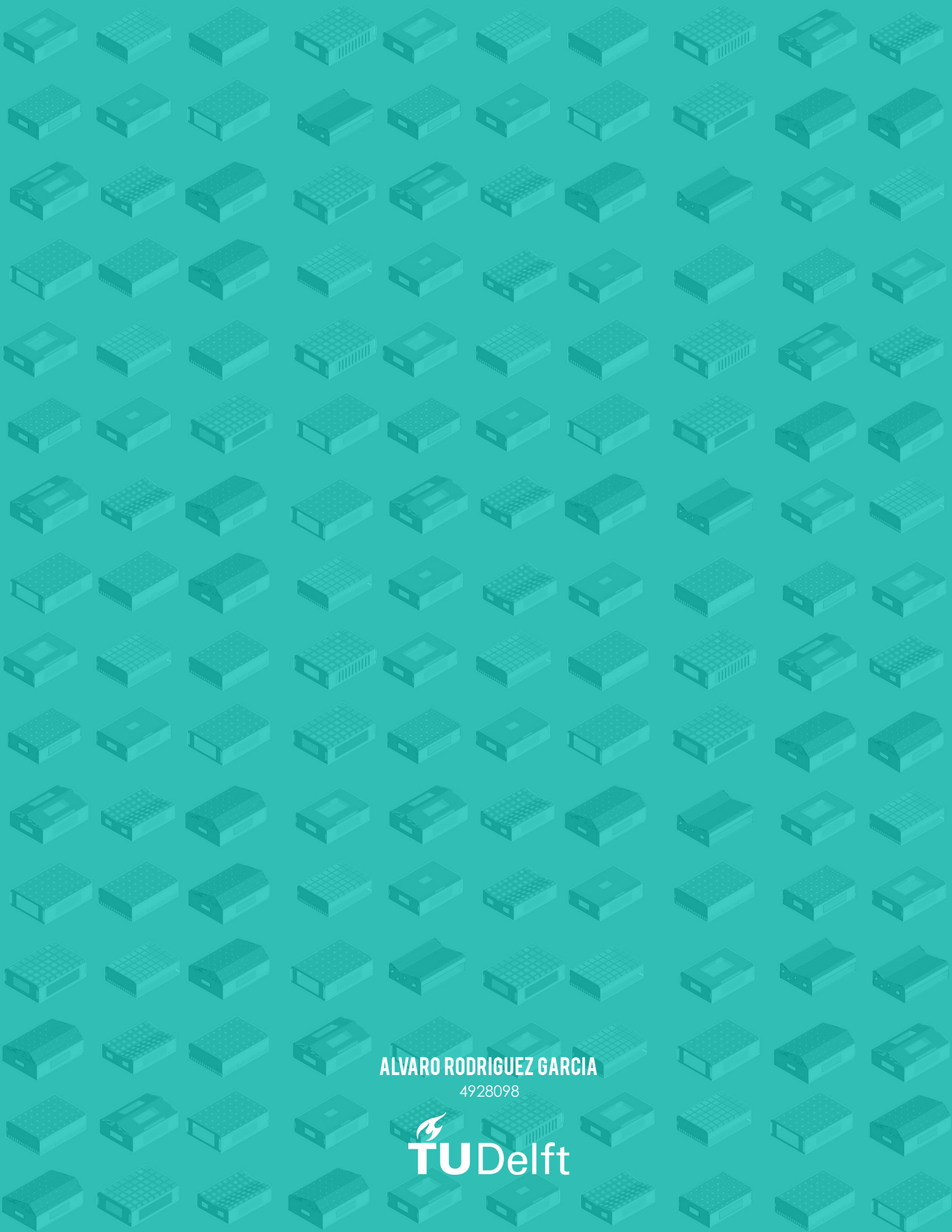
This thesis has been a big challenge for me, I have an architectural – artistic background, so at the beginning, I was a little bit skeptical about how computational design can in a way help the act of “designing” itself. Since I firmly used to believe that designing was more a kind of intuitive and creative process. However, this was, in fact, the reason I started this thesis, to understand and elaborate on this more in detail.

During the first part, trying to digest the large amount of information and trying to get very specific and narrow down the project was a complicated labor. However, as mentioned before it was this “Holistic approach” that forced the approximation of the thesis towards a complicated but at the same time fascinating and educational process. By first understanding different topics such as energy consumption, cost estimation, computational design and Sports Venues design to later on , during the conducted interviews, comprehending how professionals from different backgrounds such as students, architects and engineers work and could work with the use of technological tools. To finally designing a methodology that can be used and applied by them was an exciting and daring task.

Taking this previous research as a starting point for the following design phase was highly challenging specially when understanding the optimization and design exploration concepts such as objectives, parameters and constraints to later on being capable to build a parametric model that could allow the computer to explore and give a possible wide range of solutions. This can be a tricky procedure, in a way you are designing a whole “solution space” itself and sometimes you realize about several limitations regarding the available time, computational effort and occasionally skilling aspects. At times, it is necessary to go back and reformulate the strategy and start all over again, or even also you realize that you need to do even more research about performative aspects or computational considerations among other factors.

Therefore, I could say that the whole process has been highly educational for me, I have learned a new approach for designing based on an optimal Performance in combination with aesthetical aspects, while at the same time learning about several topics. For instance, from how much time does a simulation takes, to the maximum amount of glare that is allowed inside a Sports Hall or what is the most costly aspect of a Sports facility. But mainly I have understood the power of technology and the importance of managing the correct information at the right time

If I could resume the whole design process, I would say that designing is a continuous investigating process and that technology is changing very fast as well as the environmental conditions, so we as designers need to keep on doing research and actualizing ourselves continuously to be able to propose sustainable and efficient solutions.



ALVARO RODRIGUEZ GARCIA

4928098

