THE SUSTAINABILITY CHALLENGE: HOW MULTI-CULTURAL AND INTERDISCIPLINARY GROUPS OF MASTER STUDENTS CONCEIVED SUSTAINABLE ARCHITECTURE IN SHANGHAI

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ABSTRACT

The sustainability concept addresses complex anthropogenic challenges by soliciting approaches that are problem-driven and solution-oriented. What a 'problem' and 'solution' is, however, is not always clear, and must be negotiated on behalf of a multitude of interests and concerns. How does such a negotiation happen in an interdisciplinary and multi-cultural environment, and what does this negotiation process mean for the sustainable solutions that are attempted agreed on and achieved? In this paper we study the experiences made in an interdisciplinary and multi-cultural summer school on 'Sustainable Energy in Cities' held in Shanghai in July 2016 in order to say something about how sustainability was negotiated across different disciplines and cultural background. The summer school included 35 master's students from eleven countries with mechanical and civil engineering, social science, industrial ecology, renewable energy and architectural disciplinary backgrounds. The students were divided into four groups with mixed disciplinary and cultural backgrounds, and with an equal gender proportion. Combining this heterogeneous set up with the experimental teaching method of 'Experts in Team', all groups dealt with the same task: designing a research facility for a small group of researchers based on pristine wetland islands in Pudong, Shanghai. This study aims to understand how the four groups faced this challenge by arguing that their design was sustainable. The observation was based on the following categories: the localization, visibility and impact, technological choices and which types of visualizations were chosen to communicate the design principles, the energy strategies and the social impacts.

INTRODUCTION

The concept of sustainability addresses complex anthropogenic challenges by soliciting approaches that are problem-driven and solution-oriented. What a 'problem' and 'solution' is, however, is not always clear, and must often be negotiated on behalf of a multitude of interests and concerns. Therefore, sustainability as an organising framework involves addressing ethical questions about how Earth's resources should be shared[i]. This makes sustainability a complex topic that cannot have only one correct solution. Put differently, diversity is central in both problem-definition and in creating adequate solutions. Thus, diversity is a key understanding that underlies any dealing with sustainability issues, and we ask: To what extent are diverse understandings of sustainability agreed upon, and what does the agreement process mean for the sustainable solutions that are attempted agreed on and achieved?

This paper presents results from an interdisciplinary and multi-cultural summer school on 'Sustainable Energy in Cities' held in Shanghai in July 2016. The summer school included 35 master's students from eight universities and eleven countries with different disciplinary backgrounds. Combining this heterogeneous set up with an experimental teaching method of 'Experts in Team', all groups dealt with the same task: designing a research facility for a small group of researchers based on the Jiuduansha Wetland Islands in Pudong, Shanghai. The wetland islands emerged in 1950s at the mouth of the Yangtze River, and they are fragile and pristine islands with high ecosystem service value representative of coastal ecosystems in eastern China. They are also sensitive to global climate change (e.g., extreme weather events such as monsoon and sea level rise) and were therefore seen to be an interesting case study where future climate change effects necessarily had to be considered in the final design. We study how the four groups argued that their design was sustainable by describing the processes in which each of them starting from the same design package and the same constraints used the specificities of the localization, visibility of the intervention and impact on the wetland, technological choices, and what types of visualizations they came up with.

The paper is organized as follows: section 2 introduces theoretical perspectives on sustainability, diversity and interdisciplinarity in order to make clear how diversity can be approached. Section 3 presents the data, while section 4 introduces the main findings. Finally, the main conclusions are presented in section 5.

SUSTAINABILITY, DIVERSITY AND EDUCATION

The extent to which sustainability as a concept can be helpful from an educational perspective has been up for debate the past 15 years, since the concept has prescriptive tendencies and is fraught with conflicting values, norms, interests, and reality constructions (Wals and Jickling 2002). Wals and Jickling (2002, p. 224) argue that sustainability is productive to use as an organising concept as long as it is clear the concept has several shortcomings, and that it does not represent a 'single right vision or best way to sustain the Earth or what kind of Earth should be sustained'. In other words, using sustainability as an organising framework involves addressing ethical questions about how Earth's resources should be shared. In that regard, sustainability is also about issues such as 'cultural identities, social and environmental equity, respect, society-nature relationships and tensions between intrinsic and instrumental values' (ibid., p. 223). This implies that a more 'participatory, democratic,

pluralistic, and emancipatory approach to education and sustainability' (ibid., p. 226) is a central task for sustainability education.

Indeed, in much sustainability education research in the past years, the central message appears to be similar: in order to achieve sustainable outcomes there is a need to open up for feedback from several perspectives and actors through different experimental methods (see e.g., Dam-Mieras et al. 2007; Shepard 2008; Hansmann 2010; Karatzoglou 2013). Yet, how can such diversity and experimentation be facilitated in education? Indeed, it appears that institutional inertia and rigid traditional disciplinary boundaries pose considerable challenges to sustainability education (Jones et al. 2010). Studies going into detail about the practical challenges in teaching 'sustainability' emphasise several challenges. One such defined challenge is to agree on what types of competencies are important to teach for problem solving efforts (Wiek et al. 2011). One key competency defined by Wiek et al. (2011) is interpersonal competence, that is, the ability to facilitate collaborative and participatory research. This competence appears to be a challenge in case-studies of sustainability-oriented educational programmes (e.g., Moore 2007; Dam-Mieras et al. 2008). Dam-Mieras et al. (2008) conclude that a significant barrier in generating innovative learning environments is to facilitate mutual trust and understanding between people. Moreover, they point out that language barriers can prevent the development of intercultural and interdisciplinary work. Moore (2007) suggests seven recommendations for creating sustainability education at the university level. Two of them are: 'promote and practice collaboration' and 'focus on personal and social sustainability'. As Moore underlines: 'Unfortunately, the overwhelming climate of competition found its way into discussions about everything from entrance requirements, classroom dynamics and the stress of attaining tenure and promotion'.

This emphasis on language, interpersonal and collaborative perspectives shows that sustainability is something that must be agreed upon in each case. As pointed out by Shepard (2008), areas of higher education that focus on affective (i.e., the domain of values, attitudes and behaviour) outcomes of sustainability related to teaching have been beneficial. This also implies that 'teaching about sustainability presupposes that those who teach consider themselves learners as well and that students and other concerned groups of interest are considered as repositories of knowledge and feelings too'(Wals and Jickling 2002, p. 227). In other words, competences relevant for sustainability must be determined collectively, and different types of competences require different methods.

METHODS AND DATA

This paper is based on data collected during the International Summer School on 'Sustainable Energy in Cities' in Shanghai 2016. The summer school was organised three times; in 2013, 2015, 2016, and it is also planned for 2017 and 2018. The 2016 summer school was a collaborative effort between three universities: the Norwegian University of Science and Technology (NTNU), Shanghai Jiaotong University (SJTU), and Tsinghua University (THU). The summer school was organised around three main principles: 1) *Experts in teams*: interdisciplinary training of students and staff in teamwork, which used group work and games as a way to facilitate cross-cultural and interdisciplinary learning. 2) *Triple helix*: local industry and municipality officials suggested specific challenges for the students to address and solve in cooperation with teachers from the involved universities. 3) *Out of the lab, into the city*: The students and teachers went on fieldtrips in order to gather empirical evidence and developing solutions.

The 2016 summer school was set up with relevant lectures in the morning and group work during the afternoon over two weeks. In total 17 lectures were given by professors from eight universities, and a teacher team of five researchers from NTNU that coordinated and facilitated the group work. The

group work sessions included interactive techniques that aimed at facilitating teamwork and 'creative-thinking', including group games, daily newsletters and excursions. The different disciplinary backgrounds of the involved master students were: mechanical and civil engineering, social science, industrial ecology, renewable energy engineering and architecture. The students were divided into four groups with mixed disciplinary and cultural backgrounds, and with an equal gender share: 7 males and 2 females students. The groups were all given the same task consisting in designing a research facility for a small group of researchers at the Jiuduansha Wetland approximately 6 km outside of Pudong, Shanghai and the same design package made of design specifications and a video presentation of the flora and fauna of the Wetland. The specifications were to create a facility for 2-5 researchers who can live there for few days, with a space-limitation of 150-200 m^2, and with mixed use of living and working space (housing + office + laboratory).

The data collected during the two weeks of summer school were: (1) recordings of some of the group work discussions, (2) a broad variety of pictures taken both by the students and teachers' team, (3) meeting notes, (4) observation and a survey conducted at the end of the stay with feedback from the students' satisfaction and perception about the summer school's organization, conduction and learning experience. This paper is also based on an analysis of the students' presentations. They gave a mid-term presentation at the end of first week, and a final presentation at the end of the summer school. Moreover, the students submitted a report in which design choices, energy strategies and calculations as well as social impacts of their final proposal were explained in detail.

DESIGN CHOICES AND JUSTIFICATIONS

In this section the design choices of each group and their strategies are presented as well as a description of the groups' discussion process that led to the different designs. Figure 1 shows an overall overview of the final designs developed by each group. Group 1, called *BINGO*, chose a more moveable design solution characterized by jack-up vessels as a design inspiration. Group 2, called *Crazy Creation Forerunners*, developed a fixed installation inspired by the local birds-nests. Group 3, named *9 Pieces of Sand*, ended up with a fixed installation that was inspired by the surrounding sea-climate, and finally, Group 4, with the nickname *Way of the Dragon*, designed a fixed installation intended to serve as a landmark between Shanghai city and the wetland islands, which would sensitize Shanghai citizens to the fragile wetland islands. In the next sections, we describe the design details and negotiation processes of each group.
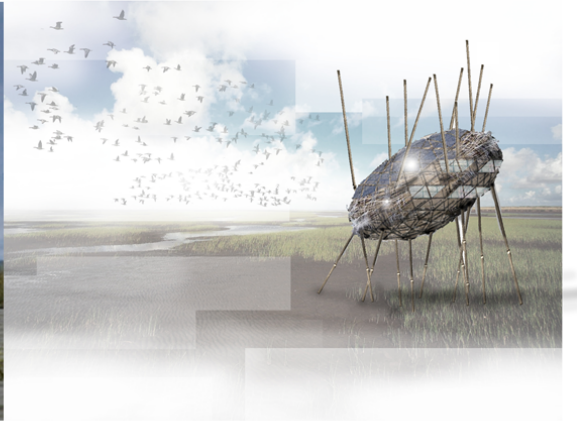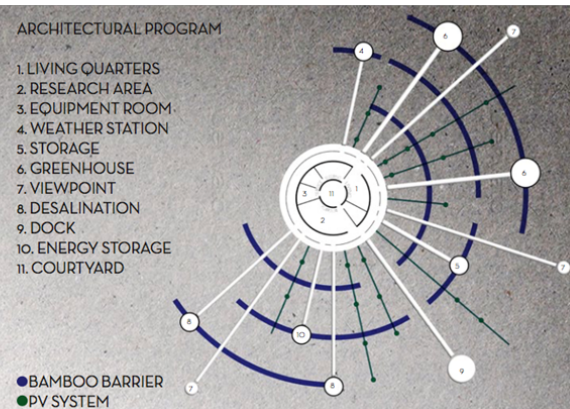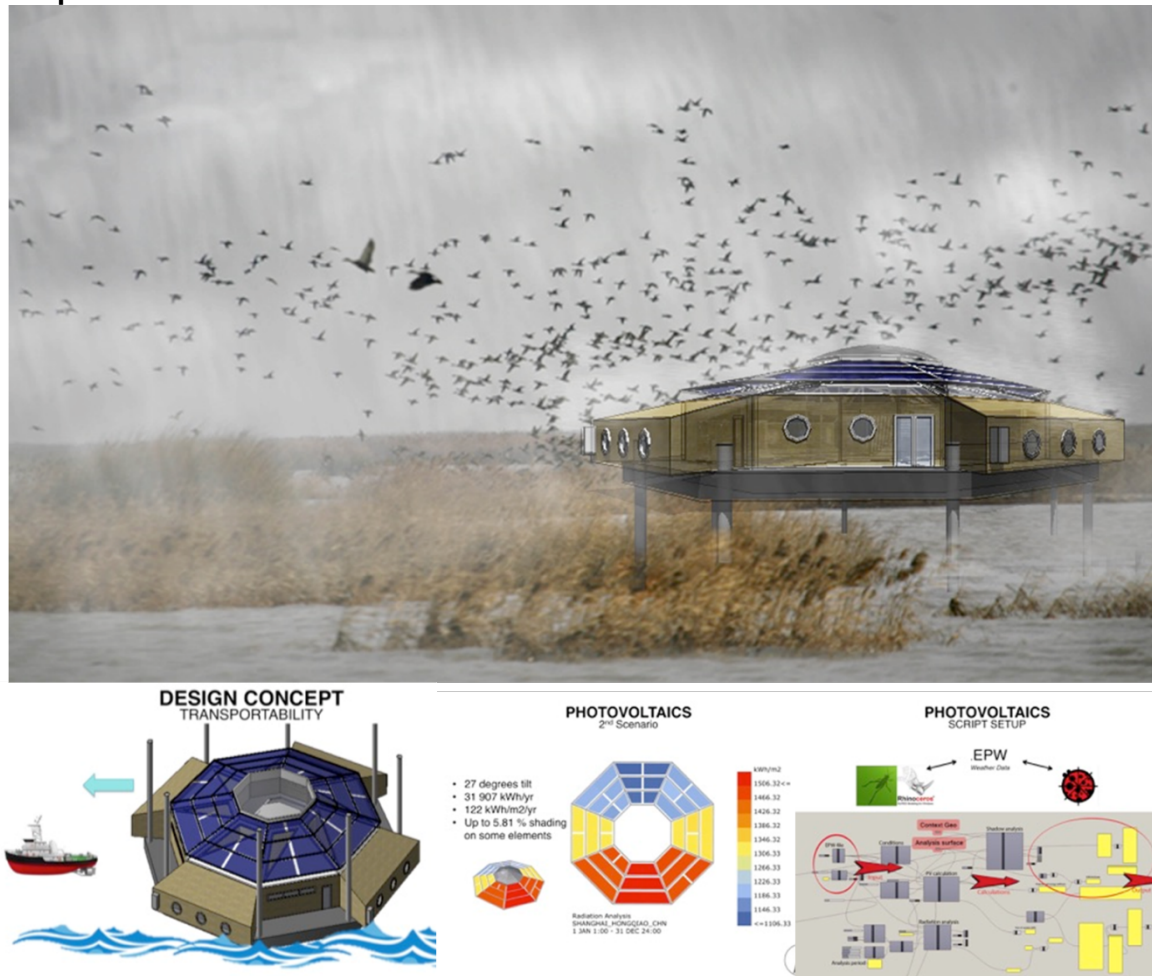
**Figure 1: The final concepts of each group**

Group 1: ReFLEX

Figure 2: Group 1 design details

Figure 2 shows a transportable and flexible design that was intended to cause a minimal impact on the wetland islands. The design driver of the project is the flexibility in which different modules could be interchanged depending on the usage and the needs of the research facility and the researchers. Four of the modules are fixed, while four can be interchanged. The facility is transportable by using 'barge technology combined with a jack-up leg system to be able to raise and lower the building' (Final report, Group 1).

The process of agreeing on the design

This group got this flexible idea early in the design process and they developed it during the entire period of the summer school. The idea of movability came through a discussion of how to best preserve the islands, as well as being able to move out in case of typhoons and bad weather. Around this idea the students discussed how to achieve the design. Their idea of flexibility and movability strongly impacted the technological solutions chosen, as they had to rely on more maritime solution with regards to engines that would drive the jack-up legs, as well as floating capacities of the barge and technological detail of the building envelope.

Group 2: HongYingPiaoMiaoGe Research Center
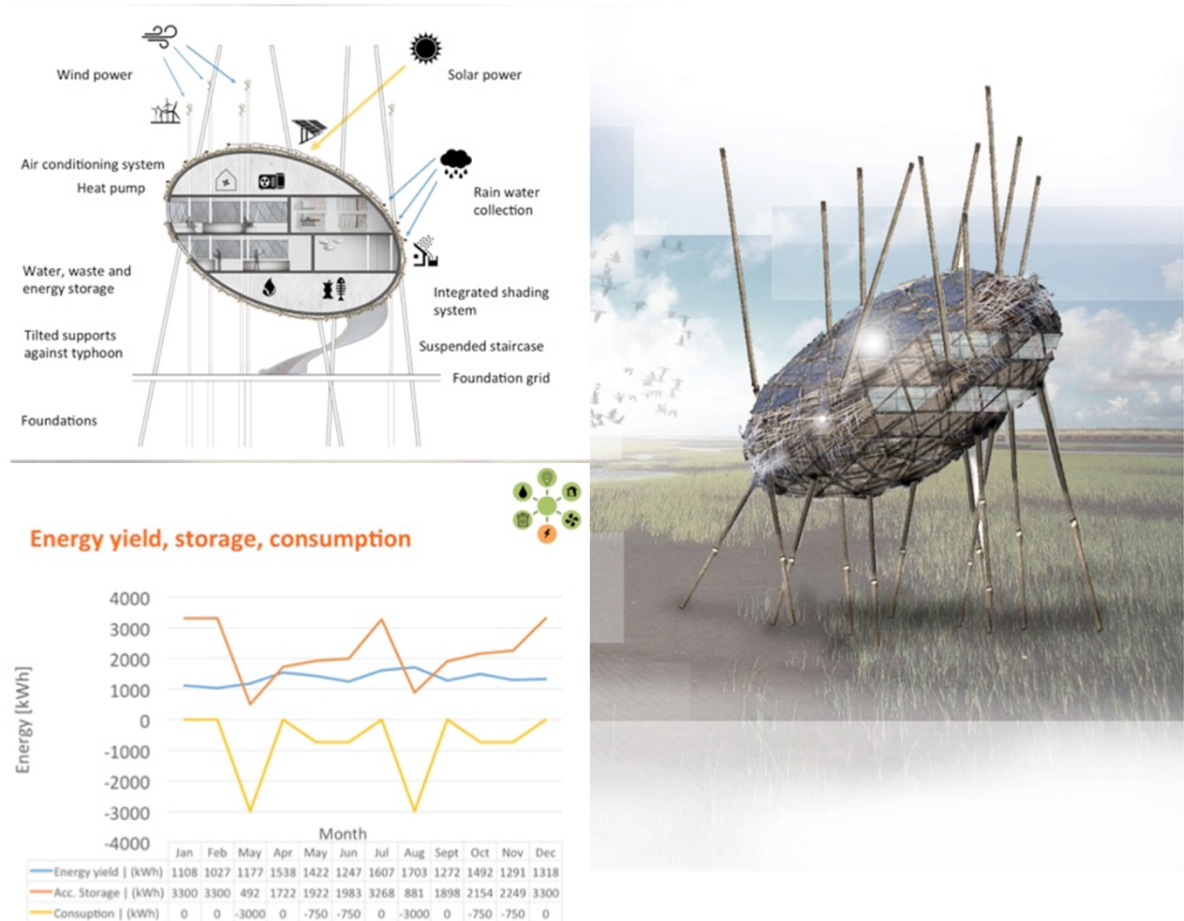
Figure 3: Group 2 design details

This group had three guiding principles that were guiding their approach: research, preservation and awareness. As the final report of Group 2 explains:

> the design 'represents a bird's nest, elevated, held up and protected by humans, as to emphasize its importance to the island and the beauty of its surroundings. The shape's similarities to an egg that is breeding life and will eventually hatch, symbolizes the power that successful research inside the egg can contribute to'.

Moreover, 'raising awareness among the public' was important to emphasise for this group, and also justified the design choice, which 'masters the art of standing out as a landmark and architectural spire' (Final report, Group 2).

The process of agreeing on the design

This group was immediately inspired by the local environment on the wetland islands described in the video provided with the design package. The presence of what we can call an intermediary person being able to speak both English and Mandarin fluently was also largely beneficial for how the team worked together. The group came up with the first idea of a nest, and much effort was focused into trying to get a buildable and functional design. This very strong first idea caused complications regarding the interior design and space zoning, which were not totally solved from both an architectural and engineering perspective at the end of the summer school. This example demonstrated

the difficulty in dealing with architectural complexity and engineering strategy and calculations in a very limited time period. It also emphasizes on the essentiality of having experts with different backgrounds from the early design stage in such projects.

## Group 3: The Green Wave
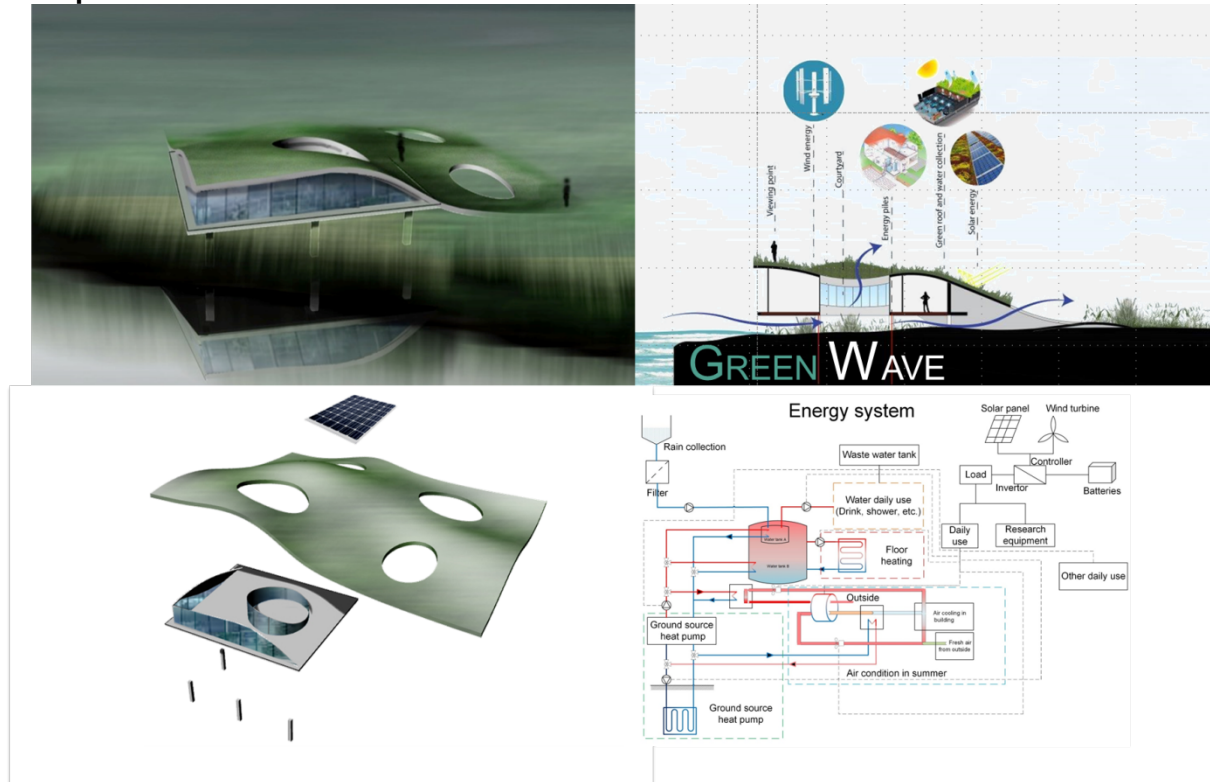
Figure 4: Group 3 design details

This group had as a main design objective to blend in with nature within an area dominated by a monsoon season which creates high waves risk, sea level rise and the deposit of sandy sediments. For this reason their design inspiration was 'the waves and how the waves can create land' (Final report, Group 3). They also argued that the researchers should have a 'high-quality comfort', meaning that they should not only have the bare minimum to survive out there, but should be safe and comfortable during their stay at the research facility.

The process of agreeing on the design

This group had discovered very early that there was another building on the wetland islands, and this finding also shaped some of their approaches, especially regarding siting. This finding was a relevant advantage and was achieved in large part because the group had a student who also acted as an intermediary. Indeed, the intermediary helped to overcome the communication barriers, and gave all members of the group access to a larger amount of documents written in Chinese. However, despite having an intermediary person, during the next phases of the design process this group struggled for some time to come up with the final design. This latter aspect demonstrates that the initial advantage of an intermediary was not enough to create well-functioning teamwork.

Group 4: Jiuduansha Lotus Research Station
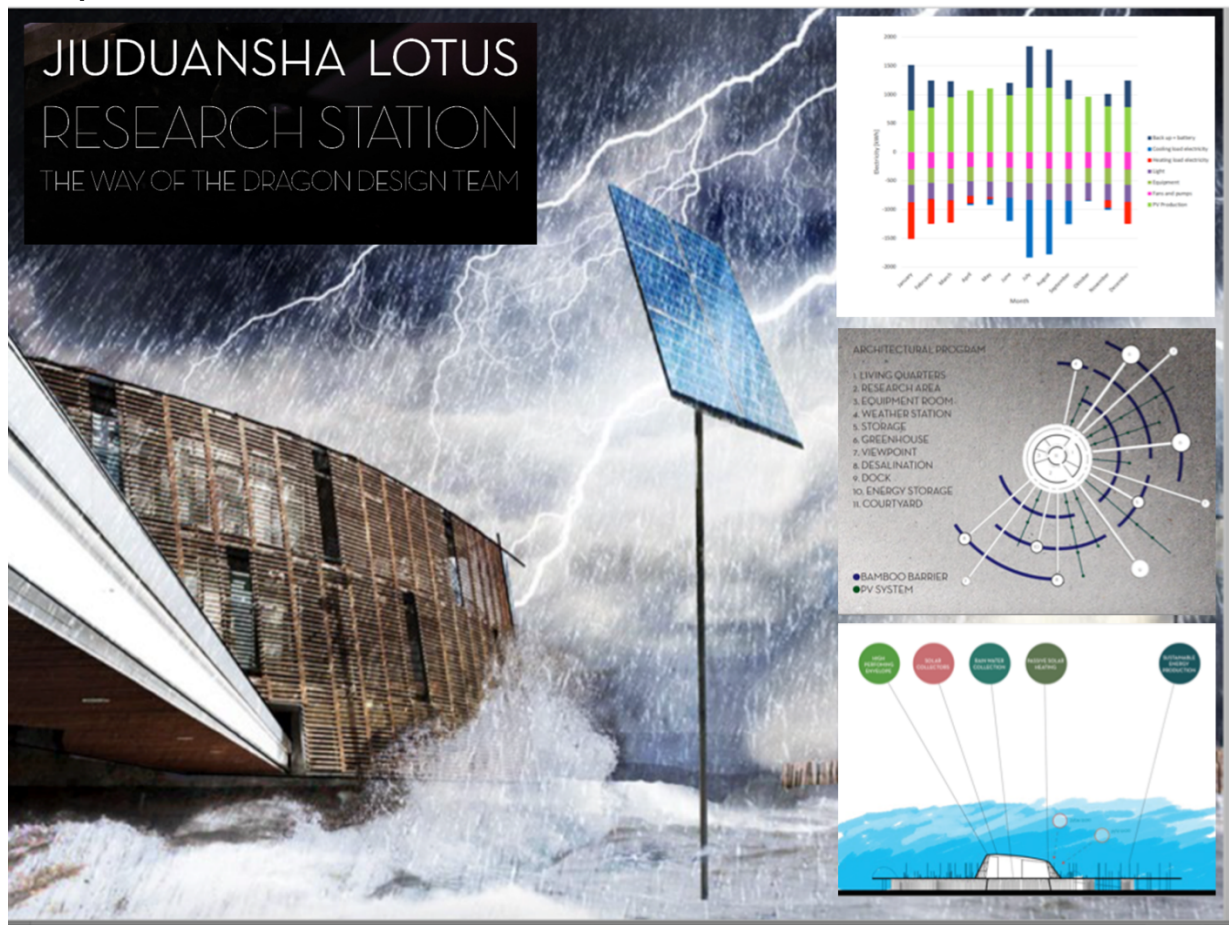
Figure 5: Group 4 design details

Similar to the other groups, this group emphasised research, preservation and minimum impact on the islands in their design choices. However, they based their design on two principles: (i) the research facility should be a landmark in which the Shanghai citizens can recognize themselves, and (2) they considered loneliness to be 'one of the main concerns for users inhabiting this building [...] since they find themselves isolated in a secluded area from civilization' (Final report, Group 4). For this reason, they developed a floor plan 'that promotes social interaction'. Moreover, this group was inspired by a local type of architecture called the 'tolou typology', exclusive for Southern China, meaning a very similar type of climate as the one found outside of Shanghai.

The process of agreeing on the design

The members of this group struggled to build social relationships during the first week, and worked somewhat independently on the architectural concept and the energy engineering. The idea of the landmark appears to have been something the two architects of the group were pushing through. After a meeting with the teachers in which the issues of cultural integration and leadership were faced, the group appeared to work better as a team the second week, and were able to agree on several important aspects of the design, such as the siting and the purpose as a landmark. The presence of an intermediary could have improved the communication level and the cooperation within the group during the entire period of the summer school by avoiding misunderstandings.
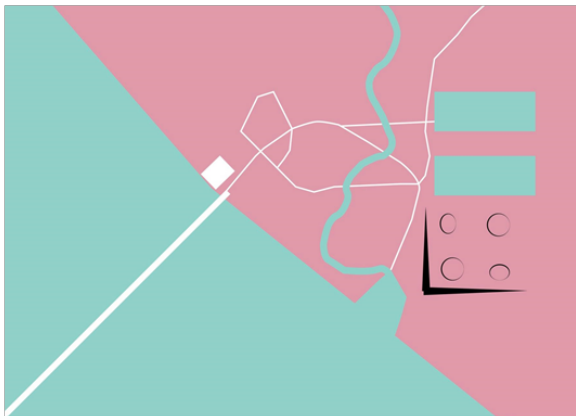
SITING

Group 1
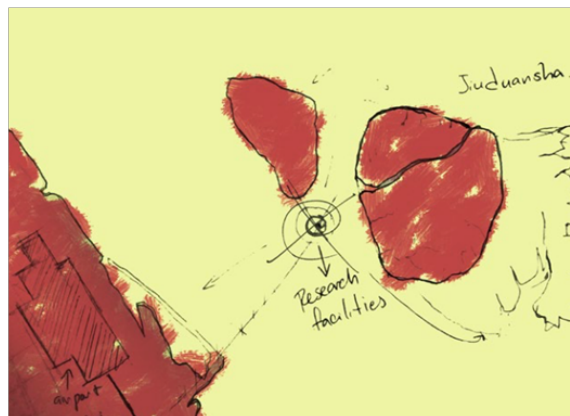

Group 2
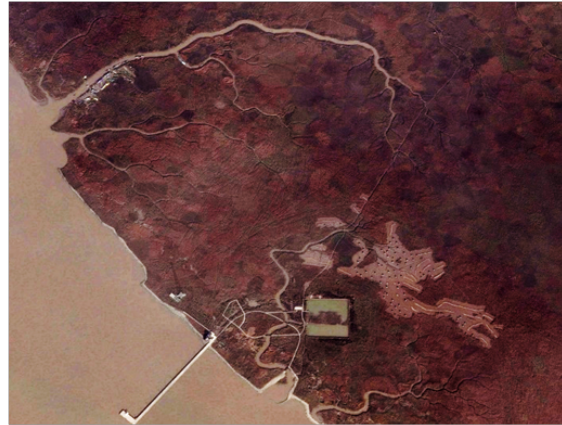
Group 3

Group 4

Figure 6: The different siting strategies chosen by the groups

It became evident that the siting of the research facility was very important for the four groups' assessments of the environmental sustainability of the research facility. This was perhaps most prominent in Group 1 who thought that there should not be any fixed installations in such pristine area. They decided to design a moveable installation that could be pulled out to the islands when needed, and also moved around according to weather and research needs. Indeed, this research facility could also be used for other research purposes in other locations. Group 2 and 3 decided to locate their facility at roughly the same place, namely close to an already existing installation on the islands with boat landing facilities already in place. It was argued that this would create minimum impact since infrastructures already were in place. Both groups were inspired by local environment and materials, such as the local reed, sand, and changing climate conditions in the area, and were seeking to 'blend in with the nature, to be one with nature and to not disturb it more than necessary' (Final report, Group 3). Group 4 chose an altogether different approach by locating the research facility in the sea between Shanghai and the islands. It was argued that this location would not create any impact at all, and it would also create an additional purpose: to serve as a landmark visible from Shanghai that would inform citizens about the presence of a fragile and pristine natural environment represented by the

wetland islands. They wanted to make the city connect with the island and create a relation between them.

To summarise, the four groups chose two main siting strategies: Group 2 and 3 entailed a form of intervention but with the aim to 'blend in'. Group 1 and 4 were very clear about non-intervention, which led to their designs opening up for other purposes that strictly being research facilities for these particular wetland islands.

DISCUSSION AND CONCLUSIONS

As this paper has shown, each of the four groups chose a different design approach, and different types of active and passive systems. In terms of microgeneration technologies to power and heat the facilities, they all chose a similar set-up: a mixture of PV, small wind turbines, battery storage and/or fuel cells. One thing that emerged during the group work was a discussion about energy need and levels of comfort. During the summer school, it was sometimes more than 40 ºC with high relative humidity in Shanghai. However, the different cultural backgrounds made calculations for heating/cooling more complicated; for Europeans it was difficult to understand that heating was at all necessary since it was so warm in the summer and preferred to focus on active cooling strategies. Nevertheless, when they did the weather calculations, it turned out to be 3000 h per year that needed heating. This surprised several of the students.

What we can conclude from this research is that there was great diversity in the proposed solutions, and each solution provided well-grounded arguments for their choice. Therefore, what is sustainable depended on the assumptions made. Here we saw priorities ranging between different matters of concern: 'blend-in' intervention or no intervention at all, fixed or moveable installations, high comfort or a bare minimum of energy production, a landmark or more functional designs. It could also be mentioned that Group 2 won the final design competition with a jury consisting of representatives from research, industry and the local municipality that were considering to make the research facility. Why did they win? It is possible that they won because it was the most visually appealing concept or because they performed better during the final presentation, and not because it was the objectively most sustainable design. Such considerations should also be taken into account when assessing the sustainability of a chosen architecture.

Lastly, it is worth emphasising that when dealing with sustainability, the learning effects from meeting new approaches, ideas, disciplines and cultural backgrounds contribute immensely to understanding what sustainability is or can be in each case. In the summer school this experience was manifested in the importance of these master students gaining a mutual understanding of what they wanted to achieve, before they embarked on their final design. The mutual understanding was largely facilitated by what we call an 'intermediary': a person that speaks fluent English and Mandarin. Nevertheless, arriving upon different choices, for instance, of whether to go for a fixed installation, a landmark, and so was a process marked by a constant re-negotiation of their mutual understanding. Hence, the sustainability of these four designs was always anchored in the agreement they were able to come to within their group.

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