Reality Design and Slow Prototyping as Methods in Sustainability Education

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ABSTRACT: Design-build projects are studio exercises for students of architecture which are actually constructed by the design team. They have led to the creation of a number of buildings with very special aesthetics, and were at the same time case studies for a problem-oriented teaching method. The projects described in this paper derive some of their very focussed and concentrated atmosphere from the exposure of the work-groups to an unknown environment with unexpected conditions. Different scenarios for the project set-up have been tested by the author over the past five years and will now for the first time be evaluated. The slow design process, which allows for research through design, is helpful for the identification and integration of local issues by the student team, which in turn makes this teaching method especially suited for interdisciplinary or intercultural cooperations.

Conference Theme: Education for sustainability Keywords: education, low-tech, experimental building, interdisciplinarity

INTRODUCTION

For a period of over four years, the faculty of architecture at the Technical University in Munich has offered students of architecture the possibility to participate in design projects with a realistic background. These projects are studio exercises that are then built by the design team. They have led to the creation of a number of buildings with very special aesthetics, and were at the same time case studies for a problem-oriented teaching method. It will be shown that this special teaching method of combining theoretical design and research with the practice of experimental building leads to a much more in-depth understanding of relations between material, construction and aesthetics than most other studio exercises. It will also be argued that this teaching method, utilising the idea of prototyping in different scales and the final execution of buildings for real users, is an excellent way to impart more than academic knowledge by improving social and environmental awareness through personal experience (Gampfer et al 2008).

1. OBJECTIVES OF DESIGN-BUILD PROJECTS IN UNIVERSITY EDUCATION

Unlike similar projects, as for example the very successful Rural Studio projects at Auburn University, which draw on years of experience and a long-term set-up (Oppenheimer Dean 2002), the projects described in this paper all have a different background and derive some of their very focussed and concentrated atmosphere from the exposure of the work-groups to an unknown environment with unexpected conditions. While this exposure is the most obvious challenge for European students who work in a different cultural context during the project, a similar effect has affected local participants: for them, the exposure to unexpected, unbiased building solutions for seemingly commonplace problems has broken with existing preconceptions. For a new thinking of professionals for the built environment, such mind-opening experiences are considered to be essential (Sinclair 2006).

Both for architectural education and for reproduction by local stakeholders it was found that a slow process of designing in studio and on site during construction led to solutions which can be described as unpretentious and restrained. This unexpected approach of avoiding technically sophisticated materials and seemingly 'modern' aesthetics in a European funded project triggered a series of discussions with both local students and professionals. It became obvious that this approach could also be used to raise awareness and interest for a kind of 'green architecture' based on simple but effective technologies.

In terms of architectural education, both in Europe and other parts of the world a tendency to look for formal, sometimes superficial solutions rather than integrated design can be found among students, sometimes also among teaching staff. The formal approach to building design is encouraged by a multitude of images available through virtual or printed media. The requirement of a design-build project to simplify the design to an extent where it can be built with little equipment and by inexperienced craftsmen forces the design team to rethink solutions again and again, reducing them to the essence of a more profound significance.

2. METHODOLOGY

In the course of four projects, different scenarios for the teamwork of groups of different numbers of students have been tested and will now for the first time be evaluated. A detailed description of each project set-up will

include the size of the groups, the steps taken throughout the design process, as well as an evaluation of each of the different scenarios.

Each of the projects described below addressed an issue identified as essential in its special context. While they all have in common an approach of simplicity and unsophisticated technical solutions, combined with a high degree of aesthetic quality, a special focus was identified during the design process to be the core of the design. Depending on the regional, social and climatic context of the projects, these issues included low-tech methods for energy supply and the conditioning of buildings (heating and cooling), experimental materials and constructions and ecological solutions for waste treatment. At the same time architectural quality and expression were derived from the buildings surroundings and context.

A general description of each project's background and context, the stakeholders involved and the determining design objective will be given as an introduction to an account of the methodology used in the student project itself. Each account will then be divided into four stages, following one upon the other chronologically: preparation – studio work – selection procedure – execution, using the following criteria:

- selection of participants
- project management team
- size and composition of the group
- collaborations
- design process
- project selection process
- team building strategy

3. PROJECT DESCRIPTIONS

3.1. Kindergarten, Orangefarm, South Africa 2007 - project 1

This first project was initiated within a whole series of design-build projects executed in the years 2005 - 2007 by several Austrian and German University teams in the communities of Orangefarm and Drieziek on the outskirts of the metropolitan area of Johannesburg. These formerly informal settlements consist of their original core areas, which have long turned into more formal communities with local administrations and public services, and a large number of so-called extensions.



fig. 1 site photograph of the design-build project Orangefarm 2007

Of these extensions, some are long established, others have only recently formed on the outskirts of the area. The structure of these settlements, while in most cases being far from informal, is characterised by the inhabitants' legal uncertainty concerning ownership of their plots and a lack of identification with the built-up structure of the community. Local centres are indeed informally organised. There are few public or communal institutions except for schools, which are fenced off and not used for the community as a whole.

Places of identification – e.g. for meeting or orientation – are shopping malls within otherwise unstructured, extensive areas of small dwellings. Within these settlements, a large number of child care facilities have been established as private businesses in small huts similar to residential buildings.

One of these facilities, situated in a fairly new extension of Drieziek community, had been identified by the local social worker to be rebuilt in order to improve safety, hygiene and the overall service offered to children in that particular neighbourhood. The new kindergarten was to remain a private business, but both the site and the building would not be in private ownership. Instead, the local community was to own the structure and guarantee its continued use as an educational institution.

Concept

The building was to reflect this concept of a semi-public building, but at the same time resemble the scale of the surrounding structures. The different scales of a landmark building for the whole community and a protecting shelter for small children were reconciled in the final design: a group of small 'houses' similar in scale to the surrounding buildings is spanned by a large canopy, which is both the protecting umbrella for the outdoor spaces and acts as a visible sign of the buildings' outstanding position. To some extent this is also reflected in the building materials used: while the roof construction incorporates some donated and even some imported materials, only locally made bricks and standardised building parts were used for the rooms below (fig.1).

The layout and construction of the building was carefully adjusted to maximise solar gains through the large windows of the North façade, at the same time shading these windows through a small roof overhang (fig.2). To avoid overheating, the rooms contain enough thermal mass and are cooled both by night ventilation and by the large, slightly sloping ventilation zone between the ceilings and the roof canopy above.



fig.2: section through building in Orangefarm with concept of solar gains

Participants

The design for the building and the surrounding playground were executed by an interdisciplinary group of students of architecture and landscape architecture. Participants were not preselected for this project, but signed up within their normal curriculum. The student group was made up of 29 students of architecture and six students of landscape architecture. The project management team consisted of two architects during the design phase and on site. The landscape team came into the project after most planning decisions for the building had already been made. A specialist tutor led the landscape team during the construction phase.

As a preparation for the actual construction, day workshops were held for the participants in Germany. These workshops were used to train students on machines and try out basic skills like brick-laying and plastering. Prototypes of building parts were built during these workshops.

Design Studio

Studio work went through a number of phases, during which the number of students in each design team was gradually increased, while the number of possible solutions was reduced through a selection process. The final stage led to the selection of one project out of a remaining field of four entries.

The objective of limiting the number of solutions in each design stage by a continuous process was to involve as many students as possible in decision making and shaping of the final building. This strategy is based on two considerations: Naturally, in the course of such a process many exceptional ideas and good solutions have to abandoned in order to reach one final outcome. By avoiding a situation of competition, dissatisfaction among the group was limited and the many controversial issues were debated during the design phase rather than during the execution of the building. On the other hand, an involvement of the whole group in the process of limiting solutions and detailed planning creates a good base of information about all stages of the building process within the team.

Construction Phase

For the construction stage, the student group was divided into smaller teams of about 6 - 8 students. Each group had a team-leader and was assigned a certain task. Team leaders had regular meetings with project management. During the construction, a large number of workers from the neighbourhood were employed on site, led by a local spokesman.

Project preparation and involvement of local stakeholders

During the preparation of this first design-built project ever to be executed by the project team, involvement of local stakeholders was limited to a minimum. However, a site visit at the beginning of the design phase and continuous contact between the design team and local authorities helped to establish a brief and to integrate the clients wishes concerning the use of materials and certain design criteria.

Several meetings with local authorities, community leaders and neighbours were held, in order to raise awareness for the project and inform the community. Finally, a big opening celebration organised by the community showed an immense support for the project.

3.2 Teacher's house, Magagula Heights, South Africa, 2008 – project 2

In the wake of the Orangetarm project, this small project was initiated by the same Austrian NGO and designed for a school complex in the Johannesburg region. This school had been the site of a number of experimental design-built projects by different Universities.

The project for one of several teachers' houses came as an opportunity to utilise some of the experiences of the first project, to work in the same region again and to follow up on the kindergarten building finished a year earlier. The set-up of the project was much smaller, there was no design phase involving the student team. Instead, the students participated in a seminar on sustainable building in developing countries.

Concept

The building was designed to fit a master plan for the school buildings of the complex, which determined size and position of each of the teachers' houses. As a reaction on the fact that a number of very diverse buildings had to be expected, a very introverted layout was developed. The building consists of two blocks of rooms, containing a kitchen, bathroom and two sleeping rooms, all oriented onto internal courtyards.

The construction was executed by a group of students of architecture who prepared the theoretical background but not the actual design of the building.

Participants

A group of twelve students of architecture, who were selected on the basis of a personal application, participated in the construction phase. The team was led by two architects, who also managed the construction. The team was joined by a small number of local workers.

Construction Phase

Since a number of other buildings for the school complex had already been realised by University groups on the same site, infrastructure, local workers etc. were well known and could be utilised without much further preparation.

3.3 Kindergarten Brak-an-Jan, Raithby South Africa, 2009 - project 3

The project for a new Kindergarten in Raithby, a small village near Stellenbosch in the Western Cape Region, was initiated by private supporters from Germany. The need to rebuild an existing child care facility on private farm land led to the identification of a more sustainable site near the public school in Raithby. The long and narrow piece of land with a slight slope to the South had been donated by the local Church, which traditionally owned all the land in the village. Although Western Cape is not an underprivileged region, there are a large number of day labourers living on farms or in informal settlements under precarious circumstances. Most students of the public school in Raithby come from these families, while children from the more middle-class families in the village visit schools in Stellenbosch.

Concept

The objective of the project was to come up with a structure made from local materials which could be built by students and local workers with only the help of simple equipment and within a short period of time. The building consists of a surrounding wall made from adobe bricks and timber framed interior and exterior walls, which are protected from the weather by the large roof. The timber frames are either filled with insulation as exterior walls or with bricks as interior partitions. For the choice of materials, it was essential that they should be locally made, highly degradable, contain little or no harmful substances and have good ecological qualities, as well as low embedded energy. The exterior envelope of the building is insulated and aims at a certain degree of airtightness. Insulation glass from a local South African manufacturer was used for the windows.

The layout of the building follows the need to utilise the very long and narrow site for a building with a fairly large floor area. The slope of the roof follows the slope of the site, creating a sheltered veranda, which gives access to the playrooms and forms an outdoor play space in front of them. From here, high above the primary school on the same plot, there is an unobstructed view all the way to the ocean.

As a special feature, the building was equipped with a solar heating system. The long North wall has fewer and smaller openings and the wall space between them is used for eight solar panels (fig.3), which collect solar energy in order to heat water in a large storage tank. This hot water tank then supplies energy for under floor heating in all the playrooms. The energy demand of the rooms, solar gains, and the materialization of the building skin were calculated and adjusted in a simulation process in order to enable the system to operate effectively.

Thus, the design addresses the urgent need for buildings which do not rely on electricity from fossil fuels for room heating during the cool and rainy winter months of the Cape region. It shows that buildings with a minimum of insulation can be kept comfortable with a low temperature heating system running on solar energy.



fig.3: section through building with concept of views and solar panels

Participants

An interdisciplinary group of students of architecture and civil engineering worked together in teams of 2 or 3 throughout the design phase. Participants were not preselected for this project. The student group consisted of a total number of 17 students of architecture and 29 students of civil engineering, forming 17 design teams. The project management team consisted of one civil engineer and one architect leading the project throughout, and a group of 6 additional tutors who joined for limited periods during the construction phase. The team leaders were also construction managers during the execution on site.

Design Studio

Studio work was carried out in interdisciplinary teams. In this case, the number of solutions was not limited in the process, because it was necessary to let the same teams work on their design form start to finish. Instead, the final project to be realised on site was selected by a jury out of the total number of 17 entries.



fig.4: site photograph of the design-build project Raithby 2008

Construction Phase

While all participating students worked on site for a certain period of time during the construction, student participation in the project management was minimised, mostly because the students only took part in short phases of the building process.

It was fortunate that a local engineer, supported by an experienced team of local workers, could be involved in the preparation and execution of the clay brick walls, which made up about half of the wall construction of the building. Students were instructed both by a local expert and the craftsmen, mixed teams were formed to do the bricklaying. Production of the prefabricated timber-framed elements was supervised by experts from the University in Munich and executed by student teams (fig.4).

Project preparation and involvement of local stakeholders

The project was well prepared by the initiators, who had been in contact with the local neighbourhood, the church as landowner and the future users to develop a brief for the new building. Nevertheless, the project team visited the site and the area, did research on the availability of materials and established contact with the future users before starting on the design. A small cooperation with Stellenbosch University was started during the construction phase, which led to an informative talk at the University and a site visit by some students from Stellenbosch.

Apart from bricklaying as described above, involvement of local workers or other stakeholders from the from the community was limited. Most inhabitants of the village come from a middle class background, working in regular

jobs in one of the nearby towns. While the neighbours were extremely helpful and supported the general progress in many respects (through infrastructure, neighbourhood security, catering service etc.), there was no actual interest in short term paid labour on site. At the same time, the general standard of living in the area does not seem to allow people to offer voluntary or unpaid help for community projects as yet.

A small local construction company was hired to help with foundation and concrete work, but again, no close collaboration between students and local work force was achieved. The reasons for this and consequences for future projects will again be discussed in 4 – Evaluation.

3.4 Vocational school, Nairobi, Kenya 2011/2012 - project 4

The initiative for this latest project came from a partnership between a German and a Kenyan NGO, who have cooperated for some years in a children and youth programme in Mathare, one of Nairobi's largest slum areas. After their regular secondary school education, many young people are unable to find either work or further training enabling them to earn their own living. For those who cannot afford to go to University, the new skills centre will offer another option by offering training for mechanical, technical or agricultural skills.

Concept

A large site in a developing rural area East of Nairobi was preselected by the local operator of the school. To ensure a sustainable growth and development, the buildings will be brought up in several stages on the basis of a master plan, according to the capability and needs of the future users. In its final stage, the skills centre will have 6 workshop units, sleeping rooms for about 60 students and 6 teachers, sanitary rooms, a communal kitchen as well as a large community room. Generous open spaces, both for the school and for recreational use, will be provided. Building on a rural, undeveloped site, the utilisation of regenerative sources of energy will be equally relevant as the employment of environmentally friendly and cost-efficient materials. The school is independent of public power supply and will separate and recycle its wastewater on site. The structures erected in the first stage of the project can be used as prototypes for the subsequent stages of construction, which local workers could complete with a minimum of outside help. In this way, there will be a two-sided transfer of knowledge, while the operating NGO will ensure a consistent building process.

The general concept of this building was to design a system of positive and negative volumes, formed by cubic buildings and courtyards between them. Thus, there are a series of indoor and outdoor rooms containing the functions needed for a boarding school. The buildings have sloped roofs with a low pitch towards the courtyard so that rainwater from the roofs can be collected inside.

Each courtyard has a different atmosphere according to its use (garden court, water well court, kitchen court). The sequence of these outdoor spaces forms an 'intimacy gradient' (Alexander 1977: 611-613) from the more public common spaces to the private courtyards in front of the sleeping rooms. Within the wide open agricultural area surrounding the site, a sense of place and space is created within the building complex.

The school buildings were constructed with solid walls from local natural stone, while for the roof and ceilings prefabricated load bearing structures made from bamboo have been developed. Bamboo was also used as a reinforcement material in some of the concrete floor slabs. This fast growing biogenic material is the focus of research in Kenya and offers a more sustainable alternative to timber as a construction material. The use of bamboo is not common in Kenya, but there are areas where traditional buildings are made from this material. Its use for roof constructions on single story buildings could be a strategy to reduce the use of timber illegally cut in natural forests, while at the same time growing bamboo could become a profitable and more sustainable alternative to the many eucalyptus plantations in the area.



fig.5: site photograph of the design-build project Nairobi 2011

Participants

The building has been planned and executed by a group of 18 students of architecture who were preselected for this project based on a personal application. Studio work went through a number of phases:

- Teams of 2 for a first design phase

- Teams of 6 during the second phase, after reducing the number of solutions to three
- (The selection of a final project by a jury out of three entries was necessary after the second design phase)
- A team of 7 students worked on different tasks during the preparation of construction drawings and details for the final design solution (third design phase after the selection of a final project)

The project management team consisted of two architects who managed the project and the construction phase. Additional tutors supported the team during the design phase and also on site. As a preparation for the actual construction, several day workshops were held in Germany, used for training and experimentation, as well as to build prototypes of the roof construction. Due to a number of unpredicted circumstances, this building could not be finished within one construction campaign. The first stage of the buildings was completed in August/September, a second stage took place in March/April 2012.

During the first building stage, when the original design team worked on site, students took over varying tasks, mostly according to the special field they had been working on during the planning phase (fig.5). Tasks for team leaders and their collaborators were assigned during site meetings every morning. Team meetings for the whole group were held at the end of each working day. On certain days, the team size increased by 18 to 20 local students out of a collaboration with Jomo Kenyatta University of Agriculture and Technology in Nairobi. A team of 10 - 15 workers from the area, led by a local foreman, worked together with the student group.

The second building phase was constructed by a new team of 20 students, who had not previously been involved in the project. The project management team consisted of the same people as in phase 1, which brought a certain amount of continuity and transfer of information from the first stage. The same set up of student teams with a team leader and collaborators was used, and regular meetings on every morning and evening stayed the rule, in order to keep the whole team as informed as possible.

Project preparation and involvement of local stakeholders

It was possible to establish an University cooperation and involve local students and professionals in the preparation for this project from a very early stage. This cooperation brought the necessary input of information on building regulations and procedures, but also helped greatly to adjust and improve certain aspects of the design. The involvement of local students, both from architecture and construction management, gave them the opportunity to support the German team with their practical experience. Exposure of students from both Universities to a different cultural context through personal contact was highly valuable to everyone involved.

4. EVALUATION OF THE PROJECTS

This section will give a short summary of the set-up of each of the design-build-projects described above and compare the procedures and outcome of each project.

Project 1 – Kindergarten Orangefarm

The large group of students coming from different fields who worked on this project made both coordination and information procedures complicated. Nevertheless, the building was completed in a exceptionally short time, with everyone involved showing the highest motivation towards this common goal. The set-up of the design project, working in different stages and avoiding a competition proved to be the right strategy to make the large group identify themselves with the project.

Regular meetings with a group of this size proved difficult, while meetings with only the team leaders sometimes led to a lack of information within the whole group. In can be concluded for future projects with a similar set-up, that the involvement of students out of the group as team leaders will require a certain preparation time. Students will in most cases only be ready to take over a leadership position among their classmates if certain rules are discussed and agreed on. Formation of the groups, responsibilities within the group and a certain hierarchy should therefore be discussed in detail with everyone involved. On the whole, the exceptional situation of this project lead to an immense effort on all sides, which was rewarded with a great success.

Project 2 – Teacher's House Magagula Heights

As a lesson learned from the Orangefarm project, the group involved here was limited to 12 students, few enough to be involved in decisions throughout the construction process. However, the fact that students had not worked on the design and were generally hardly involved in project preparations, led to a noticeable lack of interest in planning decisions on site. Both the small size of the building and the short construction period of only four weeks reduced students' involvement in the actual building process. As a teaching or learning exercise, this set-up is not as recommendable, as it lacks the theoretical background necessary to be a valuable part of architectural education.

Project 3 - Kindergarten Brak-en-Jan

The interdisciplinary approach of this project was a great success and benefit to everyone involved. Experts from different fields were involved in planning and execution of the building, which led to a high physical and aesthetic quality of the building. Cooperation with a local expert for the adobe brick construction also added much to the overall success of the building.

While on the whole the project was very successful, it was nevertheless found that a lack of information among the student team can lead to a certain decline in motivation. One reason for this lack of identification can be found in the competition process of this project, leading to the execution of a design solution which is only known well to a very limited number of students. Another reason was fact that most of the students could only participate in part of the construction of this project, which made it difficult for some of them to gain a general overview over the

construction.

As far as intercultural exchange and a transfer of knowledge is concerned, the project did not fully meet expectations. The objective of involving local workers and decision makers in the process of planning and building was not met, the resulting multiplicatory effect had not a very high impact. Nevertheless, motivation to improve the overall situation in the village and a certain environmental awareness were triggered by the project. Longer, more intensive local preparations are a prerequisite for a greater involvement of local stakeholders.

Project 4 – Vocational School Nairobi

Many of the experiences from the previous projects could successfully be used when planning this one. First, the size of the student group was limited to a number which could still participate in group discussions, but could be subdivided in small design teams as well.

A competition for the final design was avoided by forming different design teams during the different phases of planning. The small team working on the final construction drawings became team leaders for different parts of the construction on site. A large effort and considerable time were put into regular information meetings to assure that everyone kept an overview over what was going on on-site at all times.

The second construction phase with a different but extremely efficient and motivated team of students showed that information of the participants during construction on site is even more important than a long term involvement with the project. Nevertheless, the effect of putting their own design decisions to the test by building them must be considered the most important effect of these projects from an educational point of view.

During the whole project phase, users, local workers and the community were of the planning and execution process, which proved to be controversial at times. Involvement of local students and a close collaboration with academic and professional colleagues from Nairobi also brought valuable aspects to the process. Both the student groups and the team leaders profited from this intercultural exchange of ideas, different mentalities and working methods.

5. CONCLUSION

It can be concluded for almost all of the projects that they successfully address one or more issues which were found relevant for the region, site or users from the beginning of their preparation. The slow design process, which allows for research through design, is helpful for the identification and integration of these issues by the student team. This process is the principal educational goal of these projects. Instead of confronting the students with pre-formulated design tasks, much of project outlines has to be developed throughout the design and construction process. This problem-oriented teaching method is based on defining the questions before solving them, a process very similar to the professional work of architects and engineers.

From the evaluation of the different procedures of each project described, certain principles can be established, which will increase the overall success and individual benefit of similar projects. While a great amount of a team's achievement still depends on the specific situation, lucky or unlucky coincidences and a lot of personal input, some general rules can be given as a result of the fieldwork done so far. These may prove to be valuable for lecturers working in the same field.

The teaching method described here is considered to be especially suited for interdisciplinary or intercultural cooperations. It is at the same time very well suited for capacity building measures between Universities, as a significant learning process for the tutors can be expected both during the unusual design phase and the experimental building process. An exchange of ideas between students and academics with different backgrounds, tolerance for unusual or new solutions and an informal platform for research and discussion are all included in the concept.

ACKNOWLEDGEMENT

The series of design-build projects described here were organised and executed by the author during her time at the faculty of architecture at the Technical University in Munich, Germany. The projects were organised in collaboration with colleagues from the same faculty and - in the case of the Nairobi project - from Jomo Kenyatta University of Agriculture and Technology in Nairobi.

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