Practical Relevance in Architectural Education

Design-build student projects in a global context

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ABSTRACT: Combining theoretical design and research with the practice of experimental building, design-build projects lead to an in-depth understanding of the relation between material, construction and aesthetics. For a period of more than five years, students of architecture at the Technische Universität München have been offered the possibility to participate in realistic projects in several African countries, which were not only designed but also built by the design team. They are an excellent method of improving social and environmental awareness through personal experience. Tolerance for unusual solutions, an exchange of ideas between students and academics with a different background, and an informal platform for research and discussion are also part of the concept.
Keywords: student project; sustainable construction; design-build; resource efficiency; simple building

INTRODUCTION

Architectural design involves an artistic vision as well as technical solutions for realisation of a structure or building. In architectural education, both aspects are equally important parts of the overall learning objective. Design can be taught on a theoretical basis, but without the experience of realisation, the influence of technical details on the overall design can be difficult to appreciate. Students will readily rely on solutions offered by the building industry, failing to understand the close connection between – and equal relevance of – a structural concept and architectural detailing for the formal and spatial depth of their design work.

The problem-oriented teaching method of design-build offers a different approach to architectural studio projects. For a period of more than five years, students of architecture at the Technische Universität München have been offered the possibility to participate in realistic projects in several African countries, which were not only designed but also built by the design team. The following text will emphasise on a project near Nairobi, Kenya, which combines a number of interesting aspects in the context of student projects, both concerning the content and the implementation of the project.

PRACTICAL RELEVANCE IN EDUCATION

Education in architecture takes place in design studios, where students develop solutions to theoretical assignments. The only exposure to a practical application of design work are practical internships, which are part of many curricula. Here, the students are offered an inside view into professional practice, but a connection to their own design work is rarely achieved.

Practice orientation improves students' understanding of complex design processes, as well as their practical skills, creativity and problem-solving abilities. It can be achieved through the construction of architectural prototypes, which are physically built realisations used to test and explore a system with clearly defined, but unresolved questions. Models of all scales offer an opportunity to experiment with building typologies, experimental constructions and new technologies. A practical approach to architectural education is based to a great extend on building prototypes, i.e. architectural models. In the case of design-build projects, these are larger representations of certain details as well as full scale building parts and finally the whole building.

A major part of the architectural education process depends on balancing internal and external constraints within a specific architectural design. This is highly complex procedure, in which problem definition and problem solving are equally important. A circular process of thinking and making, drawing and building, leads to design decisions based on well-considered personal judgement.

The process described here is related to the one Richard Sennet describes in his book 'The Craftsman', where he compares historic workshops of craftsmen or instrument makers to modern laboratories [1], stating that it is these places where thinking and making are not only closely related but become one and the same: the craftsman develops his ideas as the researcher finds his by doing or making things. In order to describe the circular process of experimental design, an open loop of *designing – making – redesigning* similar to a craftsman's or artist's process of shaping his work can be drawn, which describes the sequence of simplifications necessary for good design solutions.

Examples of architectural learning-by-doing, which link experimental education with both the social agenda of modern architecture and technological experimentation, are not new. All three aims were of primary importance at the Bauhaus, founded by Walter Gropius in 1919 in Weimar, Germany. Here workshops were placed at the centre of a progressive curriculum that aimed to fuse craft and design education with avant-garde artistic practice. This tradition later emigrated with some of its initiators to the United States, where currently almost thirty schools offer such programs [2]. Frank Lloyd Wright worked with student apprentices when building Taliesin [2], and the first-year design-build studio at Yale University was founded as early as 1967. One of the most famous of these programmes is the Rural Studio at Alabama's Auburn University, established in 1992 by Samuel Mockbee, where students work and live with the clients for several months [3]. Most of these programmes also address issues of social commitment of students building for less privileged clients.
Contrary to conventional architectural education, design-build projects offer the possibility to combine theoretical design and research with the practice of experimental building and lead to an in-depth understanding of the relation between material, construction and aesthetics. On the broader scale of the whole building in its local context, they are an excellent method of improving social and environmental awareness through personal experience. The intercultural context of the projects described here adds a global viewpoint to the aspect of this social involvement.

BENEFITS OF COOPERATION AND EXPOSURE

The projects described in this paper derive part 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 those students who work in a different cultural context during the project, a similar effect could be observed in local participants: for them, the exposure to unexpected, unbiased building solutions for seemingly commonplace problems has broken with existing preconceptions. An exchange of ideas between students and academics with different background, tolerance for unusual solutions and an informal platform for research and discussion are also part of the concept (fig. 1).
The whole design team benefits from the fact that the whole group works for a common goal requiring a constant exchange of ideas and opinions between the participants. More than usual, students will learn from each other in this process.
At the same time, the realisation on site brings together people from extremely different circumstances of life and education. Working together on a construction site, they profit from each other's skills while sharing the satisfying experience of completing a much-needed building. For this reason, all projects described here made an effort to include local craftsman and workers as well as students from partner Universities in the building process.
The process of planning and building the Skills Centre Nairobi gives a good example of this kind of cooperation. It was started as early as 2010 during a first visit to Jomo Kenyatta University of Agriculture and Technology (JKUAT), which became a long-term cooperation partner in the project. Connections between participants on a professional as well as on a personal level have continued ever since, turning the project cooperation into the starting point of a professional network.

Figure 1: German and Kenyan students testing a prototype truss at the construction site in Kenya

FULL SCALE STUDENTS PROJECTS.

The history of design-build at the Department of Timber Construction started in 2007 with a kindergarten project for the township Orangefarm near Johannesburg, South Africa, which was planned and realised as part of a whole series of student projects by European Universities in that region.
The positive experience of highly motivated students and a very intense atmosphere during the building phase

called for a repetition. Since then, a full scale student project has been implemented every year, but it was only in 2010 when a sophisticated academic program was established within the project of the Skills Centre Nairobi.

For the first project described here, Khanyisani Preschool in Orangefarm (RSA), a large group of about 35 students of architecture was involved in a long planning phase of two semesters. The whole team worked together throughout the entire preparation, including the logistics of construction, collection of funds etc. The dynamics of the large group, together with the adverse conditions of a badly serviced site and an exposed situation of working within the township itself proved to be extreme conditions, which pushed participants' resources to a limit [4].

The second realised project, a teachers house for Ithuba Skills College in Magagula Heights, RSA, was not designed by students, but by staff of the Department of Timber Construction. The student group took part in an introductory seminar and subsequently participated in the construction phase on site.

The third project took place in 2008/2009 under less difficult conditions in a small village in the Western Cape region of South Africa. However, the project set-up chosen here also posed some challenges: Planning time had to be limited to one semester to avoid the rainy winter season during construction. A large group of 34 students produced 17 different design solutions in interdisciplinary teams of architects and civil engineers, which were then judged by a jury to choose the final design for realisation. This procedure led to a lack of identification and information of the rest of the group, which had to be compensated during construction [5].

As a fourth project, a primary school building in Mzamba, South Africa, was again designed by staff of the Department of Timber Construction. Again, the small group of students was prepared for their participation in the construction phase within a tutorial of one semester.

With the background of positive experiences and lessons learned in the process, the project near Nairobi, Kenya, started in 2010. The project was initiated by the German NGO „Promoting Africa“ in cooperation with the Kenyan NGO „Youth Support Kenya“ to help juveniles of Nairobi's second largest slum Mathare to learn simple craftsmen skills necessary for a self-employed means of subsistence.

EDUCATIONAL APROACH

All of the previous projects had faced the dilemma of a group designing or working together on a common task, while every student had to be graded individually within the academic programme. Competition between design groups had shown good results, but included the risk of frustrating parts of the group.

Different approaches had also shown that for educational matters the design – and – build projects gave a much better and more sustainable input to the students than the projects that were only built, but not designed by the students.

Finally, the integration of practical workshops as a supporting measure for the design studio work had shown very good effects.

During the design studio for the Skills Centre Nairobi a new approach was tried out for the first time: From October to January, nine design groups of two students each worked on different designs for the Skills Centre. By the end of January three design solutions were chosen for further development in groups of six students. After another month of very intense work in a workshop-like atmosphere the final design to be carried on for construction planning in the summer semester 2011 was selected in an open forum by a jury of four architects and a representative of the client.

During each of these steps, students were encouraged to to form larger groups and to integrate the best ideas of all previous proposals. This way it was not only possible to find the best solutions, but also to enable the hole group to identify with the project (fig. 2).

Figure 2: Under extrem conditions in Africa teamwork and motivation of the students are essential for the success of the project.

During the second semester from April until July 2011, a group of seven students, assembled from all three of the final groups, worked on the construction planning. This design studio work was backed-up by practical workshops. The whole designated construction team of 18 participants took part in these workshops. In this way it was not only possible to manufacture sample constructions in in search of suitable solutions for specific structural problems. It was also possible to keep everyone involved in the on-going process, instruct the students to craftsmen's tools and machines and get prepared for construction site.
Ten months of design studio and workshop gave tutors time to identify characteristics and abilities of the participants as a basis for the formation of teams for different tasks on site during the first construction stage in August and September 2011. Those students who had been working on the construction plans became assistants to the construction management and were in charge of special subjects. In this hierarchy it was fairly easy to integrate a group of participating Kenyan students into the processes.
With the beginning of the actual construction process, the design procedure was not yet finished. Many details had to be adapted to local technical possibilities and materials available in Kenya. This on-going planning process done by the students on site and during realisation was an important part of the educational programme and made the various interactions between planning and construction visible to the students.

EXTERNAL EXPERT ADVICE

During the first presentation, results were discussed with African and German representatives of the clients (a Kenyan and a German NGO in charge of the project), respectively, to synchronize the designs with their needs and expectations. As guest critics, architects Saija Hollmén and Anna Heringer gave important input concerning simple constructions and building in Africa and developing countries. (fig. 3).
In March 2011, after the final design was selected, the project architects, together with two students, travelled to Nairobi. They presented the design studio work to members of staff and students involved in the project at the cooperating Jomo Kenyatta University of Agriculture and Technology, as well as to the Kenyan client and the local project architect. This review of the layout gave important input concerning local building regulations and Kenyan construction codes – which had been impossible to obtain on a theoretical basis earlier.
The second semester was dominated by working on the roof constructions of bamboo. The Indonesian architect Dr. Andry Widyowijatnoko, then affiliated with RWTH Aachen, gave important input according suitable implementation of bamboo and traditional bamboo joints.

Figure 3: Andry Widyowijatnoko at one of the practical workshops introducing simple and suitable bamboo joints to the group.

ARCHITECTURAL DESIGN

With the experience of three successfully built projects in Africa, the tutorial of the students work could concentrate more on questions of design rather than on practical necessities. The studio syllabus for the skills centre required an integrated reflection of building and context from the scale of urban planning down to 1:1 detailing. The students were encouraged to come up with a master plan for efficient land use and future development of the institution as well as to design the complex to be built during the first of three building phases. Layout and construction should be simple but interesting enough to be replicable by future neighbours. At the same time, concepts were to be found to reduce the energy demand and ecological impact for establishing and running the buildings to a minimum. Beyond integrating all of these topics, the design was expected to be of a strong architectural expression.

STRUCTURAL DESIGN

Experimenting with building materials was a mayor part of the educational programme. From the very beginning the inner logic of the architectural design was influenced and formed by the characteristics of building materials. The aim was to use materials that are locally available, ecologically sustainable and practicable for unskilled workers.
It was clear from an early point, that using the local hand-dressed natural stone would be the most promising material for walling. It is the most common building material in the area of Nairobi and therefore readily available, inexpensive and local workers know how to use it quite well. A harder task was to find a suitable

construction material for the roof construction. Timber structures had been used for roof in the earlier projects in South Africa, where timber had been found to be suitable for student projects, since it is a material unskilled workers can handle with relatively high precision. No heavy machinery is required and the handling is rather safe.
For Kenya, however, the situation was different: Within the last 100 years the forest coverage of Kenya has been reduced from about 15% to 2% of the land area. Pressure from illegal harvesting of timber on remaining forests in the national parks is very high. Looking for alternatives, the students came up with steel constructions on the one hand, and bamboo constructions on the other hand.
Research on the topic of bamboo in Kenya led to a programme by the Kenyan Forestry Research Institute (KEFRI) trying to promote indigenous bamboo as a building material.
A century ago, Kenya had 350,000 hectares of it's only indigenous bamboo "Yushania Alpina" covering the Aberdares, Mt Kenya, the Cherangani's, Mt Elgon and the Mau. Today little more than 80,000 hectares remain. Since there is no commercial value placed on bamboo and it has been widely replaced by cash crop plantations, the destruction to Kenya's biodiversity and water catchment has been immense. Preservation of the environment seems only to work if Kenya's population will be able to profit directly from it. Against this background, it seemed promising to promote the use of bamboo as a building material, even though very little construction has been undertaken in Kenya yet.
One of the objectives of the exploration trip in March 2011 was therefore to find out about availability, quality and price. Since bamboo is not yet in use as a building material at all in Kenya, it was a lucky coincidence to find the only company capable of delivering the required amount of bamboo, and also to bring eight sample poles back to Munich.
In this way the indigenous Kenyan bamboo Yushania Alpina was tested for its strength under pressure, tension and bending for the first time at the material testing laboratory at the Technical University of Munich. The results proved Yushania to be of very good quality as a building material.
Since the roof structure was the most important and yet most indeterminate part of the project, it received a lot attention during construction planning. Even though materials tests led to reliable calculation values for the Kenyan bamboo, it was not possible to define a reliable base for computation of the load-bearing joints.
Therefore, samples of the basic parts of the bamboo construction was manufactured and tested for their structural performance by the students in the course of two workshop days. In this way, it was not only possible to gain knowledge about the structural design but also about possibilities and challenges of the manufacturing process. The final structure and details of the roof construction were developed in continuous, circular process of planning and manufacturing samples. Finally, the structure was optimised to the specific demands of broad prefabrication and safe assembling of building elements.
Towards the end of the second semester the construction became a more and more important source of shaping the architectural design. The development of very specific characteristics of roof and wall construction was integrated in the design as a synchronizing process. The architectural expression of the build ensemble relies very much of that intense relationship (fig. 4).

Figure 4: Façade of the workshop building: a hard shell of natural stone wall protects the soft core made of bamboo.

In building prototypes, attention was drawn to the topic of wholesale material use. Sorting out poles suitable for the wide span truss in the workshop building out of a bunch of harvested bamboo poles leaves 70% to 90% reject. In order to be resource efficient, the concept of the skills centre was to use a cascade sorting system into types of declining quality of bamboo poles for different applications. The straightest and longest poles were used for the structure of workshop building with a span of 6,50 meters and cantilevers of 3,50 and 1,80 meters. A second quality level was used for the structure of kitchen building with a span of six meters, while the remaining material could still be used for dormitory ceilings. Leftovers of the manufacturing process were recycled for auxiliary constructions like scaffoldings, or used as concrete reinforcement and for fillings of door and window shutters (fig. 5). Like the architectural design the structural concept was work in progress also during the construction. For the students this created the possibility for references between planning to construction and vice versa. Solutions to apparent problems were solved with both head and hands.

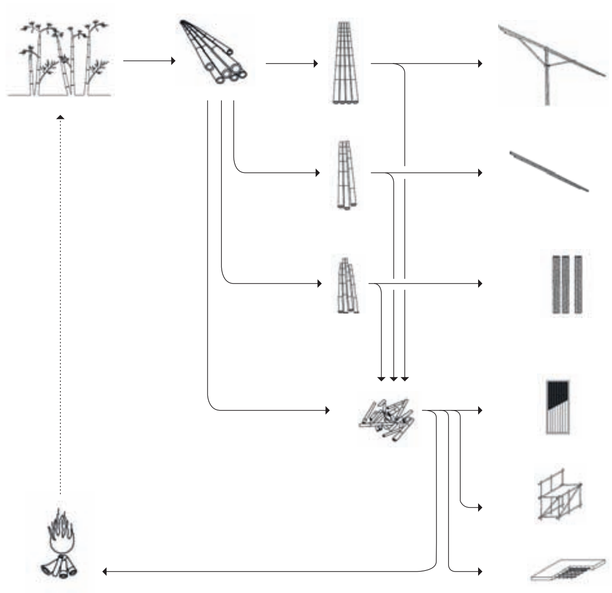

Figure 5: cascade sorting system for the delivered bamboo poles: different quality of material for different purposes

OUTPUT

The construction of the Skills Centre Nairobi was successfully finished by a second student group of the Technische Universität München and the University of Applied Science Augsburg in March 2012. A photovoltaic power plant was installed in May 2012, which not only supplies electric power for the school but also for some of the neighbouring farms. Operation of the school started in June 2012 with courses in photovoltaic installation and carpentry. The Skills Centre has already attracted attention for being the first bamboo-structure of that size in Kenya, biological waste-water treatment, a dry-toilet system and the self-sufficient energy supply. The knowledge gained in the course of the project is accessible to the public through Jomo Kenyatta University of Agriculture and Technology, one of cooperating partners.

The educational programme of design-build was a great success for the participating students.

Not only did they benefit from subject-specific knowledge, but they also gained personality by working in responsible positions under extreme conditions. They understood from personal experience the dependencies between the planning and the building process.

CONCLUSION

From four successful projects, the following results can be summarised:

The difficult environment of a foreign place, in this case African countries, where the construction process is characterised by a high effort of organising information, materials and logistics, is an important aspect of the design-build studio work. The procedure of the educational programme of the Skills Centre was very promising. It has been repeated with success in a subsequent project in Ngaoubela, Cameroon in 2012 and in an on-going project for a prototype school in Zambia.

Contrary to development aid projects, it is possible to develop very specific and adequate solutions for local challenges even in small projects during the very intensive, one-year design work.

University infrastructure provides a substantial variety of experts who can help to find profound concepts. In cooperation with local universities the design-build projects offer the opportunity for long-term collaboration and for a two-way knowledge transfer:

Architecture in many African countries seems to lack links to disappearing building traditions, solution-oriented design and experimental input. Instead, imitations of international style for representative buildings are to be found, or uniform and over-simplified outcomes of every-day architecture. The experimental work of inspired architectural students can give interesting input and idealistic freshness to an environment of continued and hardened building habits.

For the students it is not only an opportunity to expand their horizon, but also to form an emotional connection with an unknown way of living and to promote personal relationships to Africa. Experiencing a very simple way of building and being in the position to handle problems in a very straightforward way, the essentials of architecture become obvious. Simplification of complexity is a key element to the understanding of connections between planning and construction as much as finding solutions for specific problems.

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