# CONSTRUCTION EDUCATION IN AN ARCHITECTURE SCHOOL IN CHINA BASED ON REAL-LIFE PROJECT: FROM VIRTUALITY TO REALITY

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**ABSTRACT**

The skills shortage in the construction industry in China is exacerbated by a very high demand for students in architecture schools, for construction tradespeople and for architects with a working understanding of how buildings are constructed. This has become a growing problem and an invisible barrier among practitioners, universities and the construction industry in recent years. Students majoring in architecture are familiar with construction drawings, but lack construction-related knowledge to translate these drawings into buildings. In contrast, some construction practitioners are not familiar with the factors that influence design and design processes. This highlights the need for practical construction education in architecture schools. This paper explores the construction teaching practices in an architecture school in China. The Industry-Education-Research Cooperation (IERC) approach involves the construction of buildings rather their representation as drawings. This paper analyses and compares students' efforts in five-year graduate design degrees. It then analyses the benefits of IERC and the differences between it and traditional construction education. This is followed by a discussion of the significance and implications of these approaches to training, teaching and learning about construction. The findings reveal that traditional construction courses have drawbacks including not only formalism, low uptake of knowledge, but also disconnection and gaps between theory and practice, virtuality and reality, drawings and buildings, as well as universities and construction enterprises. The IERC construction education mode is based on real-life projects and is recommended as an approach that benefits universities and the construction industry as a whole.

*Keywords:* Construction education, real-life project, teaching practice, virtuality to reality

## INTRODUCTION

### Background

The past decades have witnessed rapid urban development in China. Cities there are facing a high demand for construction activities, especially for housing. This phenomenon highlights a significant demand for skilled construction tradespeople. Given this, Chinese universities have produced many architects who are familiar with design and construction drawings. However, after graduation these individuals sometimes find that they cannot translate design ideas from drawings into real-life buildings. Inexperienced and unskilled architects may make poor decisions and give instructions that result in increased costs and inefficient processes.

### Problem description

Architectural education is inextricably linked to construction education. The construction industry is complex and fragmented, involving numerous players, skills, and technologies. Like all other engineering disciplines, construction is an applied field, meaning that its education must centre not only on theory, but on how things get done (Osama et al., 2000). A US survey indicated that engineering education has to reform and it needs a paradigm shift (Leonhard, 2005). However, the dominant pedagogy for engineering education still remains "chalk and talk", despite the large body of education research that demonstrates its ineffectiveness (Mills and Treagust, 2003). Today's engineering graduates are graduating with knowledge of fundamental engineering science and computer literacy, but with little knowledge of how to apply it in practice. The complexity of modern buildings also leads to invisible barriers between architects, builders and project managers. This highlights the need for and exploration of practical construction education in Universities.

Meanwhile, China is facing similar dilemma and what's worse, architectural education in China overlooks construction education. This is because architects generally believe that builders should be in charge of site activities. This has resulted in that the current architectural education system in China attaches great value to design, but little value is placed on construction. As a Chinese architect said "Chinese architectural education largely ignore(s) this. Architects do not concern themselves with how to build the building. It leads to architects' lack of construction experience and ignorance of material characteristics when they conduct design and build activities (Peng, 2010，p.222)".

## RESEARCH AIM

Chinese architecture schools have attempted to reform their architectural education gradually. Several design-build courses have been developed to focus students' attention on building rather than on design. However, the outcomes of these courses are unpredictable. There is potential to improve the ways students are taught about construction processes. This exploratory research aims to contribute to a new paradigm shift in construction education and to identify how universities can facilitate construction education for the industry.

## RESEARCH CONTEXT

The first author is a PhD student undertaking studies in the Department of Building Science and Technology at Southeast University, China, commencing in 2010. The student was a teaching assistant in traditional design/build courses and the group leader of the five-year real-life design project "Emergency Construction" using the IERC construction mode at Southeast University. The student is conducting the research under the supervision of the second author who is an academic in Department of Building Science.

## METHODOLOGY

It is well documented that an insider position or experience is crucial to understanding a community (Thoresen and Öhlén, 2015). This research adopts a phenomenological approach to understand people's perceptions, perspectives and understandings of a particular situation (or phenomenon). A phenomenological research study thus attempts to answer the question "What is it like to experience such and such?" During the data collection phase, the first author reflected on his lived experiences as a participant in construction education activities. Then the first author collected and analysed the comments from stakeholders based on interview surveys and audio/video records.  This paper presents findings based on these data.

## IERC CONSTRUCTION EDUCATION

### Definition

Industry-Education-Research Cooperation (IERC) is not only a new kind of construction course but also a new construction education mode. The IERC mode represents a collegial and cooperative relationship between industry, education and research. Funding is at the core of this mode. The biggest difference between IERC construction courses and traditional build courses is that the learning outcomes are based on real-life buildings. If construction courses require industry funding, the learning outcomes must have commercial value and provide other benefits to industry. For example, industry may benefit by having their profile raised in students' eyes, and thus have opportunities to attract talented students. Furthermore, some academics' research programs dovetail with these courses and allow organisations to share in research outcomes.

## Real-life Project

"Emergency Construction" was the first attempt to use the IERC education mode for a graduate design project in architecture school at Southeast University (Figure 1). The purpose of the small building students were required to design and construct was to provide an effective and timely solution to provide housing after a disaster. The objective was to design a shelter that could be delivered to site three weeks after a disaster and could be used for at least one year. Therefore, the house needed to be able to be more readily transported and constructed than permanent houses.  It needed to perform better physically than tents as well. Ease of prefabrication, transportation, assembly, use, demolition and reuse were thus of paramount importance. The final learning outcome was a real-life building that was exhibited on campus.

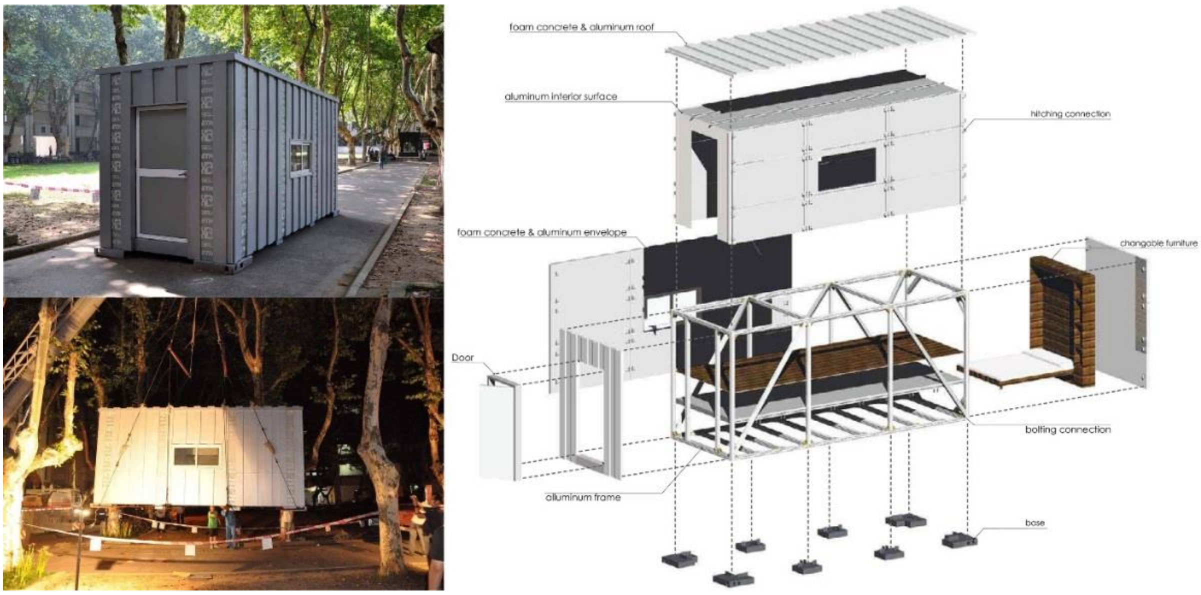


Figure 1 2011 Graduate design project “Emergency Construction”

(Source: Author, 2011)

Based on the aforementioned requirements, aluminium was chosen by students as a structural material. All the prefabricated components of the building were connected with bolts that were tightened with a simple wrench, making it possible for students to assemble the structure by themselves. The envelope system was composed of aluminium panels whose outer skin was aluminium and inner was foam concrete and glass-fibre net. This envelope assembly was the first practical application of a patent resulting from research in the architecture school. The experiences of students in the design/build exercise contributed to this research program as well.

## Funding

It was challenging to raise funds for the course the first time. The XinBa Building Decoration and Construction Company had a good cooperative relationship with the architecture school and were approached for assistance. In return for funding the course, the company were offered a partnership with an excellent architecture school that would benefit the company's reputation. In China, public praise means commercial value. In addition, by understanding the expected learning outcomes of the course, the organisation became aware of potential future applications. Finally, the XinBa Building Decoration and Construction Company decided to fund the course. Not only did it provide financial support, the company's own manufacturing factory and skilled construction workers were able to assist. This was a participant of this course as well.

### Teaching procedure and building process

There were two phrases of this course. Phase one was taught formally in school via seminars and workshops, whilst phase two was in the XinBa factory. There the teaching mode was practical and experiential.

In **phase one**, students were divided to several groups. Every group (4-5 undergraduates) had a postgraduate as group leader. The groups then developed their own designs based on the aforementioned requirements and with the guidance of teachers in building science and technology. The teachers chose one design that best met the requirements of the exercise. The design included architectural design, materials selection and a technical proposal. This procedure took seven days. The chosen design was submitted to a civil engineer to make sure the structure was safe. The building was then divided into four parts: structure, envelope, interior, and equipment and furniture. Each part was allocated to a group of students ("Structure Group", "Envelope Group", "Interior Group" and "Equipment and furniture Group"). Each group was responsible for detailing, organising and constructing their own work. To facilitate the construction process, groups used parametric software (Revit and Naviswork) to develop their designs from "design drawings" to "building process drawings". This took 14 days. In general, phase one took about 20 days.

Drawings were submitted to XinBa and work progressed to **phase two**. The teaching venue moved from campus to the factory. Here the skilled workers at XinBa first produced prefabricated components with CNC machines based on students' drawings. Students could only watch and reflect on production for obvious reasons. This process lasted four days. After production, every group assembled their part of the building with the assistance and guidance of skilled construction workers. This process took seven days. Finally, the building was delivered by a container-truck from the factory to the campus. A mobile crane was used to position the building for exhibition. After exhibition, the building was delivered back to the XinBa factory for future application and promotion.

Workplace health and safety considerations were a major consideration on this course. Before phase two, the school insured all students. In the workplace, every group was equipped with one skilled safety guard from XinBa to ensure students' safety.

## RESULTS

### Comments from stakeholders

The teachers perceived that this graduate design project, based on real-life building, had profound significance for construction education in China. An academic in School of Architecture at Southeast University commented:

> *"I think there were two significances of it. The first one was the significance for green construction technique. This building was a positive attempt to adopt off-site manufacture technique developed by students and teachers in university. The second one was the significance for construction education in universities. It was my first time to see the students attending construction courses as real builders across the whole process from drawings to real-life buildings. This building experience would benefit a lot to students and this kind of education activity worth popularizing in other universities in China."*

An undergraduate student attending this construction course said:

> *"Through this course, I felt the gaps between drawings and real-life buildings. As an architect, the drawings should be treated with strict and caution. I should learn knowledge more than design skills in the future."*

From the perspective of enterprise, a manager of a large building materials organisation that supported this project said:

> *"I was glad to see the learning outcomes was the real-life buildings and it was not easy for a university. We can seek for more cooperation opportunities in the future."*

### Benefits and learning outcomes

IERC construction education mode (based on real-life projects) presents a model of a "triple-win" construction education approach to architectural education. If the relationship between industry, education and research can be built, the funds provided by industry makes it possible to transfer teaching exercises and activities from simple structures into real-life buildings. Students have opportunities to transform their ideas from drawings into actual buildings. Teachers may also be able to identify additional opportunities for cooperation with industry. Furthermore, the teaching activities provide opportunities for and contribute to academics' research programs and allow industry to share research results. A further spin-off is that PhD students are able to guide postgraduates and undergraduates as teaching assistants (under the supervision of teachers) to improve their professional skills and abilities as organizers and coordinators.

The learning and building process required every group to produce “building process drawings” and to simulate the building/construction process using Navisworks. Drawings needed to be more detailed than the construction drawings normally prepared for academic purposes; they needed to support production, prefabrication, assembly and transportation. Through this process students and teachers became aware of gaps between theory and practice. In many cases students’ drawings could not be fabricated or assembled. They became aware that some issues cannot be represented on drawings and were easy to overlook. For example, they were not aware of the need to control manufacturing tolerances to ensure that components could be accurately assembled. Little attention was paid to these issues but when it comes to off-site construction and accurate assembly, architects need to be aware of and cater for these issues.

Of profound importance to this course was that the project leader and workers in XinBa were seasoned construction professionals. They played critical roles that could not be replaced by university academics. They took on the roles of the “masters or teachers” of the groups while the students effectively became “apprentices”. This teaching mode is very different from a simple internship on a construction site. The students were real builders instead of passive participants. They updated their “building process drawings” in a timely manner to make sure they corresponded to the building and construction processes actually used. This provided the students with powerful learning experiences of applying their construction knowledge. It helped them to bridge the gaps between digital representations and reality. The exercise was thus practical and experiential.

## DISCUSSION

### Current construction education in China

Modern architectural education in China is less than 100 years old. The Architecture School at Southeast University was established in 1927, marking the beginning of Chinese modern architectural education history (Gu, 2007). At the beginning of the 20th century, several overseas scholars including Liang Sicheng and Yang Tinbao who studied in the University of Pennsylvania introduced advanced architecture pedagogy to China. They became the earliest founders of Chinese modern architectural education. This pedagogy has played a leading role for decades in China and has profoundly influenced current Chinese architectural education. Although many architecture schools in China now have their own design-build pedagogy, most of them were based on the pedagogy introduced by Liang Sicheng and Yang Tinbao (Ding, 2009).

The Chinese University of Hong Kong was the first to open building courses in 1997 in China (Jiang, 2009). Great emphasis was placed on cultivating students' practical abilities. The courses started as small hands-on exercises to build “full-size construction”. Students were taught to design as a way of rational thinking. This encouraged students to consider more factors when they were building.

Influenced by the course “Building Walls” in ETH Zurich, Southeast University included a “Landmark Design” hands-on course in their teaching plan in 1997. This can be seen as one of predecessors of other design-build courses in China. “Landmark Design” has been the classic course in Southeast University for 18 years and continues to this day. It requires students to maintain a balance between design and build issues. It aims to help students understand the relationship between modelling and structure, as well as modelling and materials.

Although the main teaching goals of these courses were to test and verify the rationales underpinning designs and to make students realize their design ideas by building them themselves, rather than teaching students how to build them, they represent a milestone in the history of construction education.

**Limitations and shortcomings**

Construction education is being challenged to keep pace with the latest techniques. Most learning outcomes seem to prioritise improving students’ reasoning at the expense of their rational design abilities. From the perspective of construction education in China, architects are still consciously or unconsciously separate from builders. In short, modern architectural education in China can be described as “regarding form but disregarding content, regarding art but disregarding technique, regarding expression but disregarding design (Wang, 2007).” Furthermore, Professor Zhang Hong (personal communication, May 15, 2014) believed that Chinese architecture schools subconsciously hope that their students will develop into master architects rather than outstanding builders. Master architects are well respected in Chinese society and famous architects attract considerable tangible and intangible benefits for individuals and their schools. Master architects attract students who aspire to be future master architects. Naturally, schools of architecture wish the same for their students. Correspondingly, students in architecture school have little interest in construction knowledge (Ding, 2009). As a result, the class distinctions between the artist and the craftsman still exist. Despite architecture schools put great value on building courses, these courses are still weakly positioned compared to design courses. In this context, construction courses have limited appeal.

In addition, current architectural education in China has its shortcomings. (Lu, 2012) Firstly, excessive emphasis is placed on the form structures take. Students focus more on modelling design than learning about construction processes. For example, in the “2014 Hua Chen Construction Competition”, students were required to create models from cardboard. However, ironically, because of the excellent workability of this material, this exercise became one that entertained rather than taught. The main aim was to model unique solutions. All submissions attempted to show their originality. Correspondingly, the assessment criteria for these exercises were largely based on modelling instead of the proper usage of this material and building/construction processes of the structures. They thus simply became additional design exercises that were packaged as construction education. How much real and useful construction knowledge can students actually learn from them? This question deserves serious consideration.

Secondly, traditional architectural education lacks authenticity. For example, most of the learning outcomes delivered by construction courses are usually construction drawings or 1:50, 1:10 and 1:1 construction models. Where physical models are built, they are usually of paper, cardboard, timber and / or bamboo. Even when full-size models are constructed, materials and joint connections do not accurately represent real-life buildings. The models are simply representations which may deepen students' understandings of materials' characteristics, connection details and building/construction processes. Models are simple compared to real-life complex and diverse buildings, and the learning opportunities they provide are obviously limited.

Finally, it is challenging for teachers to guide students in real-life projects and hard for architecture schools to raise funds to support real-life projects. Construction involves complicated systems and engineered solutions. In China, many teachers in architecture schools concentrate on design because the traditional architectural education focus is more on design-thinking than construction knowledge. Teachers are therefore ill-equipped to build projects themselves, let alone to guide their students to build (Li, 2011). Existing faculty lack practical experience, hence are not able to adequately relate theory to practice or provide design experiences (Mills and Treagust, 2003). Moreover, it is extremely difficult to secure funding for real-life projects that serve as leaning outcomes. Consequently the build component of many courses is limited to one or two design issues whose final outputs are not usually physical buildings in any real sense. This restricts learning outcomes to how to solve design issues rather than how to build buildings.

## CONCLUSION

Architectural education is inextricably linked to construction education. The two complement each other and rely on each other. It is impossible to see them in an isolated way. The current construction education mode in China has its limitations and shortcomings which is being challenged to keep up with the rapid development of cities and the high demand for skilled tradespeople. To overcome these challenges, the IERC construction mode aims to break the barriers from virtuality to reality. In this model, industry, education and research are interdependent and the three benefit from and with each other. It presents a model of a “triple-win” construction education approach to architectural education. The findings of this exploratory study are limited to a single case study. The positive nature of these findings warrants further investigation. It is recommended that further research into the IERC construction education mode be conducted to verify the aforementioned outcomes and explore their applicability to other universities and countries.

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