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ABSTRACT

While the education of civil engineers is presently considered to be at the expected level, the engineering profession consistently points to the lack of integration of technical content in problem solving activities, and the inadequate communication and team-working skills of many graduates. Very often we all come across the students who know the content but can't seem to apply it and the question that comes to mind is how to re-energise the learning experience for both ourselves and our students? Literature consistently points out that any form of group activity will result in a better quality of student learning when compared to traditional delivery methods (Fink, 2003). Students often point to the obvious inconsequence of much of the course material learned in early years to real engineering problems. Once real design projects are encountered in later years, much of this knowledge has been lost; the application is not obvious or it is considered too theoretical for practical applications. The motivation of students to learn and integrate scientific and technological concepts from early on in their academic career is one of the key objectives for the creation of Civil Engineering Design Studios at a number of universities worldwide, as uncovered by the first author during her recent visit to several Universitas 21 (U21) member institutions as a U21 Fellow. This paper presents some of the findings concerning the Design Studios in Civil Engineering education, as revealed during the Fellowship.

INTRODUCTION

Educational research based on constructionist theories of learning has shown that learning is a social activity and people's richest learning experiences often occur when they are engaged in creating and designing (Papert, 1980; Resnick and Ocko, 1991; Papert, 1994; Kolodner et al., 1998). We tend to think that teaching causes learning but the art of teaching is to create contexts in which learning can occur. The most general and essential context of learning is social and the learning happens within relationships with other people. Traditional education, by isolating students from one another and by forcing them to compete with other, systematically destroys the very human relationships which are essential to learning. Socially constructed reality, on the other hand, is seen as ongoing, dynamic process; reality is re-produced by people acting on their interpretations and their knowledge of it. Engaging students in designing in a studio environment, therefore, helps them to become better learners and problem solvers – key goals of engineering education.

A. Design Studio

The design studio is at the heart of most industrial design, architecture, landscape and art programs curricula (Green and Bonollo, 2003), while the prospect of the design studio being a place of serious study has rarely been accepted by most other academic disciplines, often being seen both as a waste of space and a gross inefficiency in timetabling.

The architectural studio first emerged as a special form of education within the Ecole des Beaux Arts (1819-1914) and, concurrent with the programme offered by the Ecole, involved the part-time study of individual subjects, supplemented by employment, in the manner of the old atelier system of indentures and articles (Bingham, 1993). At the Ecole, the design problem and *learning by doing* superseded the lecture as the primary method of teaching architecture (Anthony, 1991). Many practitioners believed that this system of architectural training produced superior architects. Two masters of the modern architectural movement, Frank Lloyd Wright and Le Corbusier, were both trained in this way (Proudfoot, 1989).

The central method of teaching design and art today has not changed substantially from the historical models. Schön's formulation in 1970s (Kvan, 2001) of the studio method as *reflection-in-action* has since pervaded the teaching of many other professions; with the studio well established as a physical place and a unique pedagogic method.

The *design studio* is a place where students learn to visualize and represent aspects of a problem graphically and to think as a designer. In the studio, emphasis is placed on creativity, drawing, model making, problem solving and communication. Studios are usually problem-solving settings where educators who are experienced in the act of designing tutor students individually or in groups. Problems are set for the students that are "wicked" (Kvan, 2001), at least in part ill defined, uncertain or incoherent. Because there is no definitive design methodology, studio learning is "inherently dynamic, a convergence of spontaneous action and knowledge, and adaptation to changing situations" (Wojtowicz et al., 2001). Students are coached to think widely and deeply, formulating the problem using the right side of the brain, in contrast to the left-brain approaches of other disciplines, such as engineering and science where thought process associated with learning draw upon established principles and methodologies. Discussion, conjecture, imagining and stretching the boundaries of issues are tenants of design thinking and the nature of the way

projects are executed in the studio (Green and Bonollo, 2003).

The basic elements of the effective design studio courses are physical space, pedagogy, student exercises, and assessment (Little and Cardenas, 2001). Physical space can have a profound effect on how students react in any active learning situation. It is recognised that one of the most important elements in visual thinking and engineering design are "great views" and good lighting. The pedagogy of the studio is based upon the idea that students will learn best *by doing* in response to difficult and challenging assignments. Therefore, the selection of the exercises is crucial to the success of the studio method. Finally, assessment, as a key parameter in the effectiveness of engineering education, has to align with the goals of the studio course.

B. Engineering Education Challenges

In our age of technological growth and change, engineering students must be educated to not only understand the fundamentals but also to be able to apply those fundamentals, often using the extension to the knowledge, to construct systems, in what is broadly termed the "engineering design process". The single most important characteristic that distinguishes science from engineering is indeed *design*. Engineering is creativity constrained by nature, cost, concerns of safety, environmental impact, ergonomics, reliability, etc. Today's student-engineers not only need to acquire the skills of their predecessors but many more, and in broader areas. They must be able to interact effectively with other disciplines of engineers and people outside of the engineering profession; they must understand how other engineers and non-engineers think (Bordogna, 1997).

The role of the engineer has evolved from lone specialist to team player, from internally focused to globally aware, from reactionary to entrepreneur. A key challenge of engineering is that it often involves the design of a complex system with interacting parts, many of which may be quite different in character. Consequently, *engineering design* cannot be taught by non-designers nor in an environment that does not support the development of crucial engineering design skills, any more than surgery can be taught by a non-surgeon, or violin can be taught by a person who does not play the violin. It is insufficient to relay on a "capstone" design courses to prepare engineers for their careers. Engineering is something that takes place in the real world, not in a textbook. Any given engineering task almost always involves solving problems in multiple disciplines, typically including not only math and natural sciences but also human factors, sociology, economics, politics, and art.

"The school should be absorbed into the studio and the manner of teaching should arise from its character, that is, the studio should not be an adjunct of the other teaching programmes. On the contrary, all the teaching programmes should exist only to support the studio and the design problems it is working on, reflecting the reality of professional practice, which is entirely driven by the needs of the project." (Gropius, 1983)

Some observations of the successful fresh approaches in education of future Civil Engineers at several U21 member institutions are presented in following sections. In addition, design studio facilities, at some of these universities are also discussed.

II. UNIVERSITAS 21 FELLOWSHIP

Universitas 21, established in 1997, is an international network of 19 comprehensive, research-intensive universities across 11 countries. The aim of U21 is to facilitate interchange between members, to provide a framework for international collaboration and cooperation. The U21 Fellowship Program at UNSW is a tangible aspect of U21 network; up to six Fellowships are awarded each year for visits at one or more of the network members, for a period of up to two months. For academic staff, the emphasis is on developing benchmarks in educational and teaching programs, in collaboration with their colleagues at U21 universities.

For the first author the U21 Fellowship Program funded visits included: University of Nottingham, University of Birmingham, University of Edinburgh, University of Glasgow and University of British Columbia (UBC). Important observation was that the curricula at these universities have a very strong emphasis on the "hands-on experiences" and the design courses; the student projects are seen as fundamental to the learning and skill development. The School of Engineering at the University of Birmingham, for instance, promotes interdisciplinary projects in which students participate in realistic exercises in industrial design and management in close collaboration with students of other engineering disciplines and with associated companies. At the University of Birmingham recently built design studio facilities are shared between Civil, Mechanical and Electrical Engineering students. Much of the interdisciplinary design activities that are happening in the Civil Engineering Department at the University of Glasgow are also studio based. This Department only offers two programs: Civil Engineering (BEng/MEng) and Civil Engineering with Architecture (BEng/MEng). The architecture courses, comprising 20% of the program, are taught at the famous Mackintosh School of Architecture are mainly studio-based. These nature of these Programs was the main motivation for the recent introduction of the BE Civil with Architecture Program at UNSW, described in a companion paper (Vrcelj et al., 2007). Multidisciplinary approaches at the University of Glasgow are in particular emphasized in the Year 3 Design Project, so called "Interact Project". It is an inter-disciplinary design exercise which includes the Mackintosh School of Architecture students (architects), the Department of Building and Surveying at Glasgow Caledonian University students (quantity surveyors), the Department of Civil Engineering at the University of Glasgow students (civil engineers), and the Department of Civil, Structural & Environmental Engineering at the University of Paisley students (civil engineers); most of the activities in this course are studio based.

Nevertheless, one of the most impressive design studio facilities observed during the Fellowship were those at UBC, and some key features of this studio are presented in the

following section. A new Integrated Engineering (IGEN) program has also recently been established at UBC to address the needs of the industry for engineering generalists who understand the multi-disciplinary nature and non-technical aspects of projects, who can work in teams with different types of professionals, and who have excellent communications skills. This program provides students with a broad, interdisciplinary engineering education. The students in this program take courses in core disciplines: materials, solid mechanics, fluid mechanics, and systems involving biological, chemical, and electro-mechanical components. Six technical electives allow several possibilities for specialisation or simply satisfying one's curiosity. The program emphasises engineering design through design project courses taken in each year.

III. Civil Engineering Design Studio At UBC

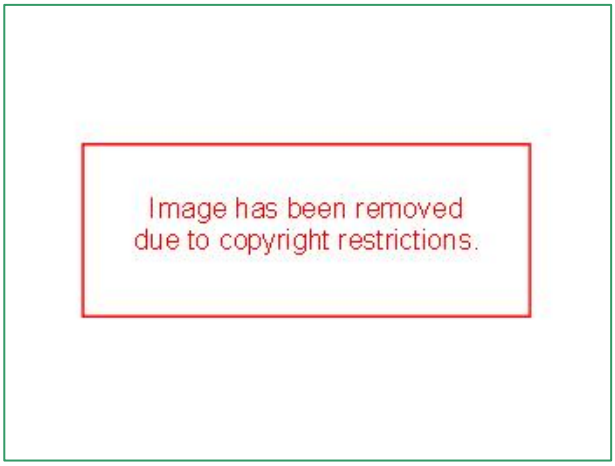

Fig. 1. Artist's rendering of the design studio at UBC (Courtesy of A/Professor Helmut Prion)

The students use the studio on a daily basis; it is a space where undergraduate students have an opportunity to work in teams on design projects, where interaction happens with design professionals, where the synergy of previously learned course material culminates in the creation of unique solutions to practical engineering problems. The design studio at UBC is created as a venue that enables the development of professional design and practice skills, stimulates creative energy, encourages exchange and free flow of ideas, and is a user friendly and professional environment. It is for the students' benefit and they are expected to take ownership of the place, to run it like a professional office, and to proudly bring practicing professionals to visit. They are encouraged to suggest and/or make improvements. All users of the design studio agree to abide by the Code of Ethics for Professional Engineers, a framed version of which is displayed at the studio entrance.

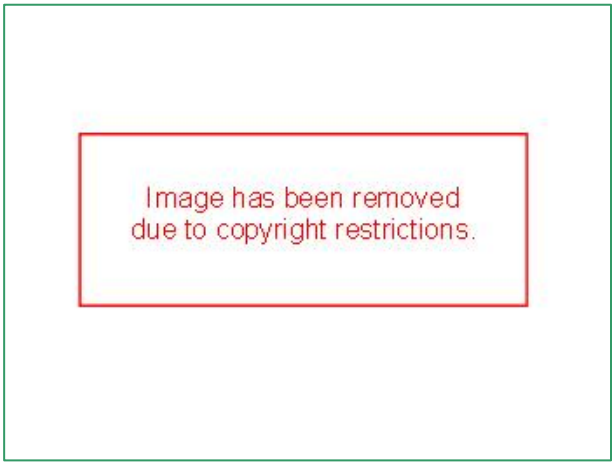

Fig. 2. Design studio ground level (Courtesy of A/Professor Helmut Prion)

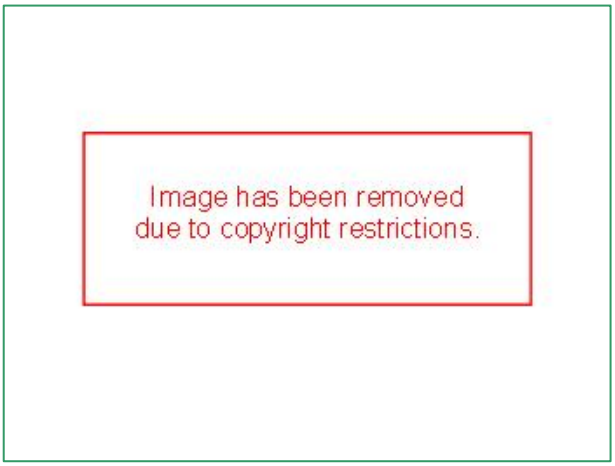

Fig. 3. Design studio mezzanine level (Courtesy of A/Professor Helmut Prion)

"It is a place where academic pursuit and professional practice meet in the formation of the next generation of Civil Engineers" are the words of A/Professor Helmut Prion, a key person in the development and construction of the design studio at UBC. At present, A/Professor Prion's office is located in the studio and he is *the designer in residence* overlooking the studio's day-to-day activities and tutoring students working on their design projects individually or in groups.

III. Summary

Design studio is an approach that focuses on centering the learning environment on the student and provides

mechanisms for the educators to create a learning environment that encourages the students to become self-directed learners and problem solvers. It is an environment conductive to student participation in the process of articulating, reflecting on, and evaluating their ideas, and which does not take for granted that students will develop these skills outside of class. The students are exposed to broad concepts, principles, and problem solving techniques that characterise the essence of engineering.

This paper has presented some of the finding of the project funded by the U21 Fellowship, focusing primarily on the design studio education at U21 member institutions visited as part of this Fellowship. It is hopped that in the near future the authors, together with their colleagues from the School of Civil and Environmental Engineering at UNSW, will be able to realise the dream of having the *design studio* facilities, which will make the undergraduate learning experience at UNSW a truly all-encompassing and practice oriented venture.

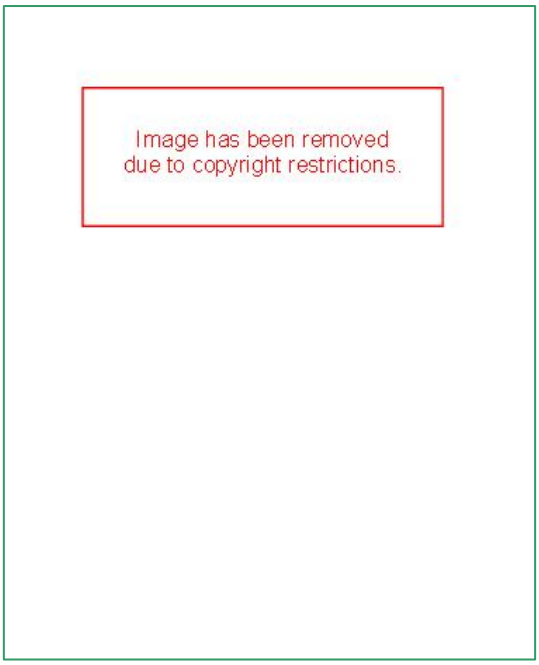

Fig. 4. Meeting space and the computer facilities (Courtesy of A/Professor Helmut Prion)

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REFERENCES

Anthony, KH, 1991. *Design Juries on Trial*, The Renaissance of the Design Studio, Van Nostrand Reinhold, New York, USA.

Bingham, N. 1993. *The education of the architect*. Proceedings of 22nd Annual Symposium of the Society of Architectural Historians of Great Britain, UK.

Bordogna, J. 1997. *Next generation engineering: Innovation through integration*. Keynote speech, NSF Engineering Education Innovators conference, April 7-8, Arlington, USA.

Green, LN, Bonollo, E. 2003. *Studio-based teaching: history and advantages in the teaching of design*, World Transaction on Engineering and Technology Education, 2(2):269:272.

Gropius, W. 1983. *The Bauhaus*, Architectural Education, 1.

Kolodner, JL, Crismond, D, Graj, J, Holbrook, J, Puntambekar, S. 1998. *Learning by Design from Theory to Practice*. In Proceedings of the International Conference of the Learning Sciences 1998, The EduTech Institute (Georgia Institute of Technology), Atlanta, USA.

Kvan, T. 2001. *The Pedagogy of Virtual Design Studios*, Automation in Construction, 10(3): 345-353.

Little, P, Cardenas, M. 2001. Use of "studio" methods in the introductory engineering design curriculum, Journal of Engineering Education, 90(3).309-318.

Mason, E. 1972. *Collaborative Learning*, Agathon Press, New York, USA.

Papert, S. 1980. *Mindstorms: Children, Computers and Powerful Ideas*, Basic Books, New York, USA.

Papert, S. 1994. *The Children's Machine*, Basic Books, New York, USA.

Proudfoot, P. 1989. *Phenomenology, a model for architectural education*? Architectural Science Review, 32: 95-100.

Resnick, M, Ocko, S. 1991. *LEGO/Logo: Learning Through and About Design*, In Harel, I., and Papert, S. (Ed.). Constructionism, Ablex Publishing, Norwood, USA.

Vrcelj, Z, Attard, M, Margalit, H, Plume, J. 2007. *New Civil Engineering with Architecture Program @ UNSW*, ConnectEd2007 International Conference on Design Education, July 7-9, Sydney, Australia.

Wojtowicz, J. 2001. *Design Studio Pedagogy*, In Virtual Design Studio, Hong Kong University Press, Hong Kong.