Implementing Innovative Ideas in Structural Engineering and Project Management
Edited by Saha, S., Zhang, Y., Yazdani, S., and Singh, A.

ISBN: 978-0-9960437-1-7

TEACHING INNOVATION IN CONSTRUCTION

S. O. CHEUNG, K. Y. CHAN, and P. T. CHOW

Construction Dispute Resolution Research Unit, Dept of Architecture and Civil Engineering, City University of Hong Kong, Hong Kong

Construction industry is a major contributor to many economies. Hong Kong is no exception. The culture of the industry is geared to accept the inevitability of competition and to develop a keen competitive spirit. Construction projects are typically secured through competitive bidding; survival of construction organizations is very much hinged on their ability to sustain competitive advantage that can be achieved through innovation and knowledge. Innovation is manifested as the successful implementation of creative ideas. Thus, creativity lies in the heart of innovation and means the production of novel and useful ideas in any domain. Built facilities are often non-repeating products and require careful considerations of numerous on-site and off-site factors. These characteristics are conducive to innovations. It is believed that feedback from the industry into the education system can enhance creativity of the construction profession. As such, universities can act as innovation brokers by consolidating experience and knowledge from innovation champions, then sharing with those future industry players. Ability to innovate is an effective, if not the most, means to meet the upcoming world challenges. Innovative products and services make an organization stands out from the competitors. Exposing students to innovations shall be the first step in fostering an innovative attitude. Further development in innovation can be optimistically projected. This study presents a pragmatic approach to showcase recent innovations in construction to students through the development of a construction innovations catalogue. Construction students are accorded the opportunity to gain insightful and novel ideas. These ideas may venture into their own spheres of innovation. Features of the innovation catalogue are reported in this paper.

Keywords: Catalogue, Education, Undergraduates, Hong Kong.

1 INTRODUCTION

The Government of Hong Kong has planned a number of mega infrastructure projects in the millennium. These developments aim to increase the competitiveness of Hong Kong and to cope with the upcoming world challenges. As such, construction industry becomes one of the main contributors and the fastest growing industries in Hong Kong in recent years. The total gross value of construction works performed by main contractors in the third quarter (Q3) of 2014 has increased by 15% over a year earlier to HK$47.9 billion (Census and Statistics Department 2014). At the same time, construction cost rockets. Construction professional has to be creative and innovative to redress the balance among quality, time and cost. Under such highly competitive environment, construction organizations strive to improve by developing competitive advantages. Differentiation refers to being distinguishable or unique among competitors

and is viewed as the long-term strategy for construction organizations to achieve competitive advantage (Dulaimi *et al.* 2004, Porter 1998, Slaughter 1998).

As an international world city, Hong Kong continues to develop and the design focus of built facilities has evolved from quality, time and cost to sustainability. A sustainable environment enables all people to enjoy a better quality of life without compromising those of future generations (United Nations 1987:37). Nevertheless, Hong Kong is now facing several environmental and social challenges that require immediate attention. The former one includes waste reduction, reuse maximization, recycling and improving energy efficiency. The latter one includes overclouded, land utilization, and deteriorating urban area. The raising awareness of general public about their living environment has pushed construction professionals to rethink their positions. They are pilot to design the built facilities that form the city landscape. Taking all these into account, our professionals are becoming more creative and are able to translate novel ideas into feasible and innovative solutions. These creativities lay in the heart of innovation. It is believed that Universities can act as innovation brokers through consolidating these experiences and knowledge shared by innovation champions in the Hong Kong construction industry, our students' creativity can be enhanced. This study presents a pragmatic approach in showcasing recent innovations in construction to students studying construction related programs.

2 DEFINITIONS OF INNOVATION

Innovation is defined as successful exploitation of new ideas that are novel to the unit of adoption (Amabile 1996, Egbu *et al.* 1998). The novel idea needs not to be brand new to every unit and it is novel so long as it is new for those who adopt it (Manley *et al.* 2005, Park *et al.* 2004). Thus innovation includes application, re-application, developing existing knowledge and adopting products and services developed outside the organization. Similarly, Dodgson *et al.* (2002) described innovation as the productive use of knowledge utilized in the successful development and induction of new products, processes and/or services. Innovation also includes the process of altering be it large and small, radical and incremental, to products, processes, and services. The result is introducing something novel to the organization that adds value to customers and contributes to the treasure of knowledge of the organization (O'Sullivan and Dooley 2009). It is also worthy to note the difference between innovation and invention (Roberts 1988). Invention has an additional feature of exploitation. Invention is a process of new idea creation and turning the idea into workable solutions. Exploitation describes commercial development and dissemination process of the invention. This implies that innovation has to be practical in real life situation (Roberts 1988). Innovations bring benefits such as improvements in efficiency and effectiveness (Manley *et al.* 2005).

3 TEACHING TOOL: A CATALOGUE OF CONSTRUCTION INNOVATIONS IN HONG KONG

According to Amabile (1996), creativity is the beginning and primary source of innovation. Creativity is the production of new and useful ideas while innovation refers to successful implementation of creativity (Amabile 1996). Thus it is a pivotal

component of innovation. Tidd *et al.* (2001) identified three conditions to achieve innovation: motivation, time and money. The pedagogical principle for the use of the catalogue is based on Kolb's learning cycle (Kolb 1984). Kolb (1984) proposed a 4-stage cycle of experiential learning in which i) Concrete Experiences (CE) provide a basis for ii) Reflective Observation (RO). These observations are assimilated and distilled into iii) Abstract Conceptualization (AC) producing new implications for action which can be Actively Experimented (AE). The catalogue offers the students opportunity to be exposed to innovation exemplars. Thus the catalogue is the instrument to enable concrete experience. The catalogue was published in early 2015 (Cheung and Chan 2015).

3.1 Learning Experience in Developing the Catalogue

Students were involved in collecting information of innovation exemplars. The collection takes several steps. These include i) an extensive search of construction innovations in Hong Kong, ii) data collection through questionnaires and interviews and iii) compilation of the catalogue. The catalogue and some of the innovations are shown in Figures 1 to 4. Concrete experience can be first-hand or from exposure to exemplars. A total of sixteen innovations have been collected for the catalogue. As of writing there has no report of similar collections of innovation in Hong Kong. This catalogue is thus viewed as a pioneering means to introduce innovations to students. Most of the innovations have been awarded by professional bodies in Hong Kong, including the Hong Kong Institution of Engineers (HKIE) and Hong Kong Green Building Council. Most of the interviewees expressed innovations are solutions to problems arising from daily operations. In other words, the innovations are need driven. Innovators do not stick to conventional solutions. Instead, they seek alternatives beyond the frame and devise innovative solutions. An innovative culture is particularly crucial to make innovations sustainable and enduring (Creed 2012: P.222). The innovators reported in this catalogue are innovation champions who advocated novel ways to achieve desired outcomes. Innovation champion facilitates developing innovations within his/her organisation. These champions are able to explore possible means to improve the current situation and turn creative ideas into viable options (Kelley and Lee 2010).

After collecting data from the interviewees, the catalogue develops review of the experience shared by the innovators and consolidation of the data. This is known as reflective observation. In composing and summarizing contents of the catalogue, the innovation is further strengthened upon successful conceptualization. The catalogue will also be distributed to students of the Department of the author. This catalogue will facilitate the students to go through the Kolb's Learning Cycle whereby inspired students would develop their own sense of innovation.

Figure 1. The catalogue.

Figure 2. Waste-derived Alternative Daily Cover for landfills.

Figure 3. Novel drainage tunnel to mitigate effect of flooding due to extraordinary rainfall.

Figure 4. Hydro-powered Sensor Water Taps.

3.2 Potential Benefits of the Producing the Catalogue

3.2.1 *Enhancing students' creativity*

Universities are ideal information intermediates for knowledge transfer and exchanges (Blayse and Manley 2004). This is known as innovation brokers. Innovation brokers can help in collecting and sharing of knowledge from the industry and this forms a linkage between the academia and the industry. The content of the traditional courses offer basic knowledge about building and construction. This catalogue is able to bring new insights to students and enhance students' awareness of the latest development of the construction industry in Hong Kong. This offers unique learning opportunities for students, stimulates students' creative thinking and provides opportunities for student to appreciate innovations in construction in Hong Kong. It is also suggested that this novel approach can enhance students' creativity (Amabile 1988). For example, by analyzing the innovation exemplars, some of the rules in the 40 invention principles in TRIZ by Altshuller (Altshuller 2005) are found to be the key of triggering innovative ideas.

3.2.2 *Creating an innovative culture in University*

Developing Construction innovations is a complex process that involves both the "soft" human side issues as well as the "hard" tools and techniques (Atkin 1999, Egbu *et al*. 1998, Blayse and Manley 2004). Culture can encourage innovations since culture shapes human behavior. Thus an innovative culture can be regarded as a reinforcement process to motivate individual to innovate. This catalogue contributes in engendering an innovative culture as and when students are receiving their professional education at the university. In addition, students' creativity can be enhanced though instilling knowledge of novel ideas (Amabile 1988). Where the catalogue contains recent developed innovations, updating can be effected on a regular and continuous basis so that the currency of the catalogue can be maintained.

4 CONCLUSION

Construction industry plays an important role in many economies. It has been suggested that effectiveness and efficiency of construction industry need to be enhanced. This can only be possible if the industry acquires an innovative culture. Furthermore, innovation is the means to sustain long-term competitiveness. Innovation is also believed to be the viable solution to build sustainable city. Innovation is successful exploitation of novel ideas, where the ideas are new to the organization that adopts it. It is believed that through carefully designed education and experience, students' creativity can be enhanced. A catalogue containing some of the recent construction innovations developed in Hong Kong has been prepared. Students will be benefited from learning these innovation showcases. This catalogue enables the university to serve as an innovation broker and build up the knowledge exchange between students and the construction industry. The innovations in the catalogue shall provide distinguished learning exposure of innovative efforts in construction. Students' innovative thinking can thereby be stimulated. An innovative culture can be cultivated among students ultimately.

Acknowledgments

The work described in this study was fully supported by a City University of Hong Kong Teaching Development Grant (Project No. 6000452).

References

Altshuller, G.S., *40 Principles, Extended Edition: TRIZ Key to Innovation, Volume 1*, Worcester, Mass.: Technical Innovation Center, 2005.

Amabile, T. M. From Individual Creativity to Organizational Innovation, *Innovation: A Cross-disciplinary Perspective*, Gronhaug, K. and Kaufmann, G. (Eds.). Oslo, Norway: Norwegian University Press, 1988.

Amabile, T., Creativity and Innovation in Organizations, Harvard Business School note 9, 396-239, 1996.

Asad, S., Fuller, P., Pan, W., and Dainty, A. R. J., Learning to Innovate in Construction: A Case Study, *21st Annual ARCOM Conference*, Khosrowshahi, F. (Ed.), SOAS, University of London, Association of Researchers in Construction Management, 2, 1215-24, 2005.

Atkin, B., *Study of Innovation in the Construction Sector*, European Council for Construction Research, Development and Innovation, 1999.

Blayse, A. M., and Manley, K., Key Influences on Construction Innovation, *Constr. Innov.*, 4(3), 143-154, 2004.

Census and Statistics Department, *Report on the Quarterly Survey of Construction Output, Third Quarter 2014*, Hong Kong SAR Government, 2014.

Cheung, S.O., and Chan, K.Y., *Construction Innovations in Hong Kong: A Catalogue*, Construction Dispute Research Unit, Department of Architecture and Civil Engineering, City University of Hong Kong, 2015.

Creed, A.C., *Organisational Behaviour*, Oxford: Oxford University Press, 2012.

Dodgson, M., Gann, D.M., and Salter, A.J., The Intensification of Innovation. *Int. J. Innov. Manage.*, 6(1), 1-31, 2002.

Dulaimi, M.F., Nepal, M. P., and Park, M., A Hierarchical Structural Model of Assessing Innovation and Project Performance, *Constr. Manage. Econ.* , 23, 565-577, 2004.

Egbu, C. O., Kaye, H. G. R, Quintas, P., Schumacher, T. R., and Young, B. A., Managing Organizational Innovations in Construction, *14th Annual ARCOM Conference*, Hughes, W. (Ed.), University of Reading, Association of Researchers in Construction Management, 2, 605-614, United Kingdom, 1998.

Kelley, D., and Lee, H., Managing Innovation Champions: The Impacts of Project Characteristics on the Direct Manager Role, *J. Prod. Innovat. Manag.*, 27(7): 1007-1019, 2010.

Kolb, D. A., *Experiential Learning Experience as a Source of Learning and Development*, New Jersey: Prentice Hall, 1984.

Manley, K., Blayse, A.M., and McFallan, S., Demonstrating the Benefits of Construction Innovation, *Creating an Entrepreneurial Economy: the Role of Enterprise and Innovation*, International Research Conference, University of Waikato, Hamilton, New Zealand, 2005.

O'Sullivan D. and Dooley L. *Applying Innovation*, Thousand Oaks, CA: Sage Publications, 2009.

Organization for Economic Cooperation and Development (OECD), *Proposed Guidelines for Collecting and Interpreting Technological Innovation Data – Oslo Manual*, OECD, Paris, 1997.

Park, M., Nepal, M.P. and Dulaimi, M. F., Dynamic Modelling for Construction Innovation. *Journal of Management in Engineering*, 20, 170-177, 2004.

Porter, M. E., *Competitive Strategy, Techniques for Analyzing Industries and Competitors: with a New Introduction*, New York: The Free Press,1998.

Roberts, E. B., Managing Invention and Innovation, *Research Technology Management*, 31(1), 11–29, 1988.

Slaughter, S. Models of Construction Innovation, *J. Constr. Eng. Manage.*, 124(3), 226-231, 1998.

Tatum, C. B., Organizing to Increase Innovation in Construction Firms, *J. Constr. Eng. Manage.*, 115, 602-617, 1989.

Tidd, J., Bessant, J., and Pavitt, K., *Managing Innovation*, Chichester, John Wiley & Sons, 2001.

Tykkä, S., McCluskey, D., Nord, T., Ollonqvist, P., Hugosson, M., Roos, A., Ukrainski, K., Nyrud, A. Q., and Bajric, F., Development of Timber Framed Firms in the Construction Sector — Is EU policy one source of their innovation? *Forest Policy and Economics*, 12, 199-206, 2010.

United Nations, *Report of the World Commission on Environment and Development: Our Common Future*, 1987.