Construction Safety Knowledge Sharing via Smart Phone Apps and Technologies

17

Rita Yi Man Li

Contents

Abstract

Construction accident rates are high in many places, leading to high compensation, loss in manpower, and extension of time. Numerous research sheds light on the causes of factor which lead to construction accidents, such as human error, hot summer, tight schedule, young age, and lack of knowledge about safety. As previous research found that (1) there are more generation Y coming across accidents and (2) many of this generation members are expert users of mobile technologies and there is a lack of research on construction safety knowledge via various apps. This chapter aims at reviewing the construction safety knowledge sharing via various mobile apps.

It wasn't that long ago that the most exciting thing you could so with your new mobile phone was to download a ringtone. Today, new iPhone or Android phone users face the quandary of which of the hundreds of thousands of apps (applications) they should choose. It seems that everyone from federal government agencies to your local bakery has an app available. . . . (Godwin-Jones 2011)

R.Y.M. Li (✉)
Sustainable Real Estate Research Center, Hong Kong Shue Yan University, Hong Kong, China

Department of Economics and Finance, Hong Kong Shue Yan University, Hong Kong, China
e-mail: ymli@hksyu.edu; ritarec1@yahoo.com.hk

© Springer-Verlag Berlin Heidelberg 2015

Y.A. Zhang (ed.), *Handbook of Mobile Teaching and Learning*,
DOI 10.1007/978-3-642-54146-9_40

> According to the European Agency for Safety and Health at Work. . .the construction is the most dangerous industry in terms of occupational safety and health. At a worldwide level, the construction workers are three times more likely to die and two times more likely to suffer injuries at work than the average of the workers in all other activities. (Vitor et al. 2014)

1 Introduction

Construction industry is one of the most hazardous industries Worldwide (Shin et al. 2014) and construction accident rates are high in many places. Many contractors have to pay for high compensation costs. In Hong Kong, monetary compensation in 2006 alone reached HK$39,643,353. Construction accidents also lead to an extension of time due to the loss in manpower and insurmountable paper work. Nevertheless, accidents are not caused by any one dominant factor. Rather, it is often of the view that construction safety is a complex issue with heaps of different factors under different circumstances, locations, and nature of the job. Accidents may happen due to complex equipment and tools, outdoor operations and fast changing design, poor workforce safety behaviors and attitudes on sites (Li and Poon 2007; Li 2012a, 2015) (Table 1). They may also happen when there is a lack of relevant information about the potential hazards on sites. As construction methods selection process on site is based on individual knowledge, hence, the construction industry needs to understand how to store, identify, obtain, share, and use the knowledge (Ferrada and Serpell 2013). Le et al. (2014) and Mitropoulos et al. (2005) posited that a lack of safety knowledge is a major reason which leads to high construction accident rate on sites. This is because some accidents occur due to the violation of prescribed defenses (Mitropoulos et al. 2005). Effective safety information and knowledge exchange, therefore, is important to lower the dangerous occurrence of safety risks, accidents, and hazards. In Korea, the safety information module (SIM), the safety semantic wiki and safety knowledge module are used to share the construction knowledge. SIM is a tool which is developed for construction engineers and other stakeholders to share accident and risky incident data. Safety semantic wiki template (SSWT) is a tool to enhance collaboration between construction safety ontology technologies and semantic wiki web to allow users to (1) share safety knowledge and information and (2) classify them in a simple and easy way without the needs of computer background. In SKM, accident information is examined and polished by the domain experts. It provides users an easy and a convenient way to share information about the causes and prevention of accidents by communicating and uploading the relevant documents. On the other hand, some of the previous research suggested that younger construction workers with relative shadow experience were more accident prone than the others. And to improve poor safety performance on sites, learning from mistakes is important (Chua and Goh 2004). Hence, younger workers have higher chance of having accidents on sites due to inadequate experience and knowledge accumulation with regards to safety issues on sites.

Table 1 Factors which lead to construction accidents/affect safety performance (Note: this table is an updated version of Li and Poon (2013))

Factors which lead to construction accidents	Supporting literature
Lack of safety knowledge	Li (2006), Atkinson et al.(2005),Mitropoulos et al. (2005), Le et al. (2014), Li(2015)
Materials handling	Irumba (2014)
Stress at work	Irumba (2014)
Young age	Li (2006), Chi et al. (2005)
Human error	Garrett and Teizer (2009), Zhi et al. (2003)
Lack of training	Chan et al. (2004), Debrah and Ofori (2001), Liu et al. (2007)
Migrant workers	Debrah and Ofori (2001)
Poor safety attitude	Toole (2002), Teo et al. (2005), Yu et al. (2014)
Poor safety climate	Li (2015)
Poor relationship with the crew	Debrah and Ofori (2001)
Fatigue	Chan (2011)
Poor Housekeeping	Haslam et al. (2005), Toole (2002)
Improper/inadequate protective equipment	Toole (2002), Eliufoo (2007), Haslam et al. (2005), Cheng and Wu(2013)
Structural failure	Hintikka (2011)
On site work complexity/unsafe working condition	Choi et al. (2011), Chockalingam and Sornakumar (2011), Shin et al. (2014)
Hot Summer	Hu et al. (2011), Chan (2011), Navon and Kolton (2006)
Hecticschedule	Debrah and Ofori (2001)
High level of subcontracting	Debrah and Ofori(2001), Rowlinson (1997), Toole (2002)
Size of companies	Lin and Mills (2001), Holmes (1999), Lingard and Rowlinson (1994)
Separation of design and build in building project	Kongtip et al. (2008), Arocena and Núñez (2010)
Legislation, regulations and various aspects of legal system	Rowlinson (1997), Chockalingam and Sornakumar (2011), Chan et al. (2004)
Usage of traditional methods in developing countries	Chun et al. (2012)
Workers' salaries are paid by piece rate	Debrah and Ofori (2001)
Low spending on safety issues	Debrah and Ofori (2001)

Generation Y, who were born between 1982 and 1995, has comparatively shadow experience and knowledge and may easily become victims on sites (Li 2012a). Generation Y is also named as Generation Why, Generation Next, the Millennium Generation, and Echo Boomers. They grow up in media and technologically saturated World, use internet more than watching television. They also use more mobile technologies than any other generations (Li 2012a). They view,

gather, and collect information from internet more than reading newspaper, books, and magazines and watching TV. They also use more mobile technologies than any other age groups. The most common type of mobile communication software use are Line in Japan, WeChat in China and Whatsapp in Hong Kong. WeChat was launched by Tencent in January 2011. It is a kind of software which allows users to send pictures, voice messages, video quickly and text via the mobile phone's internet and supports group chat online. As of 15 January 2013, the number of WeChat users exceeded 300 million (Wei and Ke 2014). Many of them are generation Y users.

In fact, Li and Poon (2009) suggested that there were more generation Y workers who came across accidents and ended up in court. This generation is also called the www generations as they know the use of the World Wide Web better than their previous generations. The popularity of other mobile devices such as smart phone also increased the internet users substantially in places like Hong Kong and Singapore. Whilst traditional internet users only access the internet via the heavy computers, generation Y can access the internet easily via mobile devices nowadays almost everywhere. As previous research on construction safety mainly focuses on the causes of construction accidents, various construction safety measures, few have studied the safety knowledge sharing by this particular generation (Li 2012a). This book chapter aims to fill this gap of research.

2 The Role of Internet in Recent Years

In recent years, the cyberspace interacts with urban space, disrupts and collapses traditional enclosures. The popularity of fixed internet in 1990s eases the process of communication, sharing and receiving knowledge via World Wide Web. Moving from one place to the others becomes increasingly virtual than physical. In recent few years, the popularity of smart phone and mobile internet allows us to communicate everywhere, in public transportation, theaters, schools, shopping malls, and so on. The idea of mobile internet combines two of the most important innovations in recent decade: mobile phone and the internet. A combination of both not only provides much convenience to us in everyday lives activities, but also powers economic growth and media transformations in the US and South Korea (Li 2011, 2012a). The popularity of Samsung and LG products in South Korea, for example, opens heaps of job opportunities in recent years. In the same vein, the Apple company in the US offers lots of new positions, not just in the US, but also the places which sell the iPhone.

Nowadays, almost 40 % of the adults use internet, e-mail, and instant messaging devices via mobile technology. They use nonvoice apps for mobile devices more in recent years, especially the young adults between 30 and 49 years old. Young adults between 18 and 29 year olds, in particular, are more likely to use their mobile phones for other mobile data applications, such as sending e-mails, taking photos, or surfing through the Internet. As construction workers often work in different sites rather than a fixed office, some workers may then be isolated from site safety

information and knowledge. As safety information on sites at different stages, safety planning and management is usually kept in the site office. All these imply that mobile safety knowledge sharing shall play important roles in the modern days and the near future (Li 2012a).

3 Knowledge: An Economic Perspective

Knowledge is a broad and abstract notion which brought epistemological debate since the classical Greek era. Current knowledge management literature points out that researchers define knowledge from different perspectives. Knowledge can be regarded as valuable commodity for an organization in knowledge economy and can be manipulated externally (e.g., buy from outside) or internally (e.g., create within organization) (Li and Zhang 2010). Alternatively, knowledge can be categorized into tacit and explicit. The former one is complicated as it belongs to individual, nonconcrete, vibrant, and specific. On the other hand, explicit knowledge is a kind of codified guidelines and hence is easily transferred and reusable in a consistent manner (Li 2012b).

General knowledge is essential to economy and social system. In Hayek's paper with regards to knowledge in society, he rebuts the possibility of a centrally planned society where the relevant knowledge is concentrated in one place. New knowledge is obtained in two different ways:

1. Observing the nature (whether by research or by less formal procedures)
2. Learning from others which is subdivided into
   (a) Intended learning (communication and education)
   (b) Inferring the knowledge of others by behavior observation (Arrow 1994)

The productivity of particular tasks and occupation depends on the knowledge we have (Becker and Murphy 1992). As each of the individuals hold a specific area of knowledge and there is division of labor, the level of economic progress depends on technological and human capital's growth. Apart from economic growth, the importance of knowledge to an economy is that it provides a rational economic order (Becker and Murphy 1992). Precious research also linked the relationship between specialization and knowledge. For example, engineers in the early nineteenth century were not highly specialized. The growth of industries according to new technologies and greater knowledge of science during the nineteenth and twentieth centuries led to the birth of many engineering specialties. The British Institute of Civil Engineering started their own society in 1818; the mechanical engineers emerged in 1847; the electrical engineers and automobile engineers emerged in 1871 and 1906 respectively. Chemical and other specialized societies started over the past 90 years. The economics, engineering, and medical sector showcased much of the growth in specialization that emerged due to an extraordinary growth in knowledge. Teams' sizes enlarge, workers become more specialized, and experts over a specific area of skills grow as human capital and

technological knowledge increase. Adam Smith recognizes there is significant relationship between knowledge and specialization. He suggests that the division of labor is flourished in countries that enjoy the highest degree of development in industry and improvement. Although workers in modern economies are well equipped with complicated technologies, a typical worker also commands very small share as compared to the total sum of knowledge used by the economy. It is the extensive cooperation among these highly specialized workers enables the advanced economies to utilize huge sum of knowledge. Nevertheless, the specialized knowledge of workers is not simply given and acquisition depends on incentives. This is why Hayek emphasizes on the role of markets and prices in combining the specialized knowledge of different workers efficiently in rich and complex economies. By means of price system, not only a division of labor but also coordinated resources based on knowledge has become possible (Becker and Murphy 1992). The "Jack-of-all-trades" is less useful than specialists with advanced technologies and skills. As the growth in knowledge depends on investments in human capital, new technologies and basic research, the incentive to invest in knowledge depends on the level of task-specific skills as well as the degree of specialization. Therefore, there is mutual relationship between knowledge and division of labor. Greater knowledge increases from specialization's benefits and thus optimal division of labor in turn. This explains why workers become expert in narrow ranges of tasks as knowledge grows and countries progress. Increase in specialization in turn raises the benefits from knowledge investments, so that growth in investments specialization in knowledge may nurture economic development (Becker and Murphy 1992).

The peculiar character of the problem of a rational economic order is determined precisely based on the premise that the knowledge never exists in concentrated or integrated form, but as the dispersed bits of incomplete and frequently contradictory knowledge which all the separate individuals have. It is a problem of how to secure the best use of resources, a problem of how to utilize knowledge that is not given to anyone in its total but piecemeal, incomplete, and often contradictory (Hayek 1945).

Asymmetric information suggests that individuals possess unequal sets of information. Information has to be transmitted from a knowledge holder to a receiver. Sometimes, costs are paid from an information transmitter, for example, the postal costs. Therefore, information is often kept by an information holder who does not need the information but decline to transmit to others who want to receive it. Knowledge holders are unwilling to share their information and there is a lack of communication channels (Li 2012a). While it may be difficult to solve the first problem, it is no longer a problem to tackle the second one nowadays. Communication and computation technologies breakthrough allows innovative and flexible forms of learning and knowledge sharing via mobile devices, such as mobile phones and tablets which allow users to send messages to the others. Besides, electronic databases offer an excellent channel to share safety information. Furthermore, generation Y often use mobile technologies. They are expert in sharing knowledge via network in mobile devices. For those who are interested in mobile apps, several safety apps are now available for them. Alternatively, they may learn safety information via e-books which

1. Substantially reduce the heavy weights of the thick books
2. Make keywords search also possible

Nevertheless, there are limitations in mobile technologies. Many information sharing methods rely on different input requirements as well as different output formats (Li 2012a).

4 A General Overview on Mobile Apps for Communication Used by Generation Y

Good development in telecommunication sector is important for economic growth of a country (Khan 2010). The most common type of mobile communication software they use are Line (in Korea), Wechat (in China), and Whatsapps (in Hong Kong). WeChat is launched by Tencent in January 2011. It is a kind of chat software to send pictures, voice messages, video quickly, text via the mobile phone's internet, and support group chat online. As of 15 January 2013, the number of WeChat users has already exceeded 300 million (Wei and Ke 2014). Similar and popular software is WhatsApp. WhatsApp is a cross-platform mobile messaging application which allows users to exchange message via smart phone. It utilizes the internet data plan for web browsing and e-mail. Moreover, the marginal cost of sending a message is zero. It also allows us to chat as a group. Each of the typed conservation can be seen by the others in the same group. WhatsApp users can also send audio and video media messages to contact people in different geographical areas (Li 2012a). Line is a South Korean-Japanese app for instant messaging on personal computers and smartphones to exchange video, text messages, audio, graphics, hold free audio or video conferences and make free VoIP calls (Line Corporation 2014). Line was launched in Japan in 2011, with 200 million users only 6 months later (Lukman 2013) (Table 2).

Modern knowledge sharing via mobile apps has become possible. Knowledge can be shared via interactive apps in an interesting way. Furthermore, various mobile technologies such as tablet PCs or iPAD allow apps that include computing Mobile System Analysis and Design to examine the level of satisfaction with regards to mobile learning (Hussin et al. 2012). In view of the above, mobile apps have been used to replace some of the traditional knowledge sharing methods which include lectures, textbooks, and face-to-face interactions.

5 Case Studies on Mobile Safety Knowledge Sharing

Case study refers to an intensive research of an event and individual. It allows researcher to obtain in-depth information from detailed descriptions of observed behaviors and events. Although the major problem of case study lies in the breadth of study, a case study could be unique that may increase validity of findings. Multiple case studies are used instead of single case study in this chapter

Table 2 Details about Line, WhatsApp, and WeChat

Types of communication tools	Platform	Advantages
Line (Line Corporation 2014)	Mobile: Android, BlackBerry, iPhone, Windows Phone, Nokia Asha, Firefox OS PC computer: Windows, Mac OS	1. Exchange free instant messages with one-on-one or group chats. LINE is available in all smartphone devices such as iPhone, Android, Windows Phone, Blackberry, Nokia and personal computer 2. Real-time video calls with friends are free 3. A wide range of emotions is available for users to express their feelings. It allows users to share photos, voice messages, up-to-date information, knowledge, contacts, videos, and location information easily with friends (Line Corporation 2014)
Whatsapp (2014)	iPhone, BlackBerry, Android, Windows Phone, and Nokia	1. Once it is downloaded, it is free to chat with 3G/EDGE or Wi-Fi 2. It allows users to send images, videos, and voice notes. It also makes group chats with friends and contacts possible 3. There is no marginal cost to send Whatsapp messages as long as they have Whatsapp Messenger installed 4. Usernames and passwords are not required. Whatsapp works with users' phone number, which is similar to SMS, integrates flawlessly with the existing phone address book and connects friends automatically 5. With push notifications, Whatsapp is always connected tousers' address book 6. Whatsapp saves messages offline and users can retrieve them during the next application even if they miss the push notifications or turn off the phones 7. It shares location, exchanges contacts, and customs wallpaper. There are notification sounds, precise message time stamps, and e–mail chat history (APP Tomato Market 2014)
Wechat (Tencent 2014)	iPhone, BlackBerry (OS5.0 or above, 10), Android, Windows Phone, NokiaS40, Symbian Kewboard, Symbian Touch	1. There are sticker gallery, voice, and group chat 2. Users can invite friends to a WeChat group chat through QR code 3. By selecting "Social" and then "People Nearby," WeChat allow users to add people nearby as friends

as single case study often falls prey to over generation results or selection bias (Li and Poon 2013).

5.1 Two Case Studies in Korea

Some of the construction safety personnel agree that mobile ITsis a modern effective way to share safety knowledge in modern era. In Korea, short message service (SMS) helps to interpret and manage safety issues on sites. Users can input the location where the device is installed, supervisor's name, contact information, and their responsibilities. There are ID codes in the devices which allow the site manager to identify their locations by codes. Authority in each location, safety officers and the supervisor are able to obtain the information via mobile phone (Li 2012a). In another example also from Korea, the mobile safety system is made up of

1. The mobile screen outputs of risk update interface (RUI) to register the risk process in the middle of the screen
2. Take operation interface (TOI) of the prototype sliding mode variable structure (SMVS) on the right side of the screen, showing augmented safety information after registration
3. The risk registration process using RUI and location matching in the left screen (Li 2012a)

A question and answer game (QAG) is also designed for construction safety education on sites. Workers get access to the game and then the user identification interface automatically displays the relevant safety education games which are related to his work. The QAG was developed and tested, where worker navigates his virtual job site by controlling with joystick, keyboard, or mouse. Workers have to make decision on what-to-do next for the risky scenario. The system calculates the number of correct answers. Finally, the system shows the information about the accidents as well as the correct measures if the worker chooses a wrong answer so as to improve workers' safety knowledge. Nevertheless, some people concern that they are not familiar with three dimension information and it is quite difficult to control the movement. Moreover, time, information, and temporary facility need to be integrated to operate the system (Li 2012a).

5.2 Case Study in the US

In the USA, there are three free apps which provide useful occupational safety and health information. For example, the Wireless Information System for Emergency Responders (W.I.S.E.R.) shares knowledge with regards to explosive potential, reactivity, and PPE. First Aid by the American Red Cross integrates with 911 and workers such that they can call EMS from the app any time. By using a modified

Table 3 Aims, objectives and functions of the app (Perry 2014)

Name of the apps	Functions
Wireless Information System for Emergency Responders (W.I.S.E.R.)	1. It assists workers in handling hazardous material incidents 2. It provides useful occupational safety and health information on reactivity, explosive potential, PPE, fire procedures, storage, toxicity, environmentalclean-up, chemical properties, treatment, carcinogenetic, health effects, occupational safety, health standard, and disposal 3. User Profiles allows users to inform the app according to their current situation such that relevant information about the incidents' emergency responds can be provided
First Aid by the American Red Cross	1. It integrates with 911 and workers can call EMS by using the app any time 2. Simple step-by-step instructions guide workers the procedures of first aid 3. Instant safety information access anytime in the absence of internet connection
Easy Lift app	1. By using a modified version of the NIOSH lifting equation, it provides the user a maximum safe weight under various lifting scenarios by following the following three steps: It calculates the maximum safe lifting weight according to the NIOSH lifting equation in absence of WiFi It indicates where the workers' lift should begin It estimates the hours of lifting per day and the number of lifts per minute

version of the NIOSH lifting equation, it provides the user a maximum safe weight for various lifting scenarios by following three steps (Perry 2014) (Table 3).

6 Future Directions

Although construction safety is a complex issue and it is impossible to eliminate all the causes of accidents with one single method, previous research showed that lack of the relevant safety knowledge is one of the major causes of accidents. As many of the construction accidents victims are generation Y workers, this paper suggests that young construction workers may be educated by using the latest mobile technologies and apps. In view of the case studies in the US and Korea and the popularity of mobile technologies, it is expected that construction safety knowledge can be shared through smart phone technologies and apps. In the future, it is expected that the use of smart phone shall increase as the increase in production in different areas.

7 Cross-References

- ▶ Adoption of Mobile Technology in Higher Education: Introduction
- ▶ Business Models for Mobile Learning and Teaching
- ▶ Characteristics of Mobile Teaching and Learning
- ▶ M-Learning and U-Learning Environments to Enhance EFL Communicative Competence
- ▶ M-Learning: Visible Approach for Invisible World
- ▶ Mobile Education via Social Media: Case Study on WeChat
- ▶ Mobile Learning and Engagement: Designing Effective Mobile Lessons

References

2014 WhatsApp Inc. 2014. WhatsApp. http://www.whatsapp.com

APP Tomato Market. 2014. WhatsApp messenger. http://apptomato.com/whatsapp-messenger.

Arocena, P., and I. Núñez. 2010. An empirical analysis of the effectiveness of occupational health and safety management systems in SMEs. *International Small Business Journal* 28: 398–419.

Arrow, K.J. 1994. Methodological individualism and social knowledge. *The American Economic Review* 84: 1–9.

Atkinson, S., A.R. Duff, G.F. Gibb, D.E. Gyi, R.A. Haslam, and S.A. Hide. 2005. Contributing factors in construction accidents. *Applied Ergonomics* 36: 401–415.

Becker, G.S., and K.M. Murphy. 1992. The division of labor, coordination costs, and knowledge. *The Quarterly Journal of Economics* 107: 1137–1160.

Chan, M. 2011. Fatigue: The most critical accident risk in oil and gas construction. *Construction Management and Economics* 29: 341–353.

Chan, A.H.S., W.Y. Kwok, and V.G. Duffy. 2004. Using AHP for determining priority in a safety management system. *Industrial Management & Data Systems* 104: 430–445.

Cheng, C.W., and T.C. Wu. 2013. An investigation and analysis of major accidents involving foreign workers in Taiwan's manufacture and construction industries. *Safety Science* 57: 223–235.

Chi, C.F., T.C. Chang, and H.-I. Ting. 2005. Accident patterns and prevention measures for fatal occupational falls in the construction industry. *Applied Ergonomics* 36: 391–400.

Chockalingam, S., and T. Sornakumar. 2011. Tools for improving safety performance of Indian construction industry-AWH & SIT approach. *European Journal of Economics, Finance and Administrative Sciences* 35: 15–22.

Choi, T.N.Y., D.W.M. Chan, and A.P.C. Chan. 2011. Perceived benefits of applying pay for safety scheme (PFSS) in construction – A factor analysis approach. *Safety Science* 49: 813–823.

Chua, D.K.H., and Y.M. Goh. 2004. Incident causation model for improving feedback of safety knowledge. *Journal of Construction Engineering & Management* 130: 542–551.

Chun, C.K., H. Li, and M. Skitmore. 2012. The use of virtual prototyping for hazard identification in the early design stage. *Construction Innovation: Information, Process, Management* 12: 29–42.

Debrah, Y.A., and G. Ofori. 2001. Subcontracting, foreign workers and job safety in the Singapore construction industry. *Asia Pacific Business Review* 8: 145–166.

Eliufoo, H.K. 2007. Gendered division of labour in construction sites in Zanzibar. *Women in Management Review* 22: 112–121.

Ferrada, X., and A. Serpell. 2013. Using organizational knowledge for the selection of construction methods. *International Journal of Managing Projects in Business* 6: 604–614.

Garrett, J.W., and J. Teizer. 2009. Human factors analysis classification system relating to human error awareness taxonomy in construction safety. *Journal of Construction Engineering & Management* 135: 754–763.

Godwin-Jones, R. 2011. Emerging technologies mobile apps for language learning. *Language Learning & Technology* 15: 2–11.

Haslam, R.A., S.A. Hide, A.G.F. Gibb, D.E. Gyi, T. Pavitt, S. Atkinson, and A.R. Duff. 2005. Contributing factors in construction accidents. *Applied Ergonomics* 36: 401–415.

Hayek, F.A. 1945. The use of knowledge in society. *The American Economic Review* 35: 519–530.

Hintikka, N. 2011. Accidents at work during temporary agency work in Finland – Comparisons between certain major industries and other industries. *Safety Science* 49: 473–483.

Holmes, N. 1999. An exploratory study of meanings of risk control for long term and acute effect occupational health and safety risk in small business construction firms. *Journal of Safety Research* 30: 61–71.

Hu, K., H. Rahmandad, T. Smith-Jackson, and Woodrow Winchester. 2011. Factors influencing the risk of falls in the construction industry: A review of the evidence. *Construction Management and Economics* 29: 397–416.

Hussin, S., M.R. Manap, Z. Amir, and P. Krish. 2012. Mobile learning readiness among Malaysian students at higher learning institutes. *Asian Social Science* 8: 276–283.

Irumba, R. 2014. Spatial analysis of construction accidents in Kampala, Uganda. *Safety Science* 64: 109–120.

Khan, M.A. 2010. An empirical assessment of service quality of cellular mobile telephone operators in Pakistan. *Asian Social Science* 6: 164–177.

Kongtip, P., W. Yoosook, and S. Chantanakul. 2008. Occupational health and safety management in small and medium-sized enterprises: An overview of the situation in Thailand. *Safety Science* 46: 1356–1368.

Le, Q.T., D.Y. Lee, and C.S. Park. 2014. A social network system for sharing construction safety and health knowledge. *Automation in Construction* 46: 30–37.

Li, R.Y.M. 2006. Effectiveness of various construction safety measures in Hong Kong. In *Real estate and construction*. Hong Kong: The University of Hong Kong.

Li, R.Y.M. 2011. Internet boost the economic growth of mainland China? Discovering knowledge from our World Wide Web. *Global Business and Management Research: An International Journal* 3: 345–355.

Li, R.Y.M. 2012a. Construction accidents compensation and game theory analysis on mobile safety knowledge sharing among generation Y in Hong Kong. *Romanian Review of Social Sciences* 3: 3–12.

Li, R.Y.M. 2012b. Knowledge management, sharing and creation in developing countries' banking industries. *Advanced in Network and Communications* 1: 13–26.

Li, R.Y.M. 2015. *Construction safety and waste management: An economic analysis*. Switzerland: Springer.

Li, R.Y.M., and S.W. Poon. 2007. A critical review of construction safety motivation in Hong Kong. In *Management science and engineering academic conference*, 13–19. Tianjin: Tianjin University.

Li, R.Y.M., and S.W. Poon. 2009. Workers' compensation for non-fatal accidents on non-fatal accidents: Review of Hong Kong court cases. *Asian Social Science* 5: 15–24.

Li, R.Y.M., and S.W. Poon. 2013. *Construction safety*. Heidelberg: Springer.

Li, R.Y.M., and P. Zhang. 2010. Motivation to share hospital building design knowledge by information technology in Hong Kong. *Lex ET Scientia Economics Series* XVII: 358–368.

Lin, J., and A. Mills. 2001. Measuring the occupational health and safety performance of construction companies in Australia. *Facilities* 19: 131–139.

Line Corporation. 2014. Line. http://line.me/en

Lingard, H., and S. Rowlinson. 1994. Construction site safety in Hong Kong. *Construction Management and Economics* 12: 501–510.

Liu, J., B. Li, B. Lin, and V. Nguyen. 2007. Key issues and challenges of risk management and insurance in China's construction industry: An empirical study. *Industrial Management & Data Systems* 107: 382–396.

Lukman, E. 2013. Line hits 200 million users, adding 100 million in just 6 months. http://www.techinasia.com/line-hits-200-million-users-adding-100-million-users-6-months

Mitropoulos, P., T.S. Abdelhamid, and G.A. Howell. 2005. Systems model of construction accident causation. *Journal of Construction Engineering and Management* 131: 816–825.

Navon, R., and O. Kolton. 2006. Model for automated monitoring of fall hazards in building construction. *Journal of Construction Engineering & Management* 132: 733–740.

Perry, I. 2014. Three powerhouse safety apps for fast solutions. http://www.thesafetydoctor.com/nl/october2014.html#powerhouse

Rowlinson, S. 1997. *Hong Kong construction – Site management and construction*. Hong Kong: Sweet and Maxwell Asia.

Shin, M., H.S. Lee, M. Park, M. Moon, and S. Han. 2014. A system dynamics approach for modeling construction workers' safety attitudes and behaviors. *Accident Analysis and Prevention* 68: 95–105.

Tencent. 2014. Features. http://www.wechat.com/en

Teo, E.A.L., F.Y.Y. Ling, and A.F.W. Chong. 2005. Framework for project managers to manage construction safety. *International Journal of Project Management* 23: 329–341.

Toole, T.M. 2002. Construction site safety roles. *Journal of Construction Engineering and Management* 128: 203–210.

Vitor, S., N.M. Almeida, and L.A. Dias. 2014. Risk-based management of occupational safety and health in the construction industry – Part 1: Background knowledge. *Safety Science* 66: 75–86.

Wei, H., and L. Ke. 2014. New weapons of ideological and political education in universities – WeChat. In *SHS web of conferences*, Wuhan, China.

Yu, Q.Z., L.Y. Ding, C. Zhou, and H.B. Luo. 2014. Analysis of factors influencing safety management for metro construction in China. *Accident Analysis and Prevention* 68: 131–138.

Zhi, M., G.B. Hua, S.Q. Wang, and G. Ofori. 2003. Total factor productivity growth accounting in the construction industry of Singapore. *Construction Management and Economics* 21: 707–718.