Construction safety knowledge sharing by Internet of Things, Web 2.0 and mobile apps: psychological and new institutional economics conceptual analysis

Rita Yi Man Li, Hong Kong Shue Yan University
RHB 307, HKSYU Real Estate and Economics Research Lab, Hong Kong Shue Yan University, North Point, Hong Kong

Kwong Wing Chau, The University of Hong Kong
Department of Real Estate and Construction, the University of Hong Kong, Pokfulam, Hong Kong

Daniel Chi Wing Ho, THEi
Faculty of Design and Environment, Technological and Higher Education Institute of Hong Kong

Weisheng Lu, the University of Hong Kong
Department of Real Estate and Construction, the University of Hong Kong, Pokfulam, Hong Kong

Mandy Wai Yee Lam, Hong Kong Shue Yan University
RHB 307, HKSYU Real Estate and Economics Research Lab, Hong Kong Shue Yan University, North Point, Hong Kong

Tat Ho Leung, Hong Kong Shue Yan University
RHB 307, HKSYU Real Estate and Economics Research Lab, Hong Kong Shue Yan University, North Point, Hong Kong

Abstract. The construction industry has always recorded a high work accident rate on sites. Many of these occur due to an asynchronous knowledge sharing problem. Some construction teams may only work occasionally on sites and may not be able to communicate to new teams at shift changes by the time they leave the sites. High-level subcontracting is another issue. The primary contractors may find it difficult to share safety knowledge down the line of subcontractors to reach the lowest level workers. The recent popularity in Web 2.0, mobile apps and the Internet of Things provides a new perspective on asynchronous safety knowledge sharing. Workers from different teams who never physically meet each other can now share knowledge easily by simple means. A natural starting point when conceptualizing the role of institutions in economic geography is to consider the constraints and incentives that affect economic action. This perspective, to a certain extent, coincides well with psychological theory which studies the factors that affect people’s behavior. In this research paper, we study the construction practitioners’ knowledge sharing behavior from 1) New institutional economic perspectives under the lens of informal institutions and 2) Psychology’s perspectives such as Homan’s proposition.

1. Construction safety knowledge sharing
The construction industry is notorious for high accident rates. It leads to the largest number of fatal accidents among all occupations and only second to the manufacturing industry, regarding serious accidents in Europe (1). Likewise, the construction industry tops all industries in industrial accident rates and fatalities. There were 1,816 accidents in the first half of 2017, an increase of 3.3% as compared with 1,758 in the same period of 2016 (2).

The so called ‘fatal four’, i.e. the four leading causes of construction workers’ deaths are: getting caught in or between objects falls, struck by objects and electrocutions. These can be prevented in many circumstances if adequate safety knowledge is communicated to workers and between teams. Nevertheless, as different teams may work at different times on sites, the transmission of safety knowledge from primary contractors to sub-sub-contractors or even those at lower levels may be difficult due to the lack of asynchronous knowledge sharing, the recent popularity of internet of things, web 2.0 etc. may help.

2. Knowledge sharing
Knowledge is a dynamic thought which has brought epistemological debate since the Greek age. Current knowledge management literature brings up that researchers define knowledge from different perspectives. Knowledge can be viewed as a valuable commodity for an organization in knowledge economy and can be manipulated internally (e.g. created inside an organization) or externally (e.g. purchased from outside) (3).

A huge amount of knowledge is required to be generated and shared in a construction project. As quoted from Tan et al (4) who suggested that, “Construction is a project-based industry. Therefore, it is not surprising that most of the knowledge of the construction industry is generated in projects during the process to deliver a custom-built factory in accordance with the client’s requirements and business objectives. The ability to manage the knowledge generated from the projects not only can help to prevent the ‘reinvention of the wheel’ and the repetition of similar mistakes, but also serves as the basis for innovation, overall improvement and sustaining competitive advantage. However, the ability to learn from within and across projects are critical but difficult to achieve. This is often due to the tight timeframe of construction projects, and the lack of sufficient resources and standard work process for managing project knowledge.”
Figure 1 Serious and fatal accidents at work (1).

The Internet has evolved from the static read-only Web 1.0 to dynamic Web 2.0 that allows users to change the content in the internet (5). As defined by O’Reilly (6), it is a set of principles and practices that tie together a veritable solar system of sites that demonstrate some or all of those principles, at a varying distance from that core, Dave and Koskela (7) developed an on-line forum to test and analyze participation in construction knowledge sharing. Unlike traditional media of communication such as phone calls and emails, social media systems, which often present different types of information from different contributors within a single message pane, a juxtaposition of potential influences challenges traditional health communication processing (8). Besides, various mobile apps can be used to share construction safety knowledge. For example, Red Cross First Aid places crucial first-responder skills in their apps “American Red Cross”. True Look apps allows users to use drones to take aerial photos of job sites and site photos received can be organized in the app by project (9). An ontology-based NoSQL database, Cassandra, can be used for supply chain data distribution (10).
Figure 2 Construction safety group in Facebook (11)

The Internet of Things enables knowledge exchange through means of a network of many connected ‘things’, such as QR code and radio-frequency identification (RFID)(12). The ease in converting the dynamic QR code change the façade of knowledge sharing. For example, we can easily convert the abovementioned Facebook group’s website to dynamic QR code, i.e. the content shown in the QR code can be changed according to the website content (Figure 2). Users can easily obtain the knowledge via scanning the dynamic QR code to update useful and up to date information. Shin, Chin et al. (13) proposed an RFID-based framework that integrated legacy systems and websites to facilitate communication but knowledge sharing does not depend only on the existence of technologies and ontologies. The willingness to use technologies for sharing construction safety knowledge is crucial. Nourbakhsh, Zin et al. (14) used the Microsoft Office SharePoint Server mobile app to report on-site accidents in Malaysia.

Figure 3 Dynamic QR code

3. Psychological perspective on construction safety

Powell and Dalton (15) suggested that a person is more likely to repeat an action under two major propositions:

1) The value proposition: the more valuable the consequence of an action
2) The success proposition: the more often remunerated for the specific action

Nevertheless, little research has shed light on the ramifications of Homan’s recommendations on knowledge sharing in the construction industry. Kuo (16) suggested that properties of shared knowledge, expected rewards and incentives affected the likelihood of knowledge sharing in high-technology firms. Having said that however, research into any of these psychological factors is scarce.

The Leader Membership Exchange theory (LMX) theory has risen as a noteworthy system in the authority writing for determining how pioneers may upgrade their effectiveness by building good associations with their followers. Central to LMX theory is the idea that leaders develop and maintain different types of exchange relationships with their followers within the group, by treating a few followers better than others (17).

Perceived Organization Support uncovers how much an organization values employees’ commitment to the companies and employees’ well-being, prompting the desire for their endeavors to be compensated. Higher Perceived Organization Support is relative to more noteworthy responsibility to the organization (18). Previous research demonstrated that better Perceived Organization Support has a huge beneficial impact on the Norwegian oil and gas industry’s knowledge sharing (19).

4. Informal institution settings and knowledge sharing

Previous research shows that there are different perceptions amongst the construction practitioners via email and personal discussion. Sanaei, Javernick-Will et al. (2013) classified construction workers into three generations:

- Baby Boomers (1946-1964) treasure vis-à-vis knowledge sharing. They are content with telephonic communications. They didn't grow up with information technology, however it has changed their lives, creating a bay between them and more youthful ages.
- Generation X (1965-1980) incline toward casual knowledge sharing. They simply choose a formal means when there is no other choice.
- Generation Y (1981-1999) grew up with information technology and online networking.

In view of these, we conjecture that workers in various ages and ethnic groups may have distinctive levels of eagerness to share knowledge by means of Internet of Things, Web 2.0 and mobile applications due to various cultural and social standards.

5. Conclusion

Adequate safety knowledge is a prerequisite in making safe decisions on construction sites, as well as safety performance and behavior. Nevertheless, ever-changing construction site conditions infer that a proper knowledge sharing platform is prominent. From this point of view, mobile apps, the Internet of Things (IoT) and Web 2.0 provide promising solutions for sharing of asynchronous knowledge on sites that results from differences in the working times amongst different trades and high-level subcontracting.

Numerous studies of safety knowledge sharing technologies have investigated the development of new, ground-breaking tools but not the willingness to utilize them, which may depend on institutional differences emerging from ages or ethnicity and cultural differences or the psychological factors identified in Homan’s Proposition, Perceived Organization Support and Leader Membership Exchange.
Acknowledgement

The authors wish to express their gratitude for the financial support received from the Research Grant Council Faculty Development Scheme “Willingness to share construction safety knowledge via Web 2.0, mobile apps and IoT” (UGC/FDS15/E01/17).

References

1. Eurostat. Euro Stat Statistics Explained 2016 [Available from: http://ec.europa.eu/eurostat/statistics-explained/index.php/Main_Page.
2. Labour and Welfare Bureau. Legislative Council Panel on Manpower Hong Kong’s Occupational Safety Performance in the First Half of 2017 2017 [Available from: https://www.legco.gov.hk/yr17-18/english/panels/mp/papers/mp20171219cb2-522-5-e.pdf.
3. Li RYM. Construction Safety Knowledge Sharing via Smart Phone Apps and Technologies. In: Zhang Y, editor. Handbook of Mobile Teaching and Learning. Berlin, Heidelberg: Springer Berlin Heidelberg; 2015. p. 1-11.
4. Tan H, Carrillo P, Anumba CJ. Case study of knowledge management implementation in a medium-sized construction sector firm. Journal of Management in Engineering. 2012;28(3):338-47.
5. Li RYM, Poon SW. Using Web 2.0 to Share the Knowledge of Construction Safety as a Public Good in Nature Among Researchers: the Fable of Economic Animals. Economic Affair. 2011;31(1):73-9.
6. O’Reilly. What is Web 2.0? 2005 [Available from: http://www.oreilly.com/pub/a/web2/archive/what-is-web-20.html.
7. Dave B, Koskela L. Collaborative Knowledge Management—A Construction Case Study. Automation in Construction. 2009;18(7):894-902.
8. Walther J, Jang J-w, Hanna Edwards A. juxtaposition. Health Communication. 2018;33(1):57-67.
9. TSheets. Top 10 Construction Apps for 2018 2018 [Available from: https://www.tsheets.com/best-construction-apps.
10. Moumida D, C.P. CJ, H. LK. An ontology-based web service framework for construction supply chain collaboration and management. Engineering, Construction and Architectural Management. 2015;22(5):551-72.
11. Construction Safety. Construction Safety 2018 [Available from: https://www.facebook.com/Construction-Safety-1390450597880578/.
12. Zhao C, Liu J, Shen F, Yi Y. Low power CMOS power amplifier design for RFID and the Internet of Things. Computers & Electrical Engineering. 2016;52:157-70.
13. Shin T-H, Chin S, Yoon S-W, Kwon S-W. A service-oriented integrated information framework for RFID/WSN-based intelligent construction supply chain management. Automation in Construction. 2011;20(6):706-15.
14. Nourbakhsh M, Mohamad ZR, Irizarry J, Zolfagharian S, Gheisari M. Mobile application prototype for on-site information management in construction industry. Engineering, Construction and Architectural Management. 2012;19(5):474-94.
15. Powell KH, Dalton MM. Co-Production, Service Exchange Networks, and Social Capital. The Social Policy Journal. 2003;2(2-3):89-106.
16. Kuo TH. How expected benefit and trust influence knowledge sharing. Industrial Management & Data Systems. 2013;113(4):506-22.

17. Chen X-P, He W, Weng L-C. What Is Wrong With Treating Followers Differently? The Basis of Leader–Member Exchange Differentiation Matters. Journal of Management. 2018;44(3):946-71.

18. van Knippenberg D, van Prooijen J-W, Sleebos E. Beyond social exchange: Collectivism’s moderating role in the relationship between perceived organizational support and organizational citizenship behaviour. European Journal of Work and Organizational Psychology. 2015;24(1):152-60.

19. Nesheim T, Smith J. Knowledge sharing in projects: does employment arrangement matter? Personnel Review. 2015;44(2):255-69.