NOVA SCIENCE PUBLISHERS, INC.
400 Oser Avenue, Suite 1600, Hauppauge, New York 11788-3619, USA
Phone (631) 231-7269 Fax (631) 231-8175 E-mail: nova.main@novapublishers.com

ENGINEER'S INTUITION IN THE CONSTRUCTION INDUSTRY

Masao Yamasaki

In: "Advances in Psychology Research. Volume 115"
Editor: Alexandra M. Columbus
ISBN: 978-1-63484-887-9
2016

In: Advances in Psychology Research. Volume 115 ISBN: 978-1-63484-887-9
Editor: Alexandra M. Columbus

Chapter 10

ENGINEER'S INTUITION IN THE CONSTRUCTION INDUSTRY

Masao Yamasaki*
Hosei University, Tokyo, Japan
Research Institute of Human Resource Development

ABSTRACT

This study discusses 'engineer's intuition' in the construction industry in Japan. Engineer's intuition can be defined as the ability to simultaneously detect a problem, investigate its cause and solve the problem in a certain environment. For example, an experienced engineer may examine design drawings and then retain some design features while altering others. As another example, if an engineer believes that a construction site is unsafe, he or she may withdraw the workers until the safety issue has been corrected, thereby demonstrating the engineer's intuition.

This study was initiated in response to other studies of how experienced engineers teach engineer's intuition to novice and mid-level engineers. The research in this study was conducted on the basis of the results obtained in the previous studies of engineer's intuition and on discussions in the 'Succession of Intuition Study Group.' In addition, we summarize the results of interviews and discussions within the study group.

Engineer's intuition can be divided into five stages: L1–L5. Figure 1 depicts the levels of engineer's intuition. L1 is simply a preparation stage. In stages L2 and L3, the decision-making process is enhanced, whereas in L4, the decisions are intuitively rearranged. Finally, in L5, new decisions are created.

In order to examine engineer's intuition; we conducted interviews with 15 preeminent, experienced engineers currently employed in the construction industry in Japan. Preeminent experienced engineers are considered to be 'irreplaceable' and to possess a high level of engineer's intuition. The results of the data analysis indicated that preeminent experienced engineers have several common characteristics. To assume responsible positions such as theirs, they incorporate the quality of high self-awareness while maintaining a daily practice of continuous training and frequent interactions with their co-workers. In this study, we observed the following three patterns concerning

* E-mail: im11w0023@im.i.hosei.ac.jp.

The procedure for these activities was as follows. The results from preceding studies on intuition have shown that when certain things are prepared for a certain person, they act by withdrawing things from the situation before making decisions. Furthermore, they do not withdraw just one thing, but multiple things. Being able to connect and combine multiple things allows engineers to make the most appropriate decision and act as the situation requires.

The Research Association began its discussion with words like 'knack' and 'hunch,' which are often used in the construction industry. However, these words are seldom used in explanations to the client, even though everyone is aware of their existence. Furthermore, following the Research Association's findings, an interview study was conducted with engineers. We validated the study by interviewing engineers working in the field. This process allowed us to objectively describe the ability known as 'engineers' intuition,' which had only previously been implied. It also allowed us to illustrate the concept to provide a visual depiction.

A declining rate of experienced engineers means that the effective transfer of accumulated technology is becoming more difficult. In addition, the selective conveying of knowledge can also be complicated. Of all the aspects of transfer, of particular importance is what needs to be transferred in the world of technology, according to Tips and Kang. Intuition is an ability acquired through training and experience. It forms the basis of skill in an engineer's development. In this study, intuition, and its related concepts, is the subject of focus.

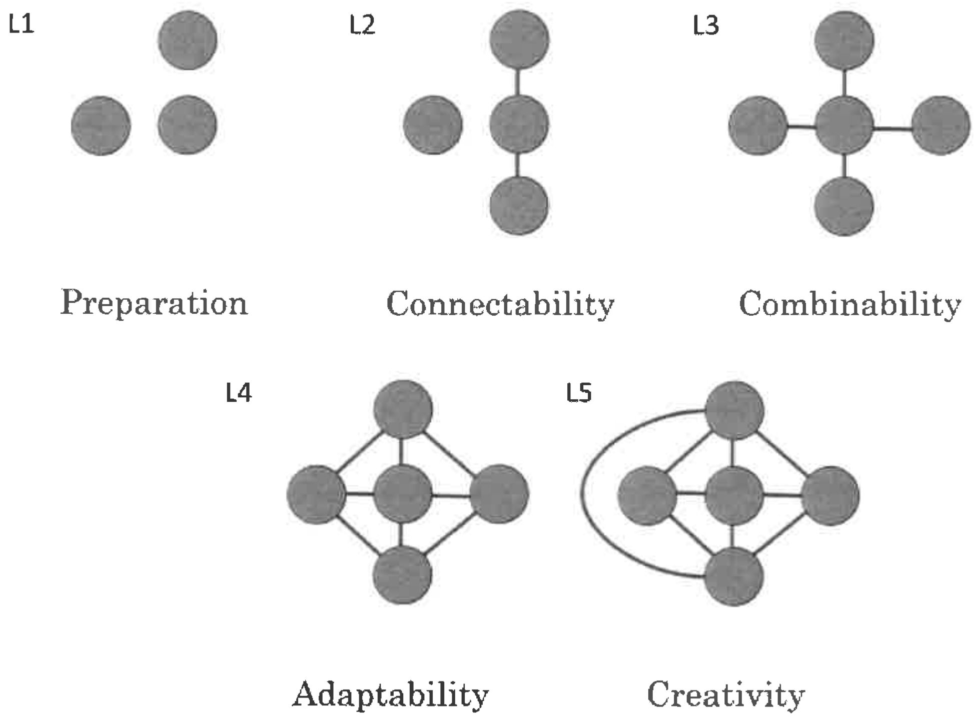
Concepts of intuition have been an area of focus for researchers in the field of economics and business administration. According to Duggan (2010), there are two types of intuitions: professional (drawn by past experience) and strategic (drawn by inspiration and creativity). Koike (2005) stated that intuition relates to intellectual skill and studies have begun to focus on this aspect, especially in terms of decision-making. Nonaka and Takeuchi (1996) proposed formatting knowledge into explicit knowledge and tacit knowledge, which is knowledge based on experience and intuition, respectively.

In the field of philosophy, Dreyfus and Dreyfus (1987) proposed a technology acquisition model consisting of five stages, ranging from beginner through to expert. Michael Polanyi (1980) proposed the concept of tacit knowledge (tacit knowing), based on Nonaka and Takeuchi's (1996) concept. Both of these studies examined the concept of intuition through scientific discovery according to remote proximity.

In psychology, intuition deals with cognition, which includes cognitive psychology and cognitive science. Klein (1998) proposed the recognition-primed decision (RPD) model; a decision-making model based on recognition, in an attempt to understand the process of decision-making in individuals. Intuition is composed of understanding and situational awareness, or in other words, one must have the ability to understand without being conscious of the overall process. This concept was the foundation of professional intuition advocated by Duggan (2010).

In education, the term 'intuition' has been used only minimally, and has not been researched as a serious concept. However, Ogura (1976) discussed the power of intuition in mathematics. Although mathematics is a purely logical science, it actually requires a high level of intuition. This concept is supported by Ogura as well as the author of this study. In addition, the level of intuition in this particular discipline can be defined as 'the ability to simultaneously detect the problem, investigate its cause and solve the problem.'

Figure 3 presents the level of engineers' intuition where L1 does not fall under either of the ranges shown in Figure 2, as it is simply a preparation stage. Moreover, L2 and L3 enhance the decision-making process, while in L4, decisions are intuitively rearranged. Finally, in L5, new decisions are created.



Source: Succession of intuition study group from Hosei University, 2012.

Figure 3. Level of engineer's intuition (2).

Figure 4 presents the stage and level of engineers' intuition. The professional level relationships are as follows: L1: new employee; L2: partly qualified engineer; L3: fully qualified engineer; L4: experienced engineer; and L5: preeminent experienced engineer. We assume these as the ideal levels for businesses and individuals.

Learning engineer's intuition by training takes place from L1 to L3, and learning engineer's intuition by experience takes place from the second half of L3 to the first half of L5. L5 requires a reciprocal relationship in which a business selects a senior engineer and allows him/her free rein and trusts him/her implicitly, allowing that individual to creatively think things through and take responsibility for implementing solutions.

In this section, we validated and defined the concept of engineers' intuition. Engineer's intuition is 'the ability to simultaneously detect the problem, investigate its cause and solve the problem.' While developing this concept, we reviewed previous research, held a discussion with the Research Association, conducted interviews with engineers and then validated the concept.

observed the following three patterns concerning the increase in the engineer's intuition level: 1) proportional, 2) emergence in youth and 3) plateau in later life. This analysis highlights the importance of decision-making experience in a responsibility position for the engineers' formation process.

3.1. Survey Methodology and Summary

3.1.1. Survey Subjects

An interview survey was conducted, with the cooperation of 15 outstanding preeminent experienced engineers. There were five participants from Kajima Corporation, four from Nippon Koei Co. Ltd., two from TOBISHIMA Corporation, two from KOKUSAI KOGYO CO. LTD., one from Taisei Corporation and one from OYO Corporation (Chart 1). The selection of these individuals was made possible with the introduction to preeminent experienced engineers who have been recognised as outstanding. Those completing the first interview survey were preeminent experienced engineers who were introduced after the purpose of the survey was explained to members of the Association for the Transmission and Study of Techniques. The Association for the Transmission and Study of Techniques is an association of enterprises, engineers and human resource development managers from the construction industry. They have been holding a meeting once every one-to-two months since May 2012, and 17 meetings have been held thus far. The interviews were a semi-structured format, with each interview lasting for about one and a half to two hours. Several of the interviews were conducted with one individual.

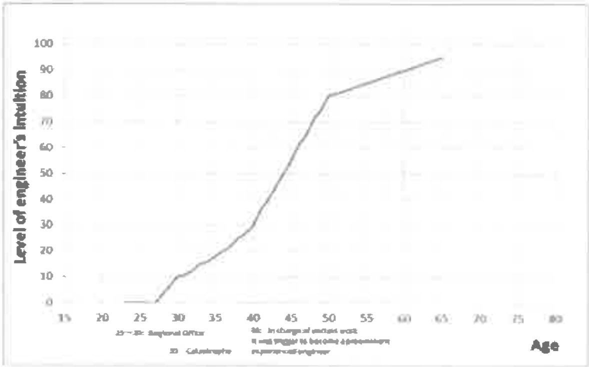
No.	Name of enterprise	Name	Speciality	Age	Career
1	KAJIMA CORPORATION	Yukiyoshi Kitamoto	Research and Development	52	28
2	KAJIMA CORPORATION	Kodoi Mituharu	Construction management	55	31
3	KAJIMA CORPORATION	Kazuyoshi Takahashi	Construction management	54	30
4	KAJIMA CORPORATION	Koichi Tanaka	Design	53	31
5	KAJIMA CORPORATION	Nagata Toshiaki	Construction management	57	35
6	NIPPON KOEI CO., LTD.	Shinjyuro Komata	Survey・Plan・Design	65	42
7	NIPPON KOEI CO., LTD.	Sadamura Hirofumi	Survey・Design ・Construction management	65	43
8	NIPPON KOEI CO., LTD.	Hatao Narimiti	Survey・Design ・Construction management	68	44
9	NIPPON KOEI CO., LTD.	Syoji Meguro	Design	65	43
10	TOBISHIMA CORPORATION	Kazumasa Matsuo	Design・Research and Development	55	33
11	TOBISHIMA CORPORATION	Yasutaka Matumoto	Construction management	58	36
12	KOKUSAI KOGYO CO., LTD.	Hiroshi Oshima	Survey	71	49
13	KOKUSAI KOGYO CO., LTD.	Akito Nakasuji	Survey・Design	66	43
14	TAISEI CORPORATION	Nobuo Fujita	Construction management	67	45
15	OYO CORPORATION	Shouji Ueno	Survey・Design	67	45

Source: Succession of intuition study group from Hosei University, 2014.

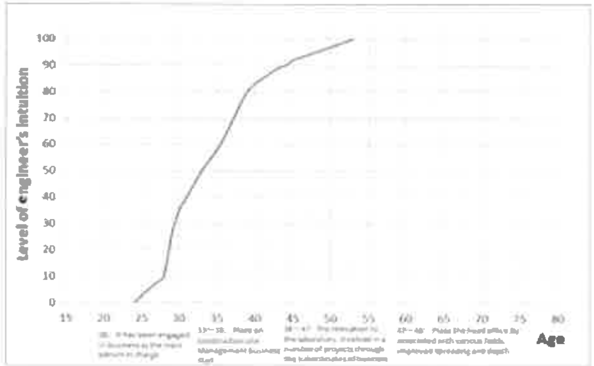
Figure 5. List of preeminent experienced engineers.

The interview content consisted of the following aspects:

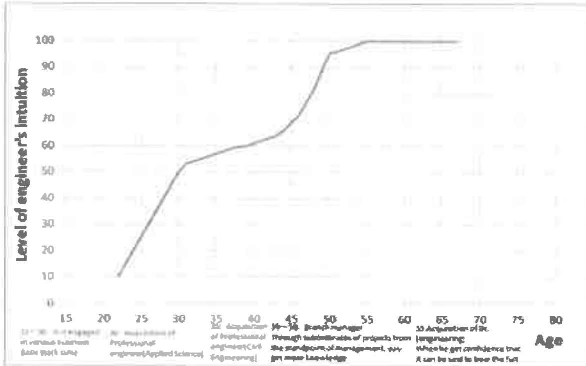
1. what type of work they have been engaged in
2. whether they had seniors who they considered as role models



①proportional 10persons
(NIPPON KOEI CO., LTD. Shinjyuro Komata)



②emergence in youth 2persons
(KAJIMA CORPORATION Yukiyoshi Kitamoto)



③plateau in later life 3persons
(OYO CORPORATION Shouji Ueno)

Source: Succession of intuition study group from Hosei University, 2014.

Figure 6. Figure of analysis results (three classifications).

Respondents of all types reached their current level of intuition by accumulating experience. Most belonged to the proportional type. This demonstrates that people who accumulate experience steadily have a high probability of becoming preeminent experienced engineers.

By analysing the interview results, we identified the growth factors. The growth factors obtained from preeminent experienced engineers were training, failure and responsibility and other. Training comprised daily effort required on the job and accumulation of experience in one's 20s. On the topic of daily effort, one engineer expressed the following opinion: 'I've done my work by myself. When I look back, I think I've done everything myself.' For accumulation of experience in one's 20s, the majority of the respondents spoke of the significance of a solid foundation, such as 'I look back on it as the time when I accumulated my foundations. The foundations I built thoroughly in my 20s have formed the basis of my ability today.' Opinions about failure included this example: 'I experienced huge failures, and decided not to do the same thing again.' Regarding responsibility, respondents noted features such as 'increased reliability after being given more responsibility (being appointed foreman, chief manager) or obtaining state certification (engineer).' Others cited 'health and strength,' 'encounters' and their 'first assignment' as important features. Opinions on health and strength included this example: 'You need strength to keep improving your ability.' Regarding encounters, respondents said, 'meetings with strict superiors were important growth factors.' For their first assignments, there were opinions such as 'I was not assigned to the specialised department that I had expected, and there was a lot I did not know, so I made a desperate effort.'

3.2.2. Were There Superiors or Seniors They Could Aspire to?

An analysis of the responses to this question led to the observation that a majority of the preeminent experienced engineers 'met with quality people or willingly interacted with people.'

After analysing the interview results, data on their encounters was collated. The encounters reported by preeminent experienced engineers were categorised as either existent or non-existent. The existent group was classified by age, people they learnt from and people they worked with. Comments on age included 'They were there at every juncture. They instructed me on what I needed at the right time.' Comments about people they learnt from included 'There were people I wanted to imitate, and looked up to.' For the non-existent group there were comments such as 'I thought that I would do it this way if it were me.' Those who thought they would do things a certain way if given a choice, provided reasons such as 'Every day I thought about what I would do when I was in charge. I was desperate to engage in the task in front of me.'

3.2.3. Thoughts on Subordinates and Juniors They Mentor

By analysing the responses to this question, we found that preeminent experienced engineers have 'high self-awareness and are continuously improving to achieve their goals and objectives.'

Growth factors were determined by analysing the interview results. The growth factors obtained from the preeminent experienced engineers were interacting with people, self-improvement and mindset. Interacting with people consisted of communication, connections with others and mentoring subordinates. Opinions on communications included 'Whatever

3.3. Summary

For the career development of outstanding preeminent experienced engineers, experience, along with responsibility, is essential. In short, for fostering young and mid-level engineers, it is imperative to gain experience along with taking on responsibility.

When outstanding preeminent experienced engineers engage in work projects that carry a high level of responsibility, they develop a high sense of self-awareness, work diligently every day, and take the initiative to interact with more people. Furthermore, they also fulfil the factors obtained in the analysis.

a. Outstanding preeminent experienced engineers succeed precisely because they do not tire of exploration. Furthermore, they fulfil most of the factors required to become an insatiable seeker.
b. These engineers take the initiative and are given opportunities to continue to grow
c. They take the initiative to meet outstanding people and willingly interact with others
d. They demonstrate a higher level of self-awareness, and work diligently to attain goals and targets
e. These engineers demonstrate the ability to work tirelessly on projects and work hard to improve their skills. They also contribute to the development of others

This study also suggests that it is important, as a research topic for the future, to explore measures that will help more engineers acquire a combination of experience and responsibility. This area must be highlighted because not all people can gain experience with responsibilities. Therefore, for engineers, having the opportunity to gain experience is essential along with responsibilities in order to successfully develop intuition and contribute to human resources development.

4. Mixed Method Cycle for Engineer's Intuition Formation

4.1. Mixed Method Cycle

Through the following five-part, mixed method cycle, the intuition of experienced engineers can effectively be transferred to younger engineers by the following:

1. Creation of a task-skill list: A list that illustrates the procedure of a certain task.
2. Utilizing keywords: this provides common recognition between experienced engineers and their younger colleagues.
3. Utilizing case studies that present images of a particular scenario.
4. Enacting case simulation where off-the-job training (Off-JT) with experienced engineers is provided to recognise and develop intuitive skills.
5. Enacting on-the-job training (OJT) whereby less-experienced engineers can gain experience and develop intuitive skills as facilitated by experienced engineers.

Name	Process of charge	Substitute	Learning situation (Process No.)						Development plan of all round skilled			
			EP	E1	E2	E3	M1		Oct.	Nov.	Dec.	
Tanaka	EP	Oki	X	X	X	X	X					
Sato	E1	Yoshida	X	X	X	X	X					
Suzuki	E2	Kimura	X	X	X	X	X			E8		
Nakamura	M1	Yoshida, Yamashita	X	X	X	X	X				M6	
· · · · ·												
Oki	Relief	—	X	X	X	X	X		E6	M8	E8R	

Source: Succession of intuition study group from Hosei University, 2012.

Figure 9. Task-skill list.

Source: Succession of intuition study group from Hosei University, 2012.

Figure 11. Skill analysis (technical version).

4.2. A Preliminary Study of Methodology

The current stage includes a preliminary study of the methodology. An experiment was conducted using a roadway design task to verify the effectiveness of the mixed method cycle. The first subjects were engineers and human resource development managers with about 20 years of practical experience and who were members of the aforementioned Research Association. In the next step of the experiment, students who had been offered jobs upon graduation were selected as the subjects, after referring to the opinions of the Research Association's members. In this experiment, the focus was on whether they could recognise what needed to be recognised in a roadway design. 'Recognizing what needs to be recognised' meant that the individual needed to demonstrate understanding of a situation by saying something like 'Oh, that's what it means!' based on their experience. The goal was to establish their ability to recognise relevant data and that their standard of engineers' intuition would improve following this experience. Many types of factors needed to be recognised, ranging from things that required short-term perspective to those that required mid- to long-term perspective. This particular experiment focused on those things that needed to be recognised based on a short-term perspective.

4.2.1. Experiment Overview

The main goal of this experiment was to determine whether the subjects could demonstrate 'recognising what needs to be recognised' in a short-term timespan. The experiment was conducted with method 4), and with the materials for methods 1)–3) presented beforehand. Method 4) comprised a) explanation, b) presentation of the problem, c) discussion and d) commentary. Step a) was conducted by an experienced engineer in a lecture format on the materials presented previously from methods 1)–3). In step b), the factors that needed to be recognised were presented as a problem. For this experiment, the question presented was 'What does Mr. A need to pay attention to while surveying the site?' In step c), each group discussed the question while interacting with experienced engineers. In step d), an experienced engineer passed a comment on the question. The solution to this problem was 'In his first survey of the site, Mr. A neglected to check for buried objects. In a linear study, checking what will become the control point is what is most important. Accordingly, he would have to go back and redo the linear study.'

Whether they recognised the solution determined whether they could proceed with tasks safely and smoothly.

4.2.2. Experiment with Engineers and Human Resource Development Managers

At the Eighth Engineering Technique Transmission Research Association, the experiment was conducted on 7th May 2013 (Tue), from 4:00 to 6:00 PM. The experiment location was Hosei University's Shin-Hitokuchizaka Campus, and 6 participants (3 engineers, 1 development manager, 1 researcher and 1 private researcher) were present. After the author presented an explanation of the engineers' intuition and described the cycle of the five methods, the author administered the experiment as the experienced engineer.. The results showed that 4 of the 6 participants recognised the problem. Following the experiment, the participants were asked for their impressions and the short-term effects were validated. This observed during the experiment, all the students were believed to be above a certain level. In view of the students' ability, there was a possibility for improvement in the way in which information necessary to recognise issues was provided. Furthermore, the small sample size was an issue with this experiment, and in future the sample size would need to be increased.

As previously stated, we conducted a preliminary study to verify the mixed-method cycle for future use. The results found that by experiencing methods 1)–4) before being presented with method 5), subjects were better able to recognise what needed to be recognised, and that repeated experience may be helpful in developing engineers' intuition.

CONCLUSION

In this study, we have introduced the concept of engineers' intuition in the Japanese construction industry. An engineer's personal characteristics and experience can determine whether a person has a high or low level of engineers' intuition.

Engineer's intuition can be defined as the ability to simultaneously detect a problem, investigate its cause and solve the problem in a certain environment. For example, on examining design drawings, an experienced engineer may retain some design features and alter others. As another example, if an engineer believes that a construction site is unsafe, he/she may withdraw the workers until the safety issue has been corrected, thereby demonstrating the engineer's intuition.

The data analysis results indicated that preeminent experienced engineers have common characteristics. To assume positions of responsibility such as theirs, they embody the quality of high self-awareness while maintaining a daily practice of continuous training and engage in frequent interactions with their co-workers. In this study, we observed the following three patterns concerning the increase in the engineer's intuition level: 1) proportional, 2) emergence in youth and 3) plateau in later life. This analysis highlights the importance of obtaining decision-making experience in a position of responsibility in the engineers' formative process.

Furthermore, we introduced a methodology for developing engineers' intuition. The cycle of five methods is a process for developing engineers' intuition: 1) a task-skill list 2) keywords, 3) a case study, 4) case simulation and 5) on-the-job training. To the best of our engineers' intuition, there is no other methodology that involves cycling through each method. We conducted a preliminary study on whether this method could effectively develop engineers' intuition, which is a necessary ability for an engineer. The results of this preliminary study showed that by undergoing methods 1)–4) before being presented with method 5), subjects were better able to recognise what needed to be recognised, and the gain of continuous experience may be helpful in forming an engineers' intuition. At present, this is only a preliminary study. Utilizing this methodology with more engineering candidates and young engineers and measuring the long-term effects are tasks for future research.

In summation, we have investigated the occurrence of engineer's intuition in the construction industry in Japan. In terms of future application, an extension of engineer's intuition into other industries could be examined. In the near future, engineer's intuition should be considered as an essential skill for improving productivity of the human race.

Yamada, R. et al. (2007), "Investigation of Clinical Nurses' Intuition Relationships between Hospital, Years of Experience and Nurses' License" *Journal of the Japan Academy of Nursing Administration and Policies,* Vol. 10, No 2, pp. 40 -47.

Yamasaki, M. (2014) "Succession of intuition and pertinent engineering experience in an ageing society with a low birth rate," *Journal of Asian Public Policy*, Vol. 7 No. 2 pp. 200-210.