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Technology Implementation and Learning Strategy: Case Study on Ramp-up Process of Hyundai Steel's Blast Furnaces

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Abstract: Implementing new technology involves a significant learning dimension for recipient firm. In this paper, we elaborate on how the recipient firm acquires and deploys knowledge of new technology for rapid ramp-up. We conceptualize learning process by two processes, 'learning-before-using' and 'learning-by-using'. The term 'using' is used to indicate the point of recipient's commercialization of technology. And the relationship between those learning modes is explained through the case study of steel making, especially blast furnace technology implementation in Hyundai Steel Company of South Korea who imported those technologies from Germany and Japan. By focusing on the relations between learning modes and learning strategies, Hyundai Steel's unprecedented rapid ramp-up of blast furnace business was able to be analyzed more clearly.

Keywords: implementation, ramp-up, learning-before-using, learning-by-using, Hyundai Steel

1. Introduction

Economic activity involves a significant learning and so does a firm's innovative activity. At this level of bald assertion, there is very little to disagree with. The more interesting questions may arise when we attempt to give this assertion some empirical content(Rosenberg, 1982). And this statement often requires qualification. A business enterprise is essentially a learning organization, and the knowledge system exists in its center place(Senge, 1990). Learning is any change in a system that produces a more or less permanent change in its capacity for adapting to environment. Understanding systems, especially systems capable of understanding problems in new domains, are learning systems(Simon, 1969). Every teacher knows that there is a profound difference between a student learning a lesson by rote and learning it with understanding, or meaningfully. Sometimes the best teacher is experience itself. Learning is the process whereby knowledge is created through the transformation of experience(Kolb, 2015). And this perspective on learning was also stressed in the intellectual origins in the work of Dewey, Lewin and Piaget.

This paper argues that we may fruitfully look upon implementing new technology as a 'learning process'. Though there are different categories of learning from the perspective of technology recipient, the main focus of this study is not on making sharp distinction among those categories of learning, but on understanding how they can be managed for better performance. In this respect, main purpose of this paper is to clarify the linkages between implementing new technology and learning process. While the existence of user's adaptation, modification of technology is well recognized, the role of learning in ramp-up stage has not received much attention.

To give insights to this need, this paper uses a case study on a steel manufacturing firm, Hyundai Steel who is the youngest integrated steel manufacturers in the world. It started blast furnace business since 2010 and is supplying its steel products for customers, mostly Hyundai Motor Group. Hyundai Steel's ramp-up time of blast furnace business is unprecedented. It took only 39 months to complete the first blast furnace and more notably the first and the second blast furnaces completed in the same year, 2010 which is the first case in the history of steel industry. In the case study, we will focus on how Hyundai Steel managed learning process, before and after commercialization while implementing new technology.

2. Relevant concepts from literature

New technologies are seldom perfect upon initial introduction. Implementation of technology involves recipient's significant efforts to understand technology and to apply technologies to reveal problems that were not apparent before introduction(Rosenberg, 1982; Dutton and Thomas, 1985). In this process, user adapts and modifies technology to its production system. Leonard-Barton(1988) showed that undertaking such modification is a complex, recursive process, involving 'mutual adaptation' of both the new technology and the organization, and requiring the active cooperation of both users and technology developers. Because the final outcome is extremely uncertain due to the difficulty of anticipating some of the interactive consequences of any given technologies, learning is widely recognized important. There are 3 major research streams on what drives a firm to continue learning activity and management particularly regarding implementing new technology.

(1) Characteristics of knowledge

Not all technological knowledge is equally accessible and understandable. In general, explicit knowledge is more accessible than tacit knowledge in the form of operating manuals and other documents (Polanyi,1958; Nonaka and Takeuchi, 1995). To acquire tacit knowledge is known as a challenging process, and in this case, the best teacher is often 'experience'. A well-established concept in organizational theory is that organizational actors use 'experience' to create routines that simplify their information-processing needs(March and Simon, 1958). In this case, the efforts to turn tacit knowledge into explicit knowledge are required though it is still challenging. 'Information stickiness' is another important factor to bring prolonged learning activity. Much data have 'sticky' qualities that make them hard or impossible to replicate and diffuse to remote sites(von Hippel, 1994). Some technology information tends to be 'sticky' to the people who know it. So recipient strives to 'unstick' this information from human factor to facilitate and continue learning activity. In addition, product architecture is also critical characteristic in implementing new technology. This is particularly important in the case of integral architecture of a product or capital good. The performance characteristics of an integral architecture product often cannot be understood until after prolonged experience with it.

(2) Recipient's learning capacity

Outside sources of knowledge are critical to the innovation process. Introducing new manufacturing technology is not simply a question of implementing a well-developed solution, but of managing a problem solving process to adapt existing ideas and create new solutions within a particular environment(Tyre, 1991). Assimilating external knowledge largely depends on firm's ability to exploit external knowledge, in other words, it is a function of the firm's level of prior related knowledge. Thus, prior related knowledge confers an ability to recognize the value of new information, assimilate it, and apply it to commercial ends. These abilities collectively constitute a firm's absorptive capacity(Cohen and Levinthal, 1990).

(3) 'Learning' and 'doing'

The aspects of learning commanding much attention deal with 'learning by doing'. As Arrow(1962) pointed out, this is a form of learning that takes place at the manufacturing stage after the product has been designed. At this stage, learning consists of developing skills in production, and it has the effect of reducing labor costs per unit of output. Related with this concept, the existence of learning curve is well recognized. Learning by doing is essentially a form of problem solving that involves application of a production process in a use environment(von Hippel and Tyre, 1995). Since the most of knowledge about the manufacturing process is acquired through actual operating experience, learning by doing approach was considered the most effective learning mode.

Another stream of learning mode is 'learning-before-doing'. In this learning mode, prior learning can reinforce following real operation. The term 'learning before doing' is used to differentiate problem-solving strategies from learning-by-doing that takes place after a process is transferred to a commercial production environment. So this learning mode focuses on lab-based learning, or what we call research and development(Pisano, 1996). Some scholars named it 'learning by experimentation(Thomke, 2003)'.

Problem solving tradition as above reveals the existence of different types of learning modes within an industry or a technology system. However, it is not easy to make a sharp distinction between learning by doing and learning before doing, or learning by experimentation. This is because due to conceptual ambiguity of 'doing', in reality 'doing' can take many other forms.

3. Research Framework

The main focus of this study is not on making sharp distinction among those categories of learning, but on understanding how they can be managed for better performance. In this paper, to analyze implementation process, we use 'using' instead of 'doing' concept. The 'using' perspective can be useful particularly in two reasons. First, 'learning before using' and 'learning by using' can be comparatively easily distinguished by the point of user's commercialization of imported technology. Second, by this distinction, we can elaborate on the impact of learning strategies on ramp-up performance. With those two learning modes, ramp-up process of blast furnace business of Hyundai Steel analyzed. The main focus here is that what learning strategies Hyundai Steel had on each mode, and its impact on ramp-up performance, especially speed.

4. Case study: Rapid of ramp-up of Hyundai Steel

Hyundai Steel is the youngest integrated steel manufacturer in the world and the 14th largest steel-producing company as of 2014. The biggest point which catches one's attention is its rapid ramp-up of blast furnace business(Table 1).

Table 1 Blast furnace construction of Hyundai Steel

	Completion (YY/MM)	Construction time (months)	Time to stabilization (days)
Blast Furnace #1	2010/01	39	25
Blast Furnace #2	2010/11	37	12
Blast Furnace #3	2013/09	29	6

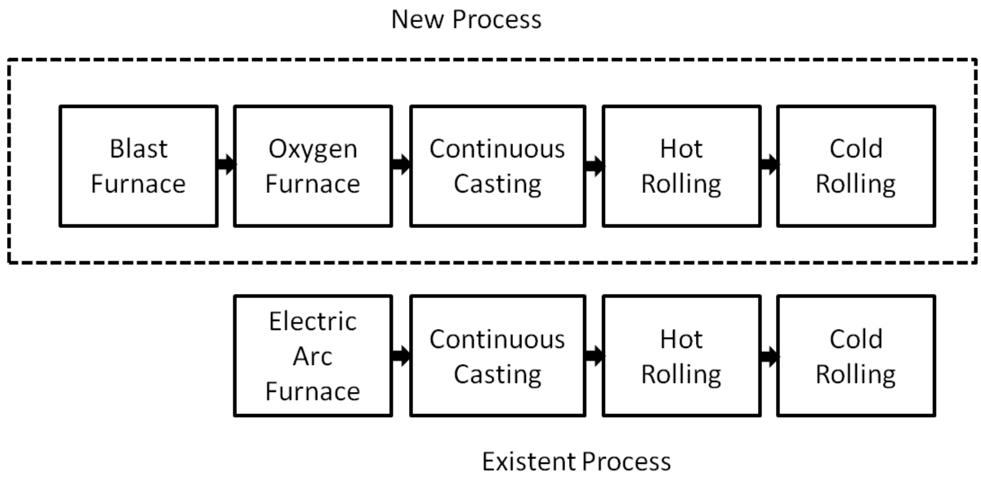
<Source: interview with Hyundai Steel Company>

In the history of steel industry, there was no other case that a steel company starts two blast furnaces in the same year. It took only 39 months to finish construction of blast furnace #1 and the time to stabilization(time to have stable output) recorded 25 days. This record is also noteworthy. As table 1 shows, construction time from blast furnace #1 through blast furnace #3 was shortened, so did the time to stabilization. Now, one can have an interesting question about this record, "How did Hyundai Steel succeed at this rapid ramp-up?". We give two explanation on this, learning modes('learning-before-using' and 'learning-by-using') and learning strategies.

(1) Learning before using (~2009)

Hyundai Steel was surely a new comer in blast furnace business, but not in steel making business. It already had operating experiences in electric arc furnace which uses steel scrap as raw materials to produce products. However, the firm had no experience in producing pig iron('virgin steel') and in producing steel with oxygen furnace. Therefore what we mean by 'blast furnace business' in this case includes three processes all together, which are blast furnace, oxygen furnace and continuous casting(Figure 1).

Figure 1 Hyundai Steel's introduction of new technology



At this stage, Hyundai Steel decided what to learn explicitly. The first strategy was 'repeated learning' strategy, exactly same furnaces repeated. Since Hyundai Steel had no experience in using blast furnace and oxygen furnace, it decided to introduce three same lines to maximize learning effect and at the same time minimize the uncertainty of technology. Hyundai Steel imported blast furnace from Paul Wurth, Luxembourg and operation technology from TKS(Thyssen Krupp), Germany. But it decided to bring oxygen furnace from Japan, SPCO(JP Steel Plantech Co.). And this combination was applied to all three newly installed lines. The second strategy was pre-research. Before its implementation of new processes, Hyundai Steel established research and development center in 2007 which was years before it commercialized new processes. However, the main focus was collaboration with its customer, Hyundai Motor Group to customize its products to automobile steel sheet. The third strategy was focusing on specific products, mainly automobile sheet and shipbuilding plate. By limiting the variation of product line, Hyundai Steel was able to deploy its resources more effectively and efficiently.

The experience in electric arc furnace could not be directly connected with blast furnace process because the fundamental differences in technology. However, the knowhow on basic inventory management and flow management did help learning new process.

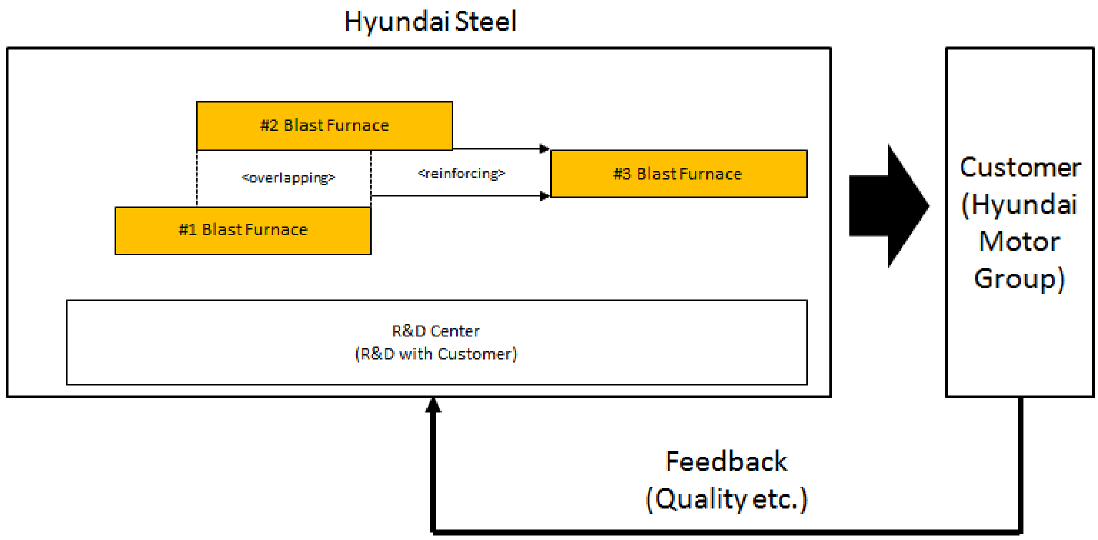
The biggest problem at this stage was that how it can learn faster without direct experience in blast furnace business. Though Hyundai Steel had agreement with TKS on operating technology transfer, this support was only for blast furnace operation, not for the oxygen making process. It could not experience what cannot be experienced since the construction process was still on going. The only way to pre-learn 'experience' was to bring the experienced manpower from outside. Luckily enough, around 2005~2007, there were quite a few retired workers who experienced working in blast furnace and oxygen furnace, most of them from its rival POSCO(Pohang Iron and Steel Company) established in 1973. Hyundai Steel hired those veterans and let them train their young operators. Hiring veterans were not limited from POSCO, some of them were from Japanese steel manufacturers such as JFE steel. Those experts shared their own 'learning-by-using' experience with younger generation in Hyundai Steel.

(2) Learning by using (2010~)

The first blast furnace starts operation from January 2010, 39 months after Hyundai Steel officially declared construction of new processes. The time to stabilization took only 25 days, and this number shortened 12 days in the second blast furnace, completed 10 months later. In this stage(learning by using), literally using of new processes started and from this point, Hyundai Steel started accumulating operating knowledge and knowhow. Also, in this stage, Hyundai Steel's learning had two major objectives. The first one is overlapping and transferring knowledge and knowhow to other lines swiftly(ex: to #2 and #3 blast furnaces). The second objective was getting feedback from its customer(Hyundai Motor Group) as soon as possible.

Blast furnace #1 and #2 are mostly overlapped(Figure 2.) in construction time as well as operation starting time. However, there exists about half year between completion of #2 and construction start of #3. As mentioned previously, those three blast furnaces are exactly the same specification.

<Figure 2 Overlapping and reinforcing among processes>



The overlapping of #1 and #2 was effective in acquiring and deploying operation knowledge in short time span between two blast furnaces. Though construction time was not shortened greatly from #1 to #2, the time to stabilization shortened from 25 days to 12 days. And accumulating operation experience for more than 6 months played a critical role for #3 blast furnace. In other words, the experience accumulation in #1 and #2 greatly reinforced both the construction and operation of #3 blast furnace(29 months in construction and only 6 days in stabilizing operation). In this respect, overlapping and reinforcing was particularly effective way based on its strategy of building 3 same lines.

The second objective of learning by using stage was getting feedback from its customer as soon as possible. As of 2012 which is only 2 years of stating operation, Hyundai Steel supplied 3 million ton(less than half of output from blast furnace) of automobile sheet for Hyundai Motor Group. When Hyundai Steel established R&D center in 2007, it started R&D activity with Hyundai Motor Group. Hyundai Motor Group sourced steel sheets from Hyundai Steel, and from the very early stage, found quality issues and established a task force team to address this issue. This was possible because they are under the same conglomerate, but this early feedback played critical role to improve quality.

5. Discussion

This paper stressed the impact of learning strategies on ramp-up process. We analyzed two learning stages, 'learning-before-using' and 'learning-by-using'. We found 'using' is very useful concept, not only in understanding time of action, but also in emphasizing user's perspective. More importantly, Hyundai Steel's learning strategies on each stage elaborated. In the first stage(learning before using), Hyundai Steel deployed repeated learning strategy to maximize learning effect and minimize the uncertainty of newly introduced technology. And in the second stage(learning by using), Hyundai Steel used overlapping and reinforcing strategy.

Implementation of new technology involves learning activity, but what this paper emphasizes through brief empirical study is that learning activity entails learning strategies. The fitness between learning mode and firm's learning strategies have a great impact on the technology implementation and its performance. Though this study used a case study on this research question as exploratory study, the causal relationship between the performance of recipient's implementation and learning strategies on each mode is worth further research.

Understanding technology transfer or technology implementation process from the recipient's perspective can also suggest many fruitful researches. Implementing new technology as learning process is just one of the various approaches possible. But ramp-up process has not been highlighted as much as user's modification and adaptation activity.

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