Knowledge Management, a Path to Technological Innovation: A Comparative International Case Study of Engineering Companies in Japan, Ghana, and Northwestern China

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A civil engineering company in Northwestern China faces communication and innovation challenges, preventing it from moving forward as an organization. These issues stem from challenges of managing knowledge related to technological innovation within the organization. While the company is developing new practices generated in its civil engineering design service, knowledge management system development is insufficiently adopted. Knowledge management has been proven to be an efficient means to create, identify, and share knowledge and best practices in developed countries such as the UK, Japan, and the US. This comparative case study explores the successful applications of knowledge management in technological innovation for companies like the one in Northwest China -- by comparing it to two different organizations in different countries. These companies were chosen as part of this research as they provide insights through the lenses of the macro and micro issues relating to knowledge management. The findings from the study should provide practical guidance for civil engineering companies to practice knowledge management of technological innovation.

Keywords: civil engineering, knowledge management, northwestern China, technological innovation, management systems

INTRODUCTION

The engineering industry in developing countries is competing fiercely for the quality and delivery of their work (Hackman et al., 2017). Especially those companies in the under-developed area long for the technological innovation that increases the competency and originality of the company's service (Moreira et al., 2019). Technological innovation is the driving force for most engineering companies in the wake of pioneers in the industry (Hall & Densten, 2002).

In the division of the engineering industry, civil engineering, especially water-related engineering practices, is a central player in the market. According to market research future's global civil engineering market report (2021), the civil engineering market share can be divided into North America, Europe, the Asia-Pacific region, and the rest of the world. The civil engineering work includes planning and design, construction, operation, and maintenance. With the awakening of information technology in the industry,

the application of technology is becoming the next core business in civil engineering companies (Hackman et al., 2017).

Our research target, "H Civil Engineering Design Institute" (pseudonym), is in northwestern China, a geographical place known for its shortage of water resources and desert-oasis economy. Properly managing water-related construction becomes the central issue in locations lacking natural water resources (Intelligence research group, 2021). Traditionally, companies in the water conservancy civil engineering industry utilize modern planning and design techniques to manage industrial, agricultural, household, and recreational water (Company promotion brochure, 2021). With the fierce competition in the market, information technology is applied to create smart water management with a digital twin, 3D animation, BIM, GIS, and other tools for design and construction.

The target company has 132 employees, two sub-companies, and eight branches and conducts business in the northwest province of Xinjiang, China. The core five businesses of our research site are hydraulic engineering design, engineering procurement and construction (also known as EPC), site operations, smart water conservancy, and 3D-animation water landscape. Other services include planning, consulting, surveying, conservation plan preparation, and ArcGIS mapping. In analyzing the company's past development, industry development trends, and development goals, the researchers discovered information technological innovation as a crucial component as it continues to expand its business.

Therefore, this research aims to provide insights into the company's future development by a comparative case study analysis of practices in knowledge management and technological innovation in global markets. The study will also add knowledge management components to the international engineering management literature from a management perspective. Knowledge and innovation management are crucial to civil engineering companies in identifying and sharing best practices and experience within the organization (Hackman & Smith, 2017). Previous studies have attempted to discuss technological innovation and its impact on leadership (Antes & Schuelke, 2011; Moreira et al., 2019). However, studies have yet to examine how knowledge management could impact technological innovation.

This comparative case study aims to uncover how knowledge management could improve technological innovation in a civil engineering company. A knowledge management framework will be used to analyze each case. Additionally, the target organization's case study data will be compared and contrasted with the findings from two case studies to provide suggestions for the target company. This global comparison could provide knowledge management models for civil engineering companies to promote technological innovation. The findings of this paper could enable the target company to adopt proactive approaches to manage technological innovation to improve project performance. This study aims to contribute to the knowledge management and technological innovation literature by comparing the findings of the three case studies. The following research questions will guide this comparative case study.

Research Questions

RQ1: *How could knowledge management improve technological innovation in an engineering company in Northwestern China?*

RQ2: *How did knowledge management improve technological innovation in the two case studies compared to this project?*

RQ3*: How did the findings of the two existing case studies compare with the case of the engineering company in Western China?*

LITERATURE REVIEW

Knowledge Management

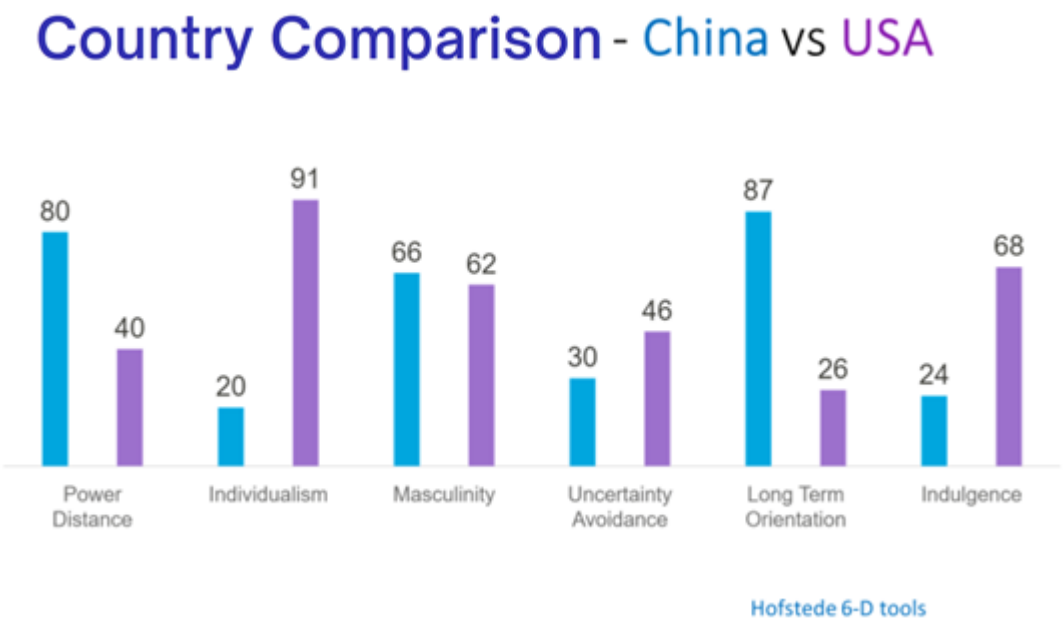
The foundations of Knowledge Management have been mentioned in the literature but never developed into a theory until it was coined in 1970 by Peter Drucker and defined by Davenport (1994) as "the process

of capturing, distributing, and effectively using knowledge." It has been proven to be an efficient means to create, identify, and share knowledge and best practices in developed countries such as the UK, Japan, and the US (Hackman et al., 2017; Hahn & Subramani, 2000). Knowledge management goes far beyond the control of data. Data can be stored, transferred, and distributed relatively quickly with capable computers and reliable networking. However, knowledge goes much more profoundly; it includes experiences, tacit knowledge, creativity, understanding, and proper data utilization. Organizations operate by having multiple departments, such as marketing, engineering, IT, legal, etc. When all departments within an organization work together effectively, productivity is optimized, which results in innovation, creativity, and achieving organizational goals. On the flip side, if one or more departments do not collaborate efficiently, it could cause miscommunication, delays, and other problems for the organization. Hence, having a knowledge management system can prove very beneficial.

China and the United States

Business practices in China and the United States are very different. To determine the best approach to the Chinese market, we started by comparing the two countries using Hofstede's (2001) six cultural dimensions: Power distance, Individualism, Masculinity, Uncertainty Avoidance, Long Term Orientation, and Indulgence. Power distance is the extent to which the less powerful members of an organization within a country expect and accept that power is distributed unequally. Individualism is the degree of interdependence a society maintains among its members. Masculinity is the extent to which people are goal-oriented as opposed to people-oriented. Uncertainty Avoidance is the extent to which the members of a culture feel threatened by ambiguous or unknown situations. In other words, the degree of being risk averse. Long-term Orientation is how a culture maintains links with its past while dealing with challenges in the present and future. Indulgence is the extent to which people try to control their desires and impulses (Hofstede, 2001).

FIGURE 1
HOFSTEDE SIX DIMENSION TOOL COMPARING CHINA AND THE UNITED STATES 2021



Power distance and Long-term orientation in China seem to be significantly higher than in the United States, while individualism, indulgence, and uncertainty avoidance are lower. Masculinity is very similar, with a slightly higher score in China. After analyzing the literature, we selected the two case studies we

deemed most appropriate. We compared them with our target organization as they have successfully integrated technological innovation into their organizations.

METHOD

The comparative case study will first identify and analyze the target company case in Western China. As the researcher works as a consultant to this company, researchers will gather archival data from different sources—websites, company reports, annual conference reports, and promotional brochures. To analyze this data, we used the PESTLE environmental scan tool (Yin, 2012). This tool gave us an essential foundation for the findings from the archival data. In addition, we will use Lewin's change model to analyze the company's performance improvement and the change technological innovation brings. All these compartments will formulate the findings from the target company case.

According to Yin (2012), case selections should be established on a solid and substantive rationale; here are the reasons for our comparative case choices. Our second case is selected from Ghana's same civil engineering industry. Ghana is in Western Africa and has similar geographical characteristics to the first case company, i.e., desert and oasis economy. Water scarcity means the two cases have the same urgency to maintain water-related technological innovation engineering practices. According to the literature, the Ghana company case is related to knowledge management and project management competencies in the construction industry (Hackman et al., 2017; Dogbegah et al., 2011; Ofori-Kuragu et al., 2016). Researchers can find clues from literature in Ghana's civil engineering construction industry.

The third case selected is based on the best practices in managing technological innovation. The knowledge management system illustrated by Sharp corporation is an excellent example of strategy realization (Bowander & Miyake, 2000). Japan is famous for maintaining its market leadership in global competency via technological innovation. Sharp's development of Liquid Crytal Display (LCD) televisions dominated the market through quick knowledge evolution and strategy adaptation (Bowander & Miyake, 2000). Although the industry of this research differs from the others, the core knowledge management and technological innovation concept overlap with the main idea of this research. Moreover, through comparison, we can draw more insights into improving the performance of civil engineering.

After analyzing the three cases, researchers will compare the findings from the target company case with the two other case studies. Analyzing case studies involves reducing and reorganizing the information in a continuing process (Evers & Can Staa, 2010). The purpose of data analysis in a case study is to interpret, comprehend, and explain what has taken place in the selected cases (Miles et al., 2014). A case is viewed as a single unit to infer enclosed information from the data analysis and enable researchers to answer the research question and generate findings (Evers & Can Staa, 2010). The in-depth analysis and data utilization include the connection between literature and case studies, advocating and refuting existing theories from the literature (Paterson, 2010).

FINDINGS

Case 1: Knowledge Management in a Civil Engineering Company in Northwestern China

The data collected for this research is mainly from archival data, including the corporate group's website, company report, annual conference report, promotional brochure, and industry report. After carefully assembling the archival data, the researcher reviewed the research question: "How could knowledge management improve technological innovation in an engineering company in Northwestern China?"

Researchers coded the company-related archival data using Nvivo software and identified words and pictures referencing technological innovation. The organization's core concept is "innovation, integrity, service, excellence" (Company promotion brochure, 2021); researchers captured the recurring themes mentioned in the archival data to indicate alignments with the core value "innovation."

Engineering 4.0

Engineering 4.0 is a group of concepts mentioned by the corporate group, including smart water, 3D animation water landscape, water resource management, information technology, BIM technology, etc. These concepts are based on the Fourth industrial revolution or Industry 4.0. Industry 4.0 has enabled progressive manufacturing and engineering technologies, big data analytics, modeling and simulation, massive digitalization, artificial intelligence, automation, etc. (Zonnenshain & Kenett, 2020).

Although engineering 4.0 is a cluster concept name, it is mentioned once in the four types of documents. The sub-technology terms appear in each project presentation of the promotion materials. This means technological innovation is newly adopted in engineering practices, and the management still needs to organize the work that falls into this category systematically.

Working Mechanism

The working mechanism is the predominant theme of the 56-page promotion brochure. Because of the nature of civil engineering work, most illustrations are on the classic engineering performance. Technological innovation, such as 3D animation, is widely applied in engineering design. The knowledge management could be better present in the promotion brochure as it illustrates the classic engineering performance case by case from page 14 till the end. The description is verbatim as the original description of the engineering work. Technological innovation is difficult to capture from the theme.

Technological Innovation

In analyzing the promotion brochure, company's annual conference, and report, technological innovation is a recurring theme in these documents. However, there needs to be a significant illustration of how technology is managed through different projects. When looking at the company's website, there is one subpage on technological innovation. But inside the web page are only some conference and meeting summaries related to conducting technology-related work. The site needs all the innovations of smart water management platforms, video presentations, and 3D animations.

PESTLE Analysis

A PESTLE analysis was conducted based on the data from industry reports. Central themes such as political, economic, social, technology, laws, and environmental are organized as categories to analyze the industry reports. These findings can provide external requirements for the company's adoption of technological innovation.

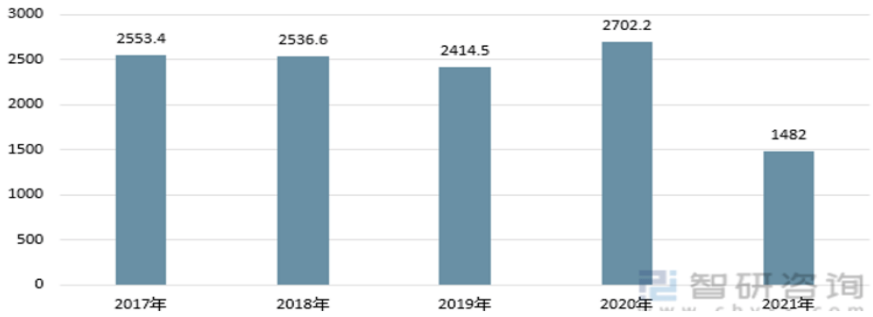
Political

In the most recent government reports from the Ministry of Water Resources, seven government policy documents promote information technology applied in the water conservancy industry (Ministry of Water Resources, 2022; Ministry of Industry and Information technology, 2021). The major themes in the documents are digital twin watershed, advanced technology applied in urban settings, smart water management, 5G Internet of things, etc. These themes demonstrate the government-guided trend of using information technology in the industry. The corporate group's primary revenue is generated from government investment, and the political factor is the most dominant factor influencing the corporate's development.

Economic

As mentioned in the previous paragraph, the company generates its most significant revenue stream from the investment of different levels of government. Therefore, how much financial budget is allocated to the water conservancy infrastructure will determine the company's economic growth. As the graph in Figure 2 demonstrates, the central government's investment remains around 230 billion RMB, which guarantees a steady source of investment in the industry (Intelligence Research Group Beijing, 2021).

FIGURE 2
THE CENTRAL GOVERNMENT WATER CONSERVANCY CONSTRUCTION INVESTMENT 2017-2021



Social

According to Intelligence Research Group Beijing (2021), total water consumption is distributed to agriculture, industrial, ecological, and water for life. Agriculture utilizes the most water consumption, around 3600 to 4000 billion cubic meters per year, followed by industrial water, about 1400 billion cubic meters, then water for live and ecological water. Therefore, water-related civil engineering is directly related to people's lives as it involves agriculture, industrial, and ecologic water infrastructure planning and construction. In the company's promotion brochure, we identified many sections discussing the social benefit the company brings to the community and society.

Technological

As stated in the government policies, the government institutes have continuously promoted technological innovation in the past three years. The trend for technological innovation is identified by the increase in patent applications received each year by the Ministry of Industry and Information technology (Intelligence Research Group Beijing). Our research site location has ranked No.3 among all applicants in the patent application cases. This discovery suggests a technological trend in the civil engineering industry in Northwestern China.

Law

The regulations and laws relative to the corporate group can be divided into engineering design and software engineering. Because of the technological focus of the study, the rules reviewed are 33 items on software engineering specifications. It provides guidelines for developing software that helps smooth the civil engineering process.

Environmental

An environmental scan is closely related to the water-related civil engineering industry. Seven of the seventeen U.N. developmental goals mentioned clean water and sanitation, clean energy, sustainable cities, climate action, life below water, and life on land (United Nations). These are all environmental factors that the corporate group engaged in their core business. Water is an essential resource affecting the environment, climate, and people's lives. From a business perspective, how to manage technology to address environmental needs is another topic to consider.

Case 2: Knowledge Management in a Civil Engineering Company in Ghana

Case Selection

This case is selected based on the company's similar industry and geoeconomic status. Unlike most knowledge management and project management cases based in developed countries, this significant case is in Western Africa. They share the same desert-oasis economy as our research target (Hackman et al.,

2017). Besides, topics like project management, competitiveness, and performance improvement are discussed based on the Ghanaian construction industry cases (Ofori-Kuragu et al., 2016; Dogbegah et al., 2011). The knowledge management concept has been applied in different industry settings (Lee & Choi, 2003; McInerney, 2002). This case study is an excellent example of the civil engineering industry adopting knowledge management strategies.

The Implication of the Case

According to Hahn and Subramani (2000), knowledge management system development can be applied to the construction industry, but there's little empirical research on this topic in Ghana. Knowledge management is mature in developed countries like the U.K. and the U.S. Construction practitioners and researchers have applied a wide range of studies and concepts (Hackman et al., 2017). This case study organizes the knowledge management literature and provides a detailed quantitative analysis that can serve as a foundation for applying technological knowledge management.

The conceptual perspective of knowledge management is associated with managing information within the organization. Knowledge management is the practical learning process of creating, identifying, and sharing knowledge that enhances the whole organization's intelligence and competency (Ashok, 2004). As the organization proceeds to acquire knowledge, knowledge can be indicated as tacit or explicit knowledge (Hahn & Subramani, 2000). And how to organize knowledge management processes using technologies and tools that motivate innovation, identify patterns, and share the most effective practices. It discusses the challenges and strategies when adopting knowledge management in civil engineering organizations (Hackman et al., 2017).

Challenges associated with adopting knowledge management systems are an essential aspect of what this case study provides. In identifying the critical challenges, the study utilized a structured questionnaire that recruited 13 civil engineering firms to generate the results. Among the 67 respondents, a lack of knowledge management system is the biggest challenge the 13 civil engineering companies encountered, followed by a lack of leadership support and awareness of K.M. practices. This confirms the necessity to introduce knowledge management systems into the civil engineering industry and identifies the need for awareness creation. Other challenges like employee resistance, lack of structured procedures, and time constraints can be some issues that need to be addressed when implementing the system.

Strategies to improve knowledge management practices are another insight generated by this case study. Innovation is the most important for companies to have a competitive edge against competitors. Awareness creation is essential, as we discovered from the challenges. A knowledge storage system that organizes codified and personalized knowledge will be a crucial measure to ensure effective knowledge management. The most effective strategies generated from the 13 Ghanaian civil engineering companies can be applied to our research site to improve performance and competency.

Case 3: The Sharp Corporation and the LCD Development

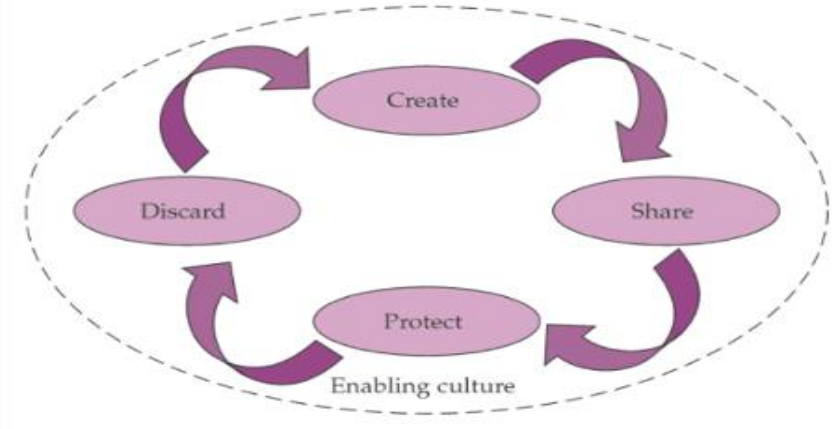
Case Selection

Among many successful knowledge management implementation cases, we decided to choose the Sharp Corporation. Since its emergence in 1912, Sharp, formally known as The Sharp Corporation, has achieved many milestones. There is no better way to prescribe success than following the principles of success that have stood the test of time.

In 1953 it was the first company to mass-produce television for the general public, making the *Sharp TV3-14T*, "The Model T" of the television industry in Japan. Which, in hindsight, is ingenious as T.Vs became a staple piece of technology in most households worldwide. Further into the future, "Sharp is known for pioneering revolutionary LCD [Liquid Crystal Display] televisions and is one of the leading players in this market. In 2004. It had a 34% global share, selling nearly 1.5 million sets" (Shibata & Takeuchi, 2006). Although they had not invented LCD panels, which the Radio Corporation of America created, RCD in 1967 (Shibata & Takeuchi, 2006), They contributed massively to its development and distribution to dominate the television market. The base of their success in this feat is rooted in knowledge management. It is rooted in: Holistic Knowledge Management, which consists of four activities: creating, sharing,

protecting, and discarding—also known as Knowledge Leveraging, the optimal use of knowledge comparatively and cooperatively.

FIGURE 3
STRATEGIC MANAGEMENT OF KNOWLEDGE



Comparative Analysis for Three Cases

Comparing the three cases, one common theme is discussed in different contexts. Knowledge management systems are crucial for creating, identifying, and sharing best practices in civil engineering companies. The third case of Sharp provided a holistic knowledge management ecosystem from a developed country's perspective. It realizes knowledge management by indicating present and future capabilities and cooperative and competitive strategies. Sharp's case can be the most compelling example of creating knowledge management awareness from other industries. At the same time, the Ghana case is a more empirical study of 13 civil engineering companies. The findings of these two case studies are the same, but their approaches are quite different. One is a theoretical analysis of knowledge management, and the other is a quantitative approach to rank the critical challenges and key strategies. Both cases can provide guidance and insight for the target company case.

Our findings from the first case study indicate that more knowledge management systems must be implemented. The poor organizing system needs to identify the critical technological innovation from each project. And sharing of the information, as presented in the company's brochure, must be included in the systematic management system. Compiling the findings from Case 2 and Case 3 can contribute to developing a knowledge management system to fulfill the need of Case 1 company's technological innovation management.

The Sharp case generates the awareness creation process, and empirical studies from the same industry in Ghana can foresee the challenges and provide strategies to overcome them. The comparison offers a progressive model for the case 1 company to adopt a knowledge management system. The first stage will be the Ghana case which increases the awareness and understanding of the system. Then, Sharp's cooperative and competitive model can be the next stage for knowledge management development. The target organization provides an experimental site for the experience gathered from the latter two cases.

DISCUSSION AND IMPLEMENTATION

Holistic Knowledge Management - Creating, Sharing, Protecting, and Discarding

Creating

Sharp elevates and maintains its status as the best by becoming a knowledge-creating company that excels beyond its competition and achieves outstanding results. To apply this to, we must prioritize

technological innovation and knowledge creation to keep our ranking in the industry, which is currently seventh in Northwestern China.

Sharing

Active knowledge sharing within the company is crucial; becoming first in the industry is more than just a one-person job. It requires communication and collaboration across all regions, functions, and business units. As a civil engineering company, many parties are involved in completing every project. We must optimize knowledge sharing among our engineers, businesspeople, contractors, suppliers, clients, and other members involved.

Protecting

Securing intellectual property is crucial to stay one step ahead of competitors in the industry. Sharp has done this by making its products complex and hard to copy. As a result, the complexity of its innovations eliminated the need to go to the patent office, as that would publicly expose its manufacturing process (Shibata & Takeuchi, 2006). To apply knowledge management techniques in H Civil Engineering Design Institute, we will determine the fine line of how much we should share to get investors to buy in our company but not give away too much that a competitor might imitate our products.

Discarding

Knowing when to pursue technological H Civil Engineering Design Institute innovation and when to call it obsolete is vital to the survival and success of a company. Sharp determined that investing in LCD panels was the way to go, and their investment paid off significantly. In the Through proper communication practices among the engineers and technicians would be able to update the decision-makers about the latest and greatest the industry has to offer to guide them into the technological innovation path our organization should pursue.

Knowledge Leveraging

Strategic management using time explores Sharp's utilization of the cooperative and competitive capabilities of its organization (Bowonder & Miyake, 2000).

FIGURE 4
KNOWLEDGE LEVERAGING POOL

	TIME FOCUS	
	Present Capability	**Future Capability**
Cooperative	**Evolving Knowledge Through networks**	**Knowledge creation Through combination of Cognitive knowledge, Internal competencies, and accumulated experience**
STRATEGY REALIZATION		
Competitive	**Leveraging Knowledge and rapid learning**	**Insuring against Uncertainties through Creation of multiple knowledge option**

Cooperative

Present Capability

Using economies of scope, besides T.V.s, Sharp produces car navigation systems, calculators, computer monitors, and personal digital assistants. This significantly lowers its production costs.

Future Capabilities

These technologies spread across the market and increased the number of users of LCD televisions worldwide. Sharp received a massive increase in consumer feedback, which ultimately provided valuable product information about what consumers liked about the product and what could be improved. Hence, allowing Sharp to integrate the feedback and improve their production and technological innovation.

Competitive

Present Capabilities

Sharp is leveraging knowledge and rapidly learning through its networks and monitoring its competitors' networks, such as Sony, IBM, and Toshiba.

Future Capabilities

Monitoring its rival companies allows Sharp to stay one step ahead of the competition. This case has been selected as its success record proved remarkable due to Sharp's recognition of the importance of knowledge management systems and implementation in their corporation.

Change Model Implementation

As the world of technology evolves at an ever-increasing rate, the need for change has never been higher. Organizations are ecosystems; they involve bureaucratic networks, massive infrastructures, established norms, a core vision, goals, aspirations, and many other elements. It is a complex process to change an organism with such complexities. However, organizations must seek to grow, develop, or adapt to their current economies to keep up with their current economies. As an EKG device from your nearest healthcare facility would tell you, "Being static is not an option." Organizations must be dynamic and adapt to change to survive and thrive. People are generally unwilling to change because change brings uncertainties that may affect their livelihood and how they do things. The people in an organization will only support change if they are convinced that the status quo is no longer an option (Cummings & Worley, 2018). Hence, convincing the organization's members that a knowledge management system is vital for the organization's future. Organizational change explains the movement of an organization from the known (current state) state to the unknown (desired future) state. With outstanding resistance comes a greater need to implement change management techniques. According to Moran and Brightman (2001), Change management continually renews an organization's direction, structure, and capabilities to serve the ever-changing needs of external and internal customers. Hence, managing change is about managing people.

Lewin's Change Model

Organizational needs for change differ depending on the culture and nature of the business. We have selected Kurt Lewin's three-step change model: Unfreeze, Change, and Refreeze (Hussain et al., 2018).

Unfreeze

First, we must determine our organization's "current state" and identify the "desired state" we want. In other words, we must draw a destination map from point A to point B by establishing new protocols for knowledge management, increasing communication between departments such as marketing, and media communication, and establishing a well-designed feedback system to monitor the progress.

Change

Once the change is set in motion, we start to let the organization go through trial and error; new practices and social norms will develop at this stage. It is vital to recognize the parties that are supportive of the

change and the ones that are resistant to change to address their concerns accordingly and get everyone on the same page.

Refreeze

At this stage of the change process, the organization has reached a "new norm" where its culture has adapted to all the changes. It is crucial to note that timing is critical at this stage; refreezing should not be initiated if some members are not on board yet or if the new procedures are still not "set in stone." This verification is a must, or changes will not stick, and the organization will revert to how it was (Manchester et al., 2014).

Reason for Selecting Lewin's Change Model

Since our goal is technological innovation, Lewin's model suited us perfectly as it has few steps, is straight to the point, and gives leeway to our innovation team in a tech environment that can be volatile.

Other Change Models

We have looked at other change models appropriate for our organization before deciding that Lewin's was the most suitable choice. One of the change models that stood out to us was John Kotter's change model. Kotter's model has eight steps (HBR, 2011):

1. Establishing a sense of urgency
2. Forming a powerful guiding coalition
3. Creating a vision
4. Communicating the vision
5. Empowering others to act on the vision
6. Planning for creating short short-term wins
7. Consolidating improvements and producing still more change
8. Institutionalizing new approaches

This model does have a lot to offer, especially being very direct and systematic. However, it has many steps; since technological innovation is very versatile, following all these steps rigidly removes freedom of creativity, innovation, and troubleshooting. In addition, knowledge management in a civil engineering company equates to managers relying on information from a specialized workforce (engineers) that might have far more knowledge about their respective fields. As a result, steps 6-8 become irrelevant.

EVALUATION

Upon embarking on the change journey in the organization, we will need to know that our methods are working. Hence, after the change has been introduced, we will conduct a monthly survey to see how employees feel about the difference and how the trial-and-error period is working. Kirkpatrick's four stages in the evaluation period help evaluate what, how, and when to accomplish the organization's change objective.

Reaction

The reaction is documented as how employees like the change facilitated by the organization. The measurement will be how employees like technological innovation integrated into their organization. It's always obtained after the change period, after the unfreezing stage.

Learning

Learning is less important than the other three steps because the nature of the change is at an organizational management level, not a learning program in the organization. But it is measured by observation simultaneously as the first step.

Behavior

Behavior is an excellent indicator of the change process from the employees' level. Employees know how to manage technological innovation and when to share their knowledge, and the behavior will be a direct measurement of knowledge management within the organization.

Result

The change process aims to have a knowledge management system of technological innovation within the organization. One objective will be to determine what percentage of the employees utilize knowledge management during their technology-related work. Another goal can be what knowledge is transferred using a knowledge management system. By measuring the results, the effectiveness of the change model can be calculated during the evaluation process.

RECOMMENDATIONS FOR FUTURE STUDY

Knowledge management is vital in every industry and helps organizations manage technological innovation. The findings from the three case studies provide detailed information on knowledge management theories and practices, as well as how to drive technological innovation to improve performance. Through creating, identifying, and sharing technological innovation knowledge, the organization can effectively maintain its competitive edges and ensure the delivery of its service.

The study is significant for developing countries' civil industries by providing a comparative case analysis. Future researchers can conduct an empirical study based on the findings from this research to investigate the best strategies and critical challenges when adopting knowledge management, performance management, and human resource management in the civil engineering corporate group. Qualitative research methods such as interviews or surveys can generate detailed discussion and application of management theories. Identifying the challenges and strategies can help the top management make decisions to improve performance and competitiveness. These are the angles waiting for researchers to investigate in the future.

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