Doctoral Thesis

Exploring Knowledge Process and Organizational Culture to Promote Individual Learning: An Empirical Study in Science Museum

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Doctoral Program in Technology Management

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Exploring Knowledge Process and Organizational Culture to Promote Individual Learning: An Empirical Study in Science Museums
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Abstract

Science museums play an important role in communicating science to the public. The purpose of the exhibitions in science museums is to convey scientific and technical knowledge to visitors. A defining characteristic of science museums in comparison to other types of museums is therefore the highly hands-on nature of exhibitions. Science museums' exhibitions are created through the process of staff learning. Knowledge management is integral in the learning process, and many science museums adopt this management tool in their organizations. However, failures in the practice of knowledge management in science museums can inhibit the learning of staff. This study thus asks whether learning in science museum staff can be enhanced by knowledge management and what other factors can enhance staff learning.

The aim of this study is to investigate the factors that can increase learning in science museum staff. To this end, the research questions are as follows: (1) Can knowledge process lead to learning in science museum staff? (2) Do science museum staff require both organizational culture and knowledge process to promote their individual learning? This research included three variables: knowledge process, organizational culture, and individual learning. First, the relation of knowledge process to individual learning was tested. Then knowledge process as a mediation variable in the relationship between organizational culture and individual learning was explored. This study in science museums can be claimed to be a pioneer empirical study, as no previous studies have been conducted in the context of science museums. In addition, previous empirical studies that have been conducted in other industries have not analyzed these three factors consecutively. Therefore, this study contributes to the subjects of knowledge management and organizational learning with analysis of these three variables.

The research sites are two science museums in Thailand and one science museum in Singapore. The research questions were answered through the utilization of mixed-method survey. First, the quantitative analysis was conducted as the major analysis. Data from questionnaire survey were analyzed by using Partial Least Square Structural Equation Model and the Hierarchical Component Model. Then the qualitative method was conducted to find reasons that could explain the relationships revealed by the quantitative analysis. The interviews' transcripts were extracted by the NVivo program by creating a coding frame with

keywords relating to the questionnaire's questions. Then mutual key points were identified in relation to the results from the quantitative analysis.

The results show the success factors that can enhance learning in science museum staff. Firstly, knowledge management, with all the knowledge process activities, can increase learning in science museum staff. Therefore, science museums that lack policy about knowledge management practice should pay attention to this management tool. Secondly, the analysis of the influence of the four knowledge process activities—knowledge acquisition, knowledge distribution, knowledge interpretation, and organizational memory—indicated that only organizational memory, which is the organizational knowledge storage, can enhance learning in science museum staff. This finding means that some knowledge process activities that are conducted in science museums are not effective. Therefore, it is important for science museums that practice knowledge management to evaluate the performance of their knowledge activities. In addition, science museums can improve the learning of their staff by using organizational memory as the major knowledge process activity. However, this study shows that science museums should aware of three issues relating to organizational memory: awareness of the depository, usage of the depository, and reliability of the technology that the depository employs. Furthermore, this research showed that a relationship exists between the three variables of knowledge process, organizational culture, and individual learning. Organizational culture is the overall culture including four culture types: adaptive culture, mission culture, bureaucratic culture, and clan culture. However, the clan culture—a culture that focuses on collaboration and close relationships among staff—is the only culture that influences knowledge process, which then influences individual learning. Therefore, science museums can improve their staff learning by arranging activities that encourage staff from different sections and from management to participate together in parallel with performing knowledge activities.

This study also contributes to the theories related to knowledge management and learning, as it has empirically supported the influence of knowledge management on staff learning in the science museum sector. Based on the science museums' philosophy of providing education to the public, this study raises a discussion about the success factors for staff learning in other types of museums or other knowledge-oriented non-profit or government organizations. In addition, the framework in this study could be a tool for the investigation of the learning resulted from knowledge management and organizational culture as the results have empirically showed the relationship between these three factors. Furthermore, this study revealed the importance of the analysis of single units of knowledge process and organizational culture. Such analysis can verify what should be the first priority concerns when the organizations want to improve their staff learning. Analyzing only overall knowledge process or overall organizational culture cannot reveal which factors to prioritize.

The limitations of this research are the small number of research sites, namely only three science museums that serve at the national level. In addition, all three are located in the Southeast Asia region. Therefore, the generalization of this study could be strengthened by including more science museums from other geographic locations. In addition, a comparative study between small-scale science museums and large-scale science museums could be conducted to identify the similarities or the differences in the success factors that lead to staff learning. Furthermore, as this study is a pioneer study within the museum sector, future study could be extended to other types of museums. Additionally, in terms of organizations aiming at knowledge provision, this study could also be conducted in other non-profit organizations or government organizations that have a similar aim.

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Table of Contents

Outputs from the Research

The contents of this thesis has been presented and sent for publications as following.

Presentations

- 日本 MOT 学会 2014 年度研究発表会, Tokyo, Japan, 14 March 2015.
- 11th International Conference on Knowledge Management 2015 (ICKM 2015), Osaka, Japan, 4-6 November 2015.
- 12th International Conference on Knowledge Management 2016 (ICKM 2016), Vienna, Austria, 10-11 October 2016.
- 17th International Conference on Knowledge, Culture and Change in Organizations, Darwin, Australia, 20-21 April 2017.

Proceedings

Thepthepa, N. and Mitsufuji, T. (2015). The Effective Practice of Learning Organization in Science Museum Contexts: The Impact of Organizational Culture. Proceedings of the 11th International Conference on Knowledge Management, pp. 434-439, 4-6 November 2015, Osaka, Japan.

Journal Articles

Thepthepa, N., and Mitsufuji, T. (2016). Knowledge Process and Learning Organization Development in Science Museums, *Procedia Computer Science*, 99, 157-170.

Thepthepa, N., and Mitsufuji, T. (2017). Knowledge Process and Individual Learning in the Organizational Culture of Science Museums, *Knowledge Management: An International Journal*, 17(2), 11-37.

List of Abbreviations

AC – Adaptive Culture

ASPAC – Asia-Pacific Network of Science & Technology

ASTC – Association of Science-Technology Centers

AVE – Average Variance Extracted

BC – Bureaucratic Culture

CC – Clan Culture

CR – Composite Reliability

CL - Continuous Learning Opportunities

DLOQ – Dimensions of Learning Organization Questionnaire

HCMs – Hierarchical Component Models

HOC – Higher-Order Construct

ICOM – International Council of Museums

IL – Individual Learning

KP – Knowledge Process

KA – Knowledge Acquisition

KD – Knowledge Dissemination

KI – Knowledge Interpretation

LOCs – Lower-Order Constructs

MC – Mission Culture

MMF – Museum Maturity Framework

NSM (TH) – National Science Museum, Thailand

OC – Organizational Culture

OM – Organizational Memory

PI – Promotion of Inquiries and Dialogue

PLS – Partial Least Square

RQ – Research Question

SCE (TH) – Science Centre for Education, Thailand

SCS (SG) – Science Centre Singapore

SEM – Structural Equation Modelling

VIF – Variance Inflation Factor

TOL – Tolerance

UNESCO – The United Nations Educational, Scientific and Cultural Organization

List of Figures

Chapter 1

Chapter 2

Chapter 3

Chapter 4

Chapter 5

List of Tables

Chapter 4

Chapter 6

Chapter 1

Introduction

This chapter presents the importance of conducting this research about the knowledge process and organizational culture in science museums. The chapter also presents the motivation and research gap of this research. The details about the research aim and research questions are provided as well. Lastly, the structure of this thesis is outlined.

1.1 The Importance of Knowledge Management and Learning for Science Museum Staff

Science museums [1] are institutions that facilitate the interpretation and presentation of knowledge of science and technology to the public. Development of positive attitudes toward science is one of the primary objectives of science museums around the world (Kaushik, 1997). Science museums play a key role in communicating science to the public and complementing formal education by presenting science through different interventions (Science and Society, 2017). Science museums are "privileged mediators between science and the public, . . . as a narrative of scientific culture, [science museums] make copies and reproductions of experiments or experiences that have changed the perception of nature and understanding of the world" (Cavalcanti and Persechini, 2011, p. 3).

According to the Mechelen Declaration (Science Centre World Summit, 2014), science museums should be reliable facilities for the public to learn about new technological solutions and sustainable technologies (Davis, 2004). Visits to a science museum can change the perception of science as an incomprehensible subject to a perception of science as a familiar, understandable subject (Cavalcanti and Persechini, 2011; Oppenheimer, 1986). Understanding and awareness of science provide the foundation for science and technology development (Oppenheimer, 1986). The products of science and technology are vital to human life, and they are invented by the development of science and technology. Therefore, the work of science museums is important for human beings.

The Association of Science-Technology Centers (ASTC) (2013) reports that more than 600 members of the ASTC are operating or establishing science museums in 46 countries as

[1] In this thesis, the term *science museum* refers to science museums and science centers.

shown in Figure 1-1. Science museums around the world attract more than 67 million visitors annually (ASTC, 2014). Table 1-1 shows the numbers for science museum attendance. These figures indicate the important role of science museums in communicating knowledge of science and technology to the public around the world.

Figure 1-1: Locations of Association of Science-Technology Centers Science Museum Members

Source: ASTC (2013)

Table 1-1: Global Science Museum Attendance

Year	Attendance		
	On-Site	Off-site	Total
2012	69,769,287	13,990,107	83,759,394
2013	76,606,897	15,006,828	91,613,725
2014	60,020,216	7,641,437	67,661,653
2015	69,265,599	6,800,201	76,065,800

Source: ASTC (2013, 2014, 2015)

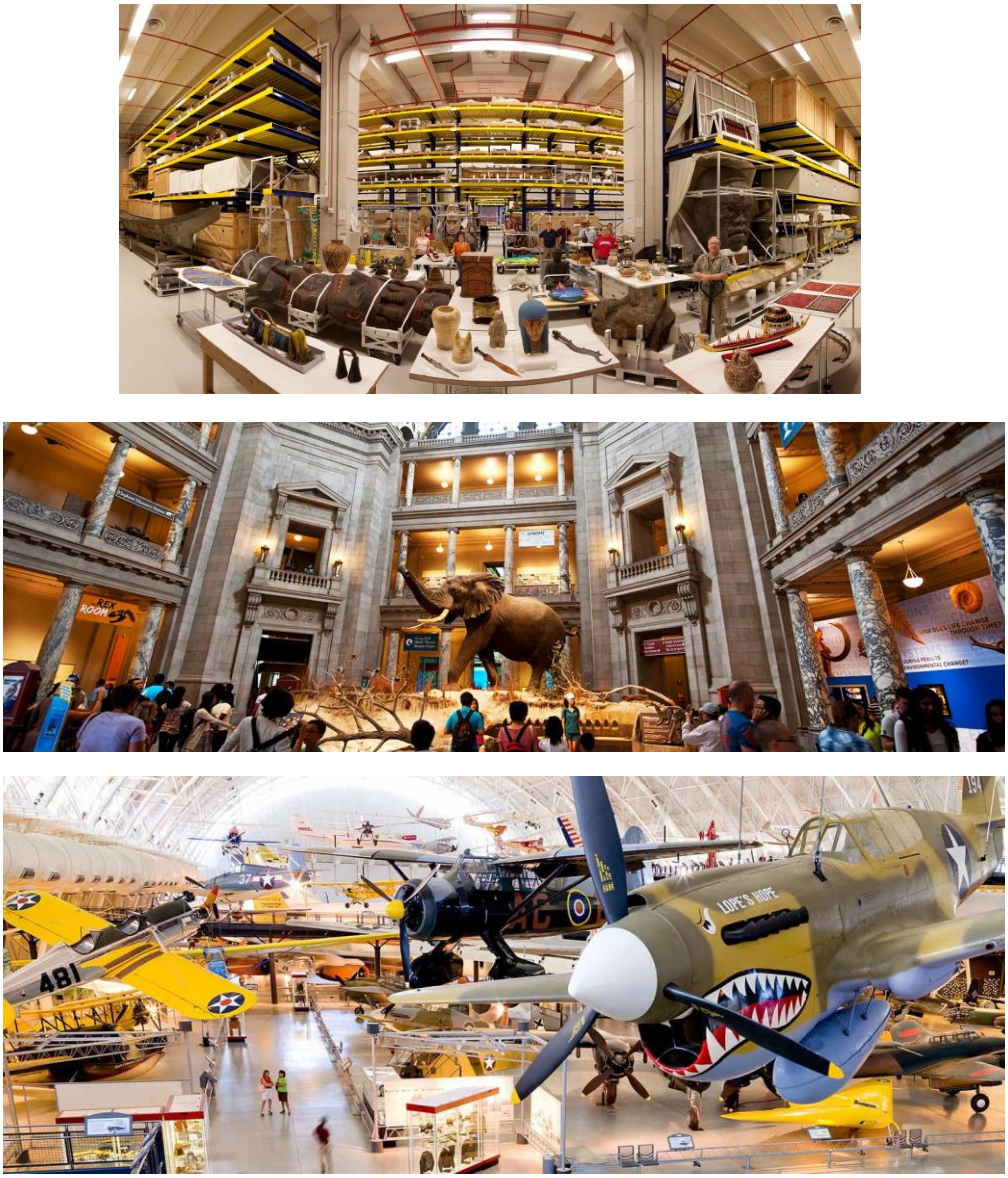
Kaushik (1997) identifies three building blocks for developing attitudes in science museums: (1) the museum (i.e. the container), (2) the exhibits (i.e. the content), and (3) the visitors (i.e. the users). Exhibits are thus important media for science presentation. The general purpose of exhibits in science museums is to convey scientific and technical knowledge to visitors. Science museums contain many hands-on, interactive exhibits to create new attitudes toward science. The comprehensive use of hands-on exhibits distinguishes science museums from other types of museums.

The exhibitions in science museums are developed based on their staff interpretation of scientific content. Staff must identify, utilize, and process their knowledge about science and technology to form an understandable and enjoyable story for visitors. Therefore, knowledge management is an area of organizational management that is very important for exhibition development. Knowledge management is the management of the identification and exploitation of knowledge (Gupta et al., 2000). Knowledge management supports learning in staff and individual learning. Learning in staff is the process of staff gaining the capability to utilize knowledge; after learning, staff have received new knowledge and can change their behavior while forming the new knowledge (Bennet and Bennet, 2003). In the process of exhibition development, the team of staff includes different kinds of expertise like clients, content specialists, designers, content interpreters, and project managers (Smithsonian, 2002). Input from each specialty is required, as well as consensus among those specialties, during exhibition making. Knowledge management during exhibition development requires that each team member be able to identify what knowledge should be contained in the exhibition content and to interpret that knowledge in order to create understanding in visitors. During exhibition development, staff utilize their knowledge and discuss the knowledge together. They can thereby determine what new knowledge is suitable for the exhibition. In parallel, as staff develop new knowledge, they also transform from subject-specific experts to exhibition makers. Without this transformation, which indicates a consensus in behavior, exhibition development cannot succeed.

1.1.1 Knowledge Management within the Best Practice Science Museums

The importance of knowledge management in science museums can be seen through different best practice science museums at the international level. One example is the Smithsonian Institution (Figure 1-2), which is the largest museum and research center complex in the world. This organization is comprised of 19 museums and 8 research centers. The Smithsonian Institution receives over 30 million visitors per year. This institution achieves this success partly through the attention paid to knowledge management. The Human Capital Strategic Plan Fiscal Year 2011-2016 describes strategic knowledge management as "systematically provide resources, programs, and tools for knowledge-sharing across the organization in support of its mission accomplishment" (Smithsonian Human Capital Strategic Plan Fiscal Year 2011-2016, p. 37).

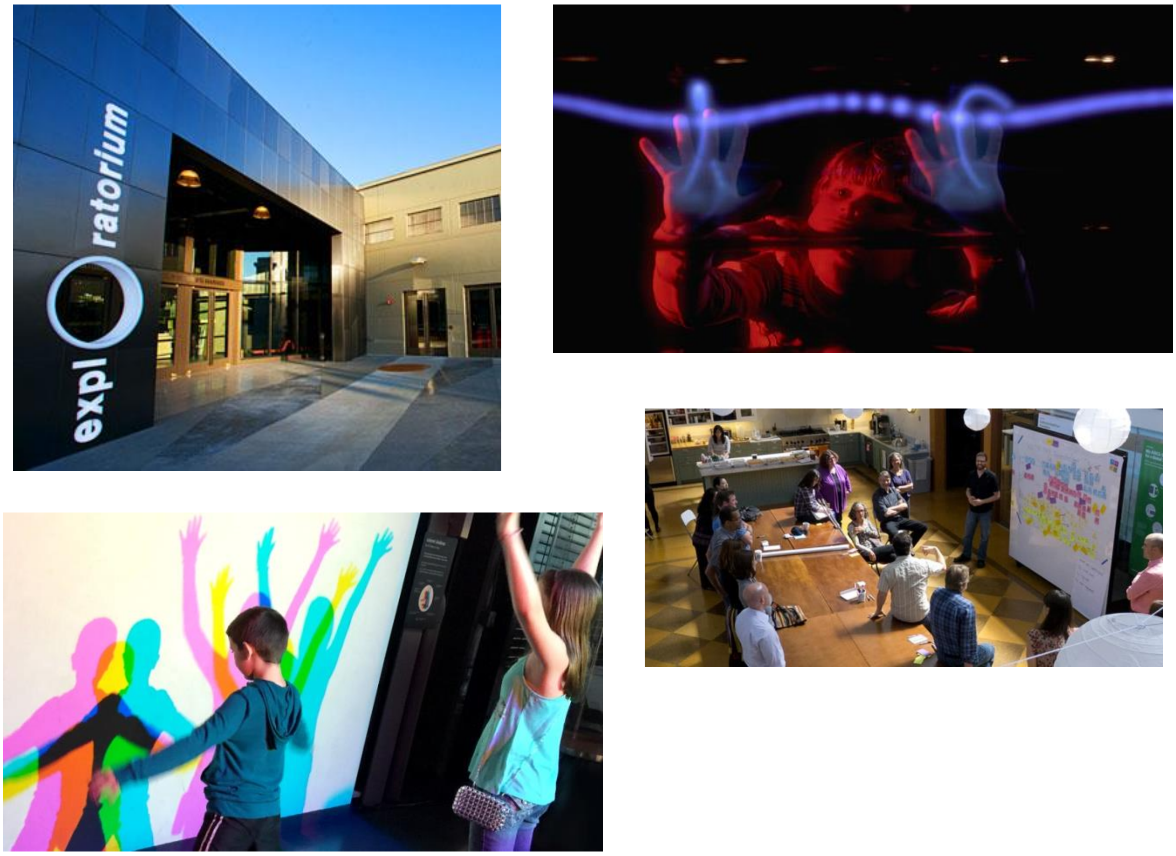
Figure 1-2: Photos of Museums of Smithsonian Institutions



Source: http://naturalhistory.si.edu/onehundredyears/profiles/Chip_Clark.html
http://www.fxva.com/smithsonian-udvar-hazy/
https://washington.org/smithsonian-institution-museums

Another example is the Exploratorium (Figure 1-3), which is among the most well-known and effective nonprofit organizations in America. Exhibits, education programs or ideas produced by the Exploratorium have been used by many science museums around the world. The Exploratorium is constantly developing new exhibits. Ideas for exhibits come from different sources such as artists, scientists, research articles, or videos, and experts from many different fields are included in exhibit development. Prototypes of exhibits are built before the permanent exhibits so that the prototypes can be evaluated for further improvement. Details of exhibits are stored on the institution's website, where everyone, including external users, can search the knowledge and develop their own exhibits. The Exploratorium thus demonstrates the importance of knowledge management from identification of knowledge to storage of knowledge (www.exploratorium.edu).

Figure 1-3: Exploratorium



Source:
http://content.time.com/time/travel/cityguide/article/0,31489,1845230_1845056_1845036,00.html
http://adaptivepath.org/ideas/exploratorium-mapping-the-experience-of-experiments/

An additional example of excellent knowledge management is the London Science Museum (Figure 1-4). In the year 2011 to 2012, this science museum received 2.95 million visitors. Exhibitions and education programs are one of its core priorities, and so new ones are constantly being produced. In addition, audience research is conducted intensively in order to gain knowledge that informs how to build and improve the exhibitions (Science Museum Group Annual Report and Accounts 2016-2017).

Figure 1-4: London Science Museum

Source: http://www.dailymail.co.uk/news/article-3692954/Science-Museum-brings-charges-Fury-families-told-pay-22-50-visit-one-exhibitions.html
http://www.wearemuseums.com/making-science-a-wonder-for-kids-at-the-london-science-museum/
https://www.heatheronhertravels.com/

1.1.2 Importance of Knowledge Management for Other Types of Museum

Science museums constitute one type of museums. According to the classification of museums by UNESCO, other museum types are (1) art, archaeology, and history museums; (2) science and technology museums; (3) ethnology museums; and (4) museums that do not fit into any classification (UNESCO, 1968 in European Group on Museum Statistics, 2004). All types of museum serve society by acquiring, conserving, researching, communicating, and exhibiting the heritage of humanity. In addition, all museums aim to achieve education and enjoyment for audiences. The International Council of Museums' (ICOM) Code of Ethics emphasizes museums' educational role and interactions with the public:

> Museums have an important duty to develop their educational role and attract wider audiences from the community, locality or group they serve. Interaction with the constituent community and promotion of their heritage is an integral part of the educational role of museums. (ICOM Code of Ethics, 2017, p. 24).

All museums thus also share the same philosophy, which aims educating and interacting with audiences in different topics. Knowledge management, which enhances staff learning, is thus important not only for science museums but also for other kinds of museums.

1.2 Research Motivation

The researcher's professional experience at the National Science Museum, Thailand (NSM) since 1996 developed the initial motivation to conduct this research. By serving in different positions at the NSM, the researcher came to appreciate the importance of possessing effective knowledge management and promoting staff learning. At the NSM, knowledge management is counted as an important feature of management because it helps to produce exhibitions and education programs. Since 2005, one of the annual performance evaluation criteria has been the practice of knowledge management. However, the evaluation results show that knowledge management activities at the NSM score only moderately well (NSM, 2016). Discussions with the management teams of another science museum in Thailand that also practice knowledge management revealed the same problem. However, no empirical studies had been done on this issue. This ineffective practice of knowledge management deepened the researcher's interest in promoting learning among science museum staff. In addition, the researcher was curious whether management factors other than knowledge management should be taken into account for the science museum context.

Science museums' importance in terms of providing education to visitors through exhibitions or education programs is evident. However, most existing studies have focused on visitor behavior (Semper, 1990). Studies that explore staff learning and factors that can promote staff learning are rare. This situation demonstrated to the researcher a gap concerning what are the factors that could promote staff learning in science museums.

1.3 Problem Statement

Few studies have examined organizational management in the science museum context (Tlili, 2008). Even fewer studies have examined the promotion of science museum staff learning. Therefore, this research adopts the study frameworks that have been developed for different organizations.

Given the importance of research on knowledge management that influences learning, the research investigated different theories and studies to identify research gaps. Previous frameworks concerning organizational learning often fail to address practical implications (Garvin, 1993; Easterby, 1997) and require identification of activities that leads to learning with the proposal of knowledge management. In addition, few studies have focused on individual learning, which is also important learning and related to organizational learning.

Senge (1990) describes a learning organization as an organization that incorporates past experiences into a continuous learning and improvement process, leading to sustainable development. However, Firestone and McElroy (2004) argue that a learning organization should be viewed through its environmental aspects, and organizational learning is hence the process in which individuals, teams, and organizations grow in knowledge together and through assimilation of member experiences (Allard, 2003). The organizational learning process thereby leads to development of a learning organization (Song et al., 2011). In addition, Nonaka and Takeuchi (1995) contend that Senge (1990) does not address knowledge management, which is important to organizational learning. Garvin et al. (2008) propose that the building blocks of a learning organization include a knowledge process[2] that consists of activities that lead to organizational learning.

Therefore, the present study explores whether the frameworks proposed about knowledge process can lead to learning in science museum staff or not. In addition, the study examines whether knowledge process that lead to learning in science museum staff are different from those of other organizations.

The researcher also found that there is an interrelationship among organizational culture, knowledge process, and individual learning, yet a lack of empirical investigation into the relationships among these three factors.

[2] A knowledge process is comprised of knowledge management activities including creating, organizing, sharing, and using knowledge (Aggestam, 2006; Chang and Lin, 2015).

Argote and Miron-Spektor (2011) propose a framework that demonstrates that both knowledge management and organizational culture influence organizational learning. In empirical studies, Karkoulian et al. (2013) and Chawla and Joshi (2011) examine the promotion of organizational learning through knowledge process, but they exclude organizational culture. Lopez et al. (2004) demonstrate the effects of a collaborative culture on the organizational learning process, and Aksu and Ozdemir (2005) explore how a supportive culture promotes individual learning, albeit while excluding knowledge management. Lai and Lee (2007) study three types of organizational cultures (i.e. entrepreneurial, task-goal accomplishment, and smoothly running cultures) and those cultures' influence on knowledge activities.

This research, therefore, explores these three components in conjunction with each other in order to fill this research gap.

1.4 Research Aim

This research is aimed at finding factors that promote individual learning in science museum staff. The two main objectives of the study are as follows.

1. To investigate how knowledge process can improve the individual learning in science museum staff

2. To determine whether both organizational culture and knowledge process are required for promoting of learning in science museum staff

1.5 Research Questions

The broad purpose of this research is to obtain practical ways to improve individual learning in science museums. This purpose gives rise to the following research questions.

RQ 1: Can knowledge process lead to individual learning in science museum staff?

RQ 2: Do science museum staff require both organizational culture and knowledge process to promote their individual learning?

1.6 Structure of the Thesis

Figure 1-6 illustrates the structure of this thesis.

Chapter 1 presents the research background, motivation, aim, and questions.

Chapter 2 discusses theories and empirical studies related to the research framework. In addition, the science museum context and the relevance of knowledge management are explained.

Chapter 3 details the research design and methodology and describes the research sites, data collection tools, and research survey.

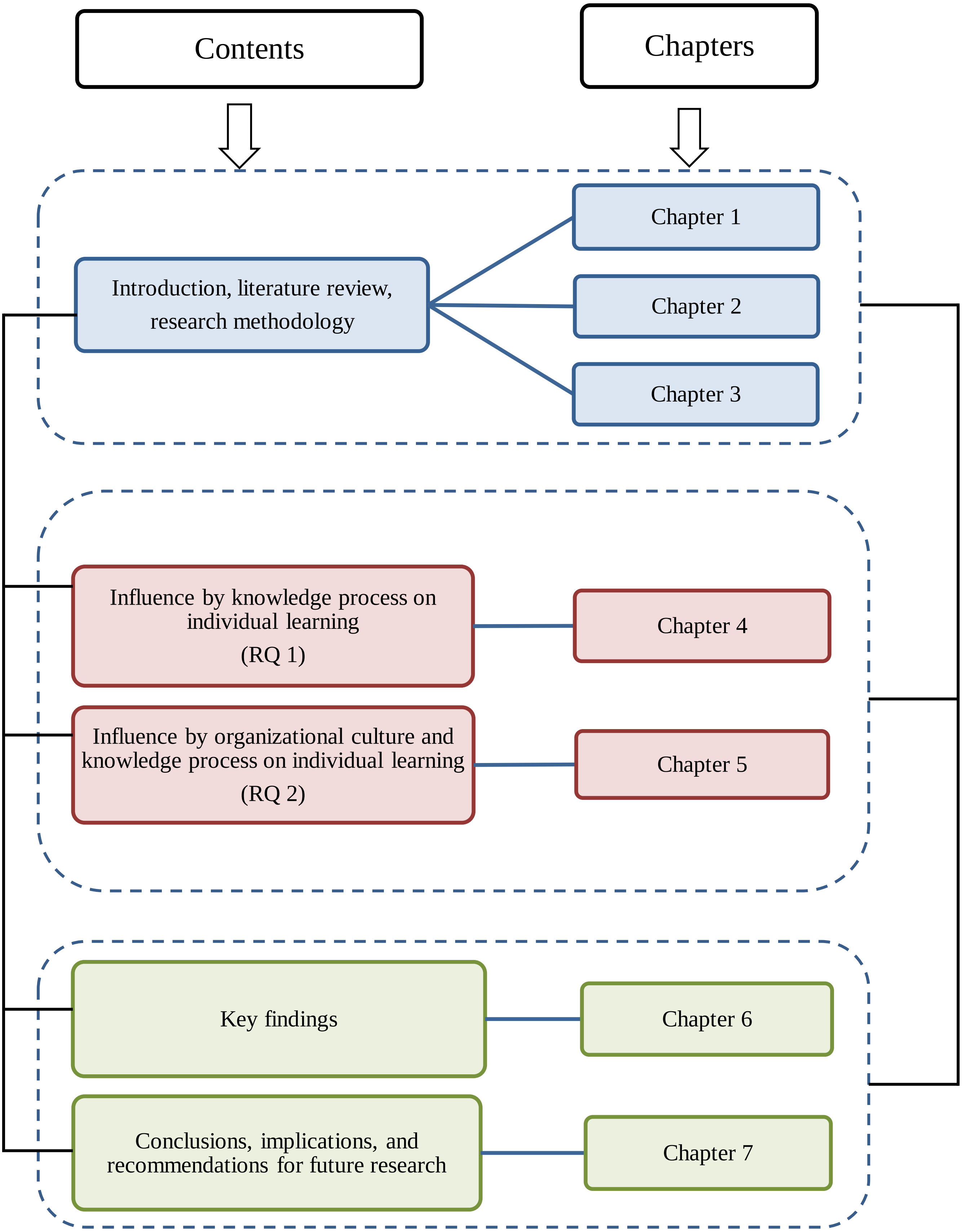
Chapter 4 presents and discusses the survey results on the influence of knowledge process on individual learning in science museum staff.

Chapter 5 discusses the survey results on the influence of organizational culture and knowledge process on individual learning.

Chapter 6 draws together the results in Chapters 4 and 5 to answer the research questions.

Chapter 7 presents the conclusions from this research and proposes theoretical and practical contributions and recommendations for future research.

Figure 1-5: Structure of the Thesis



Chapter 2

Literature Review

The aim of this research is to identify the factors that promote learning in staff of science museums. Accordingly, this chapter overviews the variables of individual learning, organizational culture, and knowledge process. In addition, measurements for each variable are explored for conducting data collection and data analysis. The research gaps relating to the research questions are outlined in detail, which leads to the establishment of the research framework and research hypotheses.

2.1 The Interrelation between Organizational Learning and Individual Learning

Learning within an organization has received much attention. The framework proposed by Senge (1990) has been widely accepted and practiced in different organizations worldwide (Jamali and Sidani, 2008; Sharifad, 2011). This framework lays out the characteristics that transform an organization into a learning organization by identifying the theory named “Fifth Discipline”. The five characteristics that should be developed to become a learning organization (Senge, 1990) are as follows:

1) System Thinking – To have an understanding of the whole pattern and the ability to conduct change systematically and effectively.

2) Personal Mastery – To expand individual capacity to create the most desirable realities. To generate a supportive environment for individual development to help individuals reach their goals and purposes.

3) Mental Models – To bring out our internal understandings of the world and improve upon those understandings and learn how they affect our behavior.

4) Building Shared Vision – To engage individuals by including their visions into a shared vision and to inspire individual commitment to the practice.

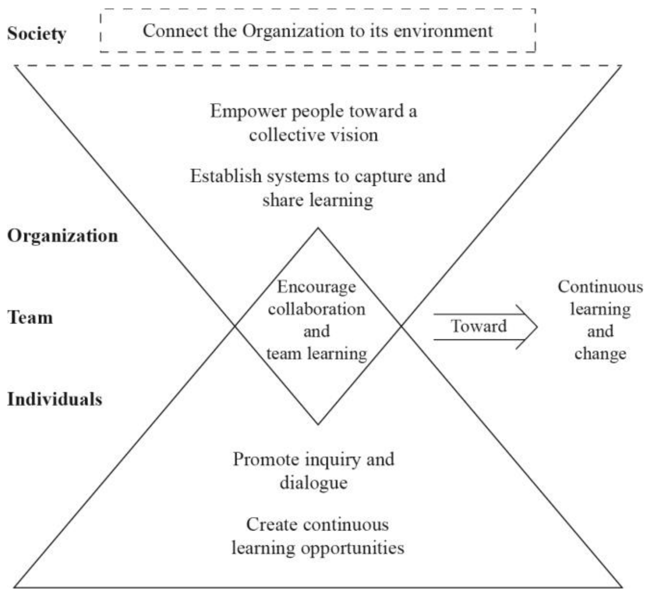
5) Team Learning – To create dialogue and interaction among individuals in teams and thereby the team learning that leads to organizational learning.

Mahler (1997) proposed that learning organizations flexibly alter procedures and routines to achieve their objectives. Even set goals can be changed in order to deliver better outcomes for the organization.

Learning organizations are viewed as organizations with specific characteristics. In contrast, organizational learning is simply the process that develops learning in an organization. Garvin et al. (2008) explain that to become a learning organization, an organization requires a concrete learning process and practices. Aggestam (2006) suggests that organizational learning is a process that moves organizations toward becoming learning organizations. Organizational learning includes processes in which individuals, teams, and the organization itself grow in knowledge together (Firestone and McElroy, 2004) through an assimilation of member experiences (Allard, 2003). In addition, organizational learning is the unlearning of old habits to develop new skills and knowledge (Yeo, 2007).

Watkins and Marsick (1993) propose a process for learning that includes six actions: (1) create continuous learning opportunities, (2) promote inquiry and dialogue, (3) encourage collaboration and team learning, (4) establish systems to capture and share learning, (5) empower people toward a collective vision, and (6) connect the organization to its environment. Their framework is illustrated in Figure 2-1, and the details of each action are provided in Table 2-1.

Figure 2-1: Model of Six Actions for Organizational Learning



Source: Watkins and Marsick (1993, p. 10)

Table 2-1: Details of Six Actions for Organizational Learning

Dimension	Definition
(1) Create continuous learning opportunities	Learning is integrated into work so that people can learn on the job; opportunities are provided for ongoing education and growth.
(2) Promote inquiry and dialogue	People gain productive reasoning skills to express their views and the capacity to listen and inquire into the views of others; the culture is changed to support questioning, feedback, and experimentation.
(3) Encourage collaboration and team learning	Work is designed to use groups to access different modes of thinking; groups are expected to learn together and work together; collaboration is valued by the culture and rewarded.
(4) Establish systems to capture and share learning	Both high- and low-technology systems to share learning are created and integrated with work; access is provided; systems are maintained.
(5) Empower people toward a collective vision	People are involved in setting, owning, and implementing a joint vision; responsibility is distributed close to decision making so that people are motivated to learn toward what they are held accountable to do.
(6) Connect the organization to its environment	People are helped to see the effect of their work on the entire enterprise; people scan the environment and use information to adjust work practices; the organization is linked to its communities.

Source: Marsick and Watkins (2003)

Details about organizational learning demonstrate that learning in organizations occurs at different levels (Watkins and Marsick, 1993). Nevertheless, many scholars agree that individual learning represents the most important level. Organizational learning cannot occur without individual learning (Argylis and Schon, 1996), and most organizational learning occurs at the individual level (Ngah et al., 2016). By itself, an organization cannot learn. Organizational learning is the accumulation of individual learning to respond to change and achieve organization survival. Individuals acquire knowledge, process it, and integrate it into their knowledge and abilities. When they interact with other members, that knowledge is transferred to the group level, and only then is it embedded into the knowledge stock at the organizational level (Bennet and Bennet, 2003). Organizations can learn because of individuals; when individuals learn, that does not necessarily mean that organizations learn, but organizational learning could not occur without individual learning (Senge, 1990).

Marsick and Watkins (2003) developed the Dimensions of the Learning Organization Questionnaire (DLOQ) based on their framework about actions for organizational learning. This questionnaire has been tested in several organizations. For example, Jamali et al. (2009) used DLOQ to survey learning organizations in Lebanon. For individual learning, they propose two dimensions for measurement: (1) creation of continuous learning, or the provision of opportunities to learn and grow, and (2) promotion of inquiries and dialogues, or the support for questioning, feedback, and experimentation.

2.2 From Knowledge Management to Knowledge Process

Knowledge is important for driving business. In the resource-based view, intangible resources like knowledge create competitive advantage, allowing firms to survive and compete in the changing business environment. Organizations' specific knowledge generates distinct products and allows organizations to differentiate themselves from others (Tuener and Pennington III, 2015; Coulter, 2010; Osterloh and Frost, 2002).

Davenport and Prusak (2000) define knowledge as follows:

> Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices, and norms. (p. 5)

Knowledge management is a set of activities that drives knowledge circulation into and within the firm (Birkinshaw, 2001); that circulation of knowledge assists in identifying and utilizing knowledge for the benefit of the organization (Corfield and Paton, 2016; Gupta et al., 2000). The goals of knowledge management are (1) to develop knowledge repositories, (2) to build up access to knowledge, and (3) to enhance a knowledge culture and environment (Davenport and Prusak, 2000). The knowledge process comprises of activities that propel knowledge management (Ngah et al., 2016). The process of knowledge management allows staff to easily access and utilize knowledge (Lai and Lee, 2007) to create new products or identify better methods of working.

Different studies have explored knowledge process by identifying key knowledge activities. Griffiths and Morse (2009) explore knowledge management contexts in different studies and propose that knowledge management has four functions and twelve enablers. The four functions are using, interacting, storing and gathering, and creating knowledge. In addition, Huber (1991) elaborated four constructs associated with organizational learning: knowledge acquisition, information distribution, information interpretation, and organizational memory. Furthermore, Ngah et al. (2016) explored the effect of knowledge management capabilities on organizational performance through activities for the acquisition, conversion, application, and storage of knowledge. O’Brien (2015) observed that the knowledge life cycle consists of the capability to create, acquire, share, and reuse knowledge. As different studies have shown, observations of knowledge activities are based on achieving or creating knowledge, sharing knowledge, interpreting knowledge, and storing knowledge.

The following sub-sections therefore evaluate these four main dimensions of knowledge process.

2.2.1 Knowledge Acquisition

Acquiring knowledge supports continual retention of education (Richard and Duxbury, 2014) because it develops new awareness or adjusts existing knowledge (Chang and Lin, 2015). Knowledge acquisition entails information that should be collected, knowledge sources that should be accessed, methods to obtain knowledge, and introducing persons responsible for helping with acquisition (Garvin, 2000). Knowledge acquisition is significant because it is the ability of organizations to select knowledge that fits their needs, to incorporate that knowledge into new ideas, and to utilize it to benefit the organization (Cohen and Leventhal, 1990; Nagano et al., 2014; Tidd and Bessant, 2013). In this regard, having a stock of organization knowledge is important in order to find knowledge for utilization (Roper et al., 2008). Kim (2004) suggests that a prior knowledge base and efforts put into managing that knowledge are important to finding new knowledge. Therefore, knowledge from both internal and external sources is important (Roper et al., 2008; Hansen and Birkinshaw, 2007). Garvin (1993) suggests that first an organization should identify knowledge that is needed. Nevis et al. (1995) propose that two main activities are related to knowledge acquisition: (1) identify goals for achieving knowledge and (2) identify knowledge sources. Therefore, knowledge acquisition is about accumulating knowledge by acquiring, seeking, creating, capturing, and collaborating through experience, observing others, or learning from past mistakes (Huber, 1991; Aksu and Ozdemir, 2005; Chang and Lin, 2015; Ngah et al., 2016).

2.2.2 Knowledge Distribution

Distribution of knowledge includes activities that spread knowledge to others or make knowledge available to others throughout the organization (Nevis et al., 1995). This process creates a culture of learning that can continually create and support new knowledge (Nonaka and Takeuchi, 1995). This activity refers to translating individual knowledge to common knowledge for organizational members (Aksu and Ozdemir, 2005; Huber, 1991) and the knowledge flowing from one part of the organization to other parts where it is needed and can be applied (Lai and Lee, 2007).

Knowledge can have a high impact when it is shared widely in organizations (Garvin, 1993) through systematic and clearly defined ways (Garvin et al., 2008). Garvin (1993) suggests implementing activities that give active experience, incentivize evaluation of shared knowledge, and reward knowledge sharing. Nevis et al. (1995) suggest that these activities include documentation of knowledge; a variety of informal or formal activities for distribution; activities for discussion about problems, errors, or conflict; and solutions and training that support continued development of member knowledge.

2.2.3 Knowledge Interpretation

Interpreting knowledge involves integration of knowledge where it is available institutionally, applying that knowledge across diverse situations (Nevis et al., 1995; Huajing and Chi, 2015), and bringing the knowledge to practical use (Chang and Lin, 2015; Martelo-Landroguez and Cegarra-Navarro, 2014). Interpreting knowledge thus involves refining individual knowledge by comparing and developing it into new knowledge that can improve efficiency and effectiveness (Aksu and Ozdemir, 2005) through the actual use of knowledge (Ngah et al., 2016). Nevis et al. (1995) suggest that an organization should have a goal to utilize knowledge or identify which function needs such knowledge. Utilization should provide options proposed by different members for variety. Garvin et al. (2008) suggest the importance of reviewing after utilization and integrating the development of new knowledge into the knowledge process.

2.2.4 Organizational Memory

Organizational memory refers to storing of knowledge (Griffiths and Morse, 2009) for easy distribution and future use in an organization (Griffiths and Morse, 2009; Chang and Lin, 2015; Ngah et al., 2016). It is the process of identifying, codifying, and storing both tacit knowledge and explicit knowledge in a usable and accessible form (Alajmi et al., 2015; Palanisamy, 2007). Organizational memory prevents information loss and tells staff where certain knowledge is kept, even if the knowledge is possessed by other members. An effective organizational memory improves learning (Huber, 1991). The different ways to store knowledge include human and technological memory as well as internal and external sources (Griffiths and Morse, 2009). Ngah et al. (2016) describe organizational memory as a series of knowledge collections for organizational use. Knowledge can be preserved in an organization in physical locations, working procedures, individuals, and culture (Aksu and Ozdemir, 2005). Lai and Lee (2007) suggest the articulation of tacit knowledge via formats such as formulas, manuals, or documents that are comprehensible and accessible to others. Organizations must arrange and structure knowledge, thereby making it easier to access and distribute within the organization (Chang and Lin, 2015). Alavi and Leidner (2001) suggest that organizational memory can have both positive and negative effects on knowledge activities. On the one hand, organizational memory can help to store previous successful practices, ensuring that those practices are reapplied in new situations; on the other hand, it can impede new ideas if staff are satisfied with a stable situation.

The effectiveness of organizational memory depends on (1) involvement by members, (2) distribution and interpretation of information, (3) standards and methods for storing information, and (4) means to locate and retrieve stored information (Huber, 1991). In addition, technologies can facilitate the establishment of organizational repositories. The use of information systems can support the accuracy, feedback, and review of knowledge (Bennet and Bennet, 2003).

2.3 Organizational Culture

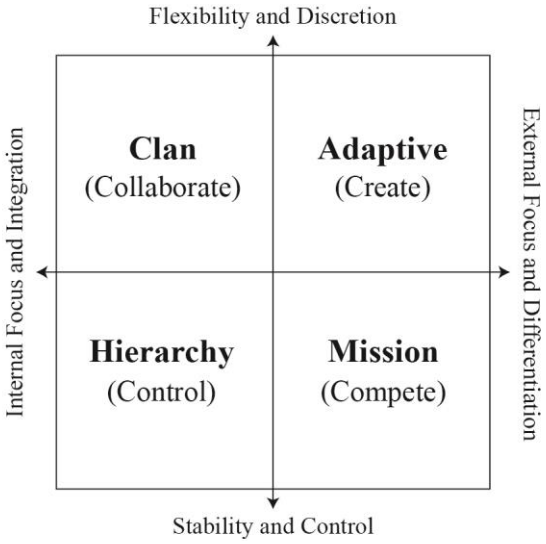
An organizational culture is comprised of the ideas that members have regarding the meaning of their organization and what they work for (Mahler, 1997). In addition, organizational culture embodies the deeply held, shared beliefs of an organization and influences the organization's ability to learn, share information, and make decisions (Schein, 2010). It is reflected in values, norms, and practices. At the deepest level, culture consists of values that are embedded implicitly in an organization's goals (De Long and Fahey, 2000). Therefore, organizational culture differentiates members of one group from other (Hofstede et al., 2010).

Organizational culture is established at the start of an organization, but it can be altered over time (Prugsamatz, 2010). Organizational culture can be changed by process changes, i.e. new work procedures, control changes, increases in staff independence, and reforms in communication procedures (Hofstede et al., 2010).

Cameron and Quinn (2011) identify the types of organizational cultures by using the criteria that determine whether or not an organizational is effective which is also the results occurred when there is organizational learning. By combining two dimensions, namely internal/external focus and stable/flexible structure, Cameron and Quinn (2011) identify four types of organizational culture: 1) *clan culture,* which views collaboration among the organization members and teamwork as critical; 2) *adhocracy culture,* which emphasizes the building of a creative workplace and retaining a leadership position in terms of new knowledge, products, and services; 3) *hierarchy culture,* which focuses on the stability of the organization and maintains a formalized structure and working procedure; and 4) *market culture,* which is competitive, result oriented, and focused on market share as a measure of success.

Cameron and Quinn's (2011) typology has been used by different studies concerning organizational learning and knowledge management. Arditi et al. (2017) adopt the typology to identify the effect of organizational culture on delays in construction companies. In addition, Fong and Kwok (2009) utilize these four organizational cultures in their study on organizational culture and knowledge management success in contracting firms. In other studies, the names of the typologies have been adjusted—i.e. to clan, adaptive, bureaucratic, and mission cultures, respectively (Figure 2-2)— in order to resemble the organizational context of the studied sites (Cavaliere and Lombardi, 2015; Chang and Lee, 2007).

Figure 2-2: Identification of Organizational Culture Types



Source: Adapted from Cameron and Quinn (2011)

2.4 Research Hypotheses

This study proposes two research questions. The first research question gives establishing a broad scope in examining whether knowledge process can enhance individual learning in science museum staff or not. The second question narrows the research scope by focusing on the influence of knowledge process on the relationship between organizational culture and individual learning. Then, based on the research framework, different studies are investigated to establish hypotheses for the study as follows.

2.4.1 Hypothesis for RQ 1: Can Knowledge Process Lead to Individual Learning in Science Museum Staff?

Knowledge process is relevant to individual learning (Nonaka and Takeuchi, 1995; Bennet and Bennet, 2003; Aggestam, 2006). Therefore, this study on science museums makes the following proposition:

P1: Individual learning in science museum staff can be increased by knowledge process.

Fiol and Lyles (1985) review different frameworks that have been proposed for promoting organizational learning. The authors propose that organizational learning should include not only behavior change but also knowledge change. As individuals utilize knowledge, they exhibit changes in their own behavior and knowledge. Then individuals exchange knowledge with others and achieve better knowledge, which in turn further improves the actions within the organization and becomes organizational learning. Vera and Crossan (2003) propose that organizational learning requires the co-alignment of learning strategy and knowledge strategy. In addition, Bennet and Bennet (2003) point out that knowledge management and organizational learning intersect and that individual learning is an important part of this intersection. Further, they highlight that knowledge management activities can accelerate learning at both the individual and organizational levels.

The SECI model proposed by Nonaka and Takeuchi (1995) shows the evolution of knowledge that leads to organizational learning and individual learning. Four modes of knowledge conversion constitute a continuous cycle of socialization, externalization, combination, and internalization, which can create new knowledge. This creation of new knowledge, then, advances individual knowledge. This individual knowledge then spreads to the group level, followed by the organizational level (Nonaka and Takeuchi, 1995). When knowledge can move laterally and vertically through sharing within an organization, organizational learning can occur (Garvin, 2000). In addition, knowledge management through knowledge sharing and knowledge integration can connect individual learning to organizational learning (Aggestam, 2006).

Several empirical studies have examined the influence of knowledge management on learning. In the retail industry in Lebanon, Karkoulian et al. (2013) report that organizational learning depends on the knowledge process, which in turn can enhance organizational learning. Moreover, according to a study on the Roads and Transport Authority of Dubai, to build an effective platform for learning, organizations need to develop a knowledge process (Ngah et al., 2016). Chawla and Joshi (2011) investigate the influence of knowledge management on organizational learning in IT, IT-enabled services, and power generation and distribution companies in India. Their study finds that most knowledge management dimensions influence organizational learning regardless of organizational types. Previous studies have indicated that knowledge process can enhance organizational learning. In addition, as individual learning is relevant to organizational learning, knowledge process should also influence individual learning.

Consequently, the hypothesis regarding the relationship between knowledge process and individual learning was as follows:

H1: Knowledge process influences individual learning in science museum staff.

2.4.2 Hypothesis for RQ 2: Do Science Museum Staff Require both Organizational Culture and Knowledge Process to Promote Individual Learning?

The framework proposed for analyzing organizational learning contends that both organizational culture and knowledge process should be considered systematically to have effective transformation of experience and knowledge in individuals and thereby to achieve organizational learning. This study thus makes the following proposition:

P2: Learning in science museum staff requires both an organizational culture that supports learning and a knowledge process.

Nevis et al. (2001) propose that organizational culture influences organizational learning; specifically, they argue that a learning system is comprised of learning orientation, in which organizational culture is a facilitating factor. The perceived organizational culture exerts an influence on staff members' attitudes and behaviors (Cavaliere and Lombardi, 2015) and influences individual learning behavior (Chang and Lee, 2007).

In addition, several studies have examined how different organizational cultures promote discussions, teamwork, experimentation, and generally influence learning. Huajing and Shi (2015) suggest that a learning culture includes three components: (1) openness to new ideas, (2) psychological safety, and (3) team orientation. Lopez et al. (2004) recommend a collaborative culture, as an organizational culture that supports organizational learning has the following aspects: a long-term vision and proactive management of change, communication and dialogue, trust and respect for members, teamwork, empowerment, ambiguity tolerance, permission to take risks, and support for diversity. Furthermore, a culture that supports communication and teamwork could promote collaboration among staff (Aksu and Ozdemir, 2005; Chang and Lee, 2007; Janz and Prasarnphanich, 2003; Lopez et al., 2004). By working together, staff can discuss individual strengths and weaknesses and effective and ineffective ways of doing work to identify weaknesses and encourage improvement (Janz and Prasarnphanich, 2003). Furthermore, communication dissolves boundaries between units and promotes teamwork (Allard, 2003). Experimentation, risk-taking, and failure tolerance encourage staff to acquire new knowledge and enhance individual learning (Chang and Lee, 2007; Lopez et al., 2004; Ortenblad and Koris, 2014). Maden (2012) proposes that an organizational culture that can transform a public organization into a learning organization is a culture in which expression of new ideas is welcome and time is provided for reviewing organizational processes.

A few specific proposals have been made regarding the organizational cultures that museums should have. Jung (2016) proposes that museums are cultural and organic places where staff interact with each other and create a workplace together. Therefore, organizational learning in museums occurs when there is a collaborative and supportive culture that encourages staff to work together. In addition, Humphrey and Yochim (2000) propose the Museum Maturity Framework (MMF) as the tool to diagnose the maturity of museum management. Ultimately, at the mature level, museum staff take part in building a shared vision. Customers and markets are considered as well, which reflects the requirement that the organizational culture promote collaboration and pay attention to external environment factors like museum visitors. Furthermore, Janes (2013) proposes several features by which to evaluate museum performance. The features include innovative work styles, a focus on customers' needs, and the transformation of new knowledge into common assumptions in staff.

In contrast to the recommendations for museum culture, in a bureaucratic culture, members pay more attention to politics and power than to innovation. In addition, management prefers colleagues who have the same opinions and staff who will become accustomed to rigid and fixed practices. Furthermore, a bureaucratic culture, in which there is a preference for an organized and systematic administration (Cavaliere and Lombardi, 2015), allows limited opportunities for staff to create new things and experiment with new ideas (Lai and Lee, 2007). Therefore, activities concerning knowledge and learning are minimal (Lai and Lee, 2007). In addition, in a mission culture, which emphasizes getting the job done, there is minimal communication; staff members remain focused on their own work and even compete with one another (Lai and Lee, 2007).

The influence of organizational culture on learning has been proposed and studied by multiple scholars. However, Argote and Miron-Spektor (2011) argue that organizations trying to promote organizational learning should consider both learning environment, which includes organizational culture, and knowledge process. In their framework, organizations exist in two major contexts. The external context, or environmental context, includes components that are outside of the organization, e.g. customers, legal requirements, and competitors. The internal context includes two major sub-contexts: the latent organizational context and the active context. The latent context includes the aspects that identify the organization, such as structure, culture, or goals. The active context includes the elements that can interact with the organization's tasks, such as staff or tools. The latent context cannot take action, but it does influence the active context. Therefore, for learning to occur, the active context is a media to transfer knowledge within the organization. However, this interaction is influenced by latent organizational context. The framework by Argote and Miron-Spektor (2011) is demonstrated in Figure 2-3.

Furthermore, Garvin et al. (2008) identify three necessary components in promoting organizational learning. The three components are as follows:

(1) An environment supportive of learning, specifically one with the following characteristics:

  i. Psychological safety, or conditions that make staff feel comfortable about expressing their thoughts.

  ii. Appreciation of differences, such that members are not concerned about proposing opposing ideas.

  iii. Openness to new ideas, so new approaches are welcome.

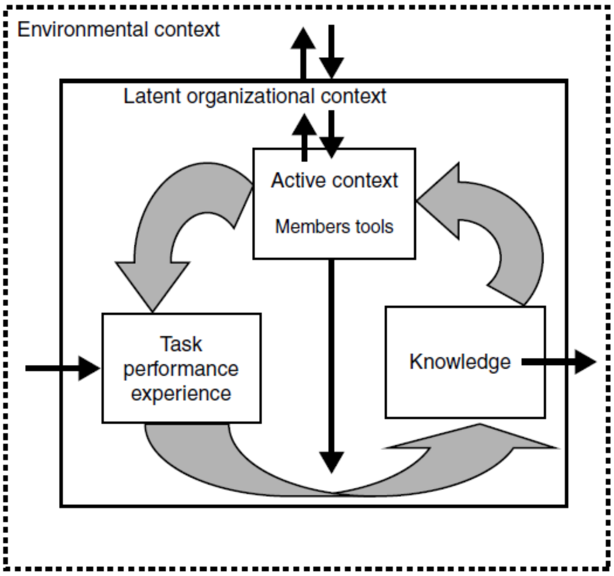
  iv. Time for reflection, which generates an environment that provides time for review of organization processes.

(2) A learning process that involves the generation, collection, interpretation, and dissemination of knowledge.

(3) Leadership that promotes learning with behavior like actively questioning and listening to employees, which in turn promotes dialogue and debates.

Therefore, the proposal of Garvin et al. (2008) also supports that both organizational culture and knowledge management are important for learning. However, none of the existing empirical studies analyzed the relationship among all three factors (i.e. organizational culture, knowledge process, and individual learning). Consequently, this study tries to analyze the relationship by empirically observing the influence of knowledge process on the relationship between organizational culture and individual learning.

Figure 2-3: Framework for Analyzing Organizational Learning



Source: Argote and Miron-Spektor (2011, p. 1125)

Knowledge management is a dynamic knowledge process that entails identification, utilization, and storage of knowledge (Gupta et al., 2000). Organizations learn when they acquire useful knowledge (Huber, 1991). The organizational culture either promotes or prevents members from sharing and disseminating their knowledge (De Long and Fahey, 2000; Janz and Prasarnphanich, 2003). Consequently, a supportive organizational culture, together with good knowledge management, can leverage learning (Gupta et al., 2000). Thus, organizations that promote both a culture that is conducive to learning and knowledge activities tend to foster more learning than organizations that promote only one of these.

Therefore, regarding the influence of knowledge process on the relationship between organizational culture and individual learning, the hypothesis was as follows:

> *H2: Knowledge process influences the relationship between organizational culture and individual learning in science museum staff.*

Chapter 3

Research Methodology

The research questions for this study explore factors that can enhance individual learning in science museum staff via knowledge process alone and via organizational culture in combination with knowledge process. The research questions used in the survey were as follows: (1) Can knowledge process lead to individual learning in science museum staff? (2) Do science museum staff require both organizational culture and knowledge process to promote individual learning? The method used to conduct this research and thereby answer these questions is explained in detail as follows.

3.1 Research Sites

Referring to the motivation of this research, the researcher aims to improve the learning in staff of science museums in Thailand, in particular the National Science Museum, Thailand (NSM (TH)) and the Science Centre for Education, Thailand (SCE (TH)). Therefore, these two organizations were selected as the research sites. In addition, to improve the generalizability of the findings in the science museum context, other research sites were chosen from the members of the Asia-Pacific Network of Science & Technology (ASPAC), of which both the NSM (TH) and SCE (TH) are also members.

The criteria to choose additional research sites were as follows: the site must (1) belong to a large-scale science museum category (ASTC, 2013) as shown in Table 3-1, (2) serve at the national level, and (3) practice knowledge management activities. Three science museums in Japan and one science museum in Singapore were approached by the researcher. However, the only one science museum consented to be included in the survey was the Science Centre Singapore, Singapore (SCS (SG)). Table 3-2 outlines the details of the three science museums selected as the research sites. Figure 3-1 shows photos of the NSM (TH), Figure 3-2 shows photos of the SCE (TH), and Figure 3-3 shows photos of the SCS (SG).

The survey was conducted over two periods of time. First, in November 2016, the survey was carried out at the NSM (TH), SCE (TH), and SCS (SG) by questionnaire survey and interviews. Then, in January 2017, the survey was carried out at only the NSM (TH) and SCE

(TH) in order to gather more interviewees, namely staff serving different functions at different levels.

Table 3-1: Category of Science Museums by Size

Size	Interior Exhibit Space (sq. m.)
Very small	<1,115
Small	1,115-2,322
Medium	2,322-4,645
Large	>4,645

Source: ASTC (2013)

Table 3-2: Details of Research Sites

Detail	NSM (TH)	SCE (TH)	SCS (SG)
Mission	To be a leading learning center in science and technology and promotes science awareness in the Thai public.	To be a vigorous learning center of science and technology with a variety of innovations and opportunities for public learning.	To promote interest, learning and creativity in science and technology, through imaginative and enjoyable experience and contribute to the nation's development of its human resource
Exhibition space	23,500 sq. m.	9,890 sq. m.	14,500 sq. m.
Number of staff	248 staff	83 staff	239 staff
Number of attendants/year	2,500,000	2,200,000	1,200,000

Note. NSM (TH) = National Science Museum, Thailand, SCE (TH) = Science Centre for Education, Thailand, SCS (SG) = Science Centre Singapore

Source: NSM retrieved from www.nsm.or.th; SCE retrieved from www.sciplanet.org, SCS retrieved from www.science.edu.sg

Figure 3-1: Photos of NSM (TH)

Figure 3-2: Photos of SCE (TH)

Figure 3-3: Photos of SCS (SG)

3.2 Research Method

This research adopted the mixed-method approach with the quantitative approach as the major methodology. The quantitative method was conducted by questionnaire survey, and the qualitative method was conducted by interview. First, the data from the questionnaire survey were analyzed in order to find answers for the two research questions. The relationships among the three variables were thus identified. Then the data from the interviews were extracted with the purpose of retrieving in-depth information that could explain the relationship between the variables calculated by the quantitative method.

3.3 Quantitative Approach

This section explains the questionnaire design, the measurement items for the research variables, and the procedure for data analysis.

3.3.1 Questionnaire Design

The first page of the questionnaire was a cover letter explaining the aim of this research. Namely, the letter stated that the research aimed to identify knowledge management practices and organizational cultures that could enhance learning in science museum staff. The letter further stated that this learning could lead to improvement of the work of science museums. In addition, confidentiality of participants was confirmed, and plans for use of any information gathered were clarified.

The questionnaire questions were developed by referring to questionnaires from previous studies. These examples were modified to suit the context of science museums according to comments from knowledge management experts and museum studies experts working at the research sites. The questions were divided into four parts: (1) demographic data relating to age group, position, job role, and length of employment; (2) organizational cultures (Lopez et al., 2004; Chang and Lee, 2007; Lai and Lee, 2007; Janz and Prasarnphanich, 2003); (3) knowledge process (Lopez et al., 2004; Palanisamy, 2007); and (4) individual learning (Marsick and Watkins, 2003). All of the measurement items utilized a five-point Likert scale with choices ranging from “almost never true” to “almost always true.” Details of questionnaire used in this research are provided in Appendix 1.

The questionnaire was translated into Thai for the respondents in Thailand, and the accuracy of the translation was checked by museum staff with proficiency in English–Thai proofreading. An English questionnaire was used at SCS (SG). From all three institutions, managers and junior employees from different departments, both administrative and visitors' communication departments, were invited to offer comments on the questionnaire's wording, overall ease of comprehension, and any difficulties associated with completing it. Subsequently, before wider distribution, some modifications were made on the basis of these comments.

3.3.2 Measurement of Variables for Questionnaire Survey

This study explores three variables: knowledge process, organizational culture, and individual learning. The following sub-sections detail the measurement of each variable.

i. Knowledge Process (KP)

Based on the literature review, the measurement of knowledge process was classified into four dimensions: knowledge acquisition, knowledge distribution, knowledge interpretation, and organizational memory. The four dimensions are based on Huber's (1991) framework, which is about knowledge management activities that create organizational learning. Then, the questions were adopted and adjusted from the questionnaire used by Lopez et al. (2004) and Palanisamy (2007) in their empirical studies about the influence of knowledge process on organizational learning.

The first dimension, knowledge acquisition (KA), measured the extent of acquisition of knowledge. The acquisition from different knowledge sources was observed in terms of activities and policies established by the organization to support retrieval of knowledge from both within and outside the science museum. The second dimension, knowledge distribution (KD), measured the spread of knowledge among all members of the organization. The distribution was investigated in terms of opportunities provided to meet and exchange knowledge. In addition, knowledge coordinators, publications, and other distributing channels were also explored. The third dimension, knowledge interpretation (KI), measured the incorporation of knowledge to achieve optimal effects, including the integration of knowledge into problem solving and organizational routines. Furthermore, group efforts to solve problems were also measured. Lastly, organizational memory (OM) investigated the different aspects of storage of organizational knowledge for future use, such as staff awareness of the storage methods, storage updating, and staff access to storage. Each knowledge activity dimension was measured by 5 questions. Details of measurement items are provided in Table 3-3.

Table 3-3: Knowledge Process Measurement Items

Variables	Dimensions	Code	Measurement Items
Knowledge Process (KP)	Knowledge Acquisition (KA)	KA_1	Your organization actively promotes cooperation with other science museums/centers, universities, professionals, and experts.
		KA_2	Staff are encouraged to join events and/or exhibitions that are arranged both within and outside the organization.
		KA_3	Your organization collects information on other science museums/centers, visitors, economic and social trends, or scientific and technological trends.
		KA_4	Your organization has a clear policy and sufficient resources for R&D activities.
		KA_5	New ideas and approaches for doing jobs are tested continuously.

Source: Lopez et al. (2004); Palanisamy (2007)

Table 3-3: Knowledge Process Measurement Items (continued)

Variables	Dimensions	Code	Measurement Items
Knowledge Process (KP)	Knowledge Distribution (KD)	KD_1	Meetings are periodically held to inform all staff of the latest ideas and work processes.
		KD_2	Best practices among different jobs are shared.
		KD_3	Your organization has staff members who are in several teams or divisions and also act as links between them.
		KD_4	Your organization has staff members who are responsible internally for collecting, assembling and distributing employee opinions about doing jobs.
		KD_5	Knowledge for doing jobs is transferred by internal publications, job rotation, informal networks, etc.
Knowledge Process (KP)	Knowledge Interpretation (KI)	KI_1	Approaches from successful projects have been turned into standardized rules or ways of doing similar jobs.
		KI_2	Approaches from successful projects have been integrated into training materials.
		KI_3	Staff with different expertise are often brought together to solve problems.
		KI_4	Problems are solved through discussions and other social interactions.
		KI_5	Problems are solved by applying previous lessons learned or best practices.

Source: Lopez et al. (2004); Palanisamy (2007)

Table 3-3: Knowledge Process Measurement Items (continued)

Variables	Dimensions	Code	Measurement Items
Knowledge Process (KP)	Organizational Memory (OM)	OM_1	Your division has a system for organizing data concerning problems, solutions and lesson learned.
		OM_2	In your division, data is collected systematically and is kept up-to-date.
		OM_3	You can easily access and use data that are collected.
		OM_4	You often consult data that are collected.
		OM_5	You have access to required data from other divisions.

Source: Lopez et al. (2004); Palanisamy (2007)

ii. Organizational Culture (OC)

Dimensions for measurement of organizational culture were based on the four organizational culture types defined by Cameron and Quinn (2011). The measurement items were adjusted from the questionnaires used in the studies of Chang and Lee (2007), Lai and Lee (2007), and Janz and Prasarnphanich (2003) concerning the influence of organizational culture on organizational learning. The organizational cultures were measured by the organizational culture profile perceived by the science museum staff. The first culture type is adaptive culture, which focuses on the external environment. Therefore, the measurement items investigated awareness of change, customer satisfaction, new challenges, and competition with other science museums. The second culture type is mission culture, which focuses on the responsibility of staff to efficiently finish assigned tasks. The measurement items were thus about the importance of getting jobs done and interaction between staff. The third culture type is bureaucratic culture, which focuses on high consistency, obedience, and cooperation among members. Therefore, the priority of rules and regulations when working was investigated. The fourth culture type is clan culture, which focuses on staff involvement and organizational commitment. The measurement items were about collaboration and close relationships among staff. Each organizational culture dimension had four measurement items. The measurement items are detailed in Table 3-4.

Table 3-4: Organizational Culture Measurement Items

Variables	Dimensions	Code	Measurement Items
Organizational Culture (OC)	Adaptive Culture (AC)	AC_1	Your organization considers change to be natural and necessary.
		AC_2	Staff are aware of visitor/client satisfaction.
		AC_3	Readiness to meet new challenges is important.
		AC_4	There is an emphasis on being ahead of other science museums/centers.
	Mission Culture (MC)	MC_1	Your organization prioritizes getting the job done.
		MC_2	Staff are not very socially involved amongst each other.
		MC_3	Schedule is important in completing tasks.
		MC_4	Staff are too busy to spend time on improvement.
	Bureaucratic Culture (BC)	BC_1	Formal rules and policies. Maintaining a smooth-running organization is important here.
		BC_2	Your organization focuses on hierarchy and fixed organization structure.
		BC-3	Established procedures generally govern what staff do.
		BC_4	Administrative operations are prioritized.

Source: Chang & Lee (2007); Lai and Lee (2007), Janz and Prasarnphanich (2003)

Table 3-4: Organizational Culture Measurement Items (continued)

Variables	Dimensions	Code	Measurement Items
Organizational Culture (OC)	Clan Culture (CC)	CC_1	Your organization treats staff like a large family.
		CC_2	Collaboration and cooperation among the different departments are encouraged.
		CC_3	There is a lot of warmth in the relationships between management and staff.
		CC_4	Employees are promoted to create bonds with and dedication to the organization.

Source: Chang and Lee (2007); Lai and Lee (2007), Janz and Prasarnphanich (2003)

iii. Individual Learning (IL)

The dimensions to investigate individual learning were based on Watkins and Marsick's (1993) framework, which proposes individual actions that lead to learning. The questions were adapted from the Dimensions of the Learning Organization Questionnaire (DLOQ) by Marsick and Watkin (2003). Individual learning was investigated in two dimensions. The first dimension was continuous learning opportunities (CL), which evaluates provision of opportunity to learn and grow through staff cooperation, rewards for applying learning to work, and provision of time for learning. The second dimension was promotion of inquiries and dialogues (PI). This dimension measured support for asking questions of others, giving feedback, and spending time to learn together. Each dimension included three items. The measurement items are detailed in Table 3-5.

Table 3-5: Individual Learning Measurement Items

Variables	Dimensions	Code	Measurement Items
Individual Learning (IL)	Continuous Learning Opportunities (CL)	CL_1	Staff in each division help each other to learn how to do their job.
		CL_2	Staff in each division are rewarded when they apply what they have learned to their jobs.
		CL_3	Staff in each division are given the time to learn about doing their jobs.
	Promoting of Inquiries and Dialogues (PI)	PI_1	Staff in each division give open and honest feedback to each other.
		PI_2	Whenever staff state their views, they also ask what others think.
		PI_3	Staff in each division spend time to learn about work together.

Source: Marsick and Watkin (2003, p. 142-145)

3.3.3 Quantitative Data Analysis Procedure

For the data analysis, results from the questionnaire survey were analyzed by the Partial Least Square (PLS) version 3. The structural equation modeling (SEM) was established by utilizing the hierarchical component models (HCMs). The details of the quantitative data analysis procedure are explained as follows.

i. Partial Least Square Structural Modelling (PLS-SEM) (Hair et al., 2017)

The multivariate analysis is an application of a statistical method that simultaneously analyzes multiple variables. The SEM is one technique of multivariate analysis. It measures the unobservable variables indirectly by indicator variables. Therefore, the unobservable variables are composite variables. The composite value is the linear combination of several variables by calculating a set of weights, multiplying the weights (e.g., w_1 and w_2) times the associated data observations for the variables (e.g., x_1 and x_2), and summing them. The formula to calculate composite value is as follows:

$$\text{Composite value} = w_1\, x_1 + w_2\, x_2 + w_3\, x_3 + \ldots$$

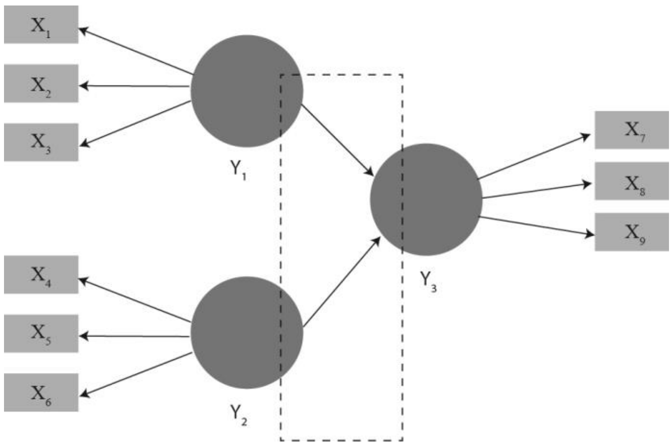
The first step of SEM is to illustrate the research hypotheses and the variable relationships for testing. This step is referred to as a path model. The path model is comprised of two components: the structural model and the measurement model.

The PLS-SEM was adopted for data analysis in this research. The PLS-SEM was adopted for two main reasons: (1) It is able to examine relationships between more than one independent latent variable and many dependent latent variables. (2) It is suitable for a relatively small sample size (30 or more). In addition, the hypothesis about the influence of knowledge process on the relationship between organizational culture and individual learning required a mediation analysis. A mediation analysis is an analysis of sequence of relationship, in which an antecedent variable affects a mediating variable, which then affects a dependent variable (Nitzl et al., 2016). The mediation analysis could be accomplished by PLS-SEM (Hair et al., 2017).

- Structural Model

The structural model displays the relationships (paths) between different variables. The value of each variable was retrieved from the measurement items that directly measured that variable. The measurement items contained raw data. The location and sequence of variables were decided based on theories. The structural model was specified according to the hypotheses and their relationship to the theory being tested. Two primary issues had to be considered. The first issue was the sequence of the variables, which was based on theory, logic, or the practical experience of the researcher. The sequence was displayed from left to right. The second issue concerned the relationships between the variables. The relationships were shown via arrows between the variables. Figure 3-4 displays an example of a structural model.

Figure 3-4: Example of Structural Model



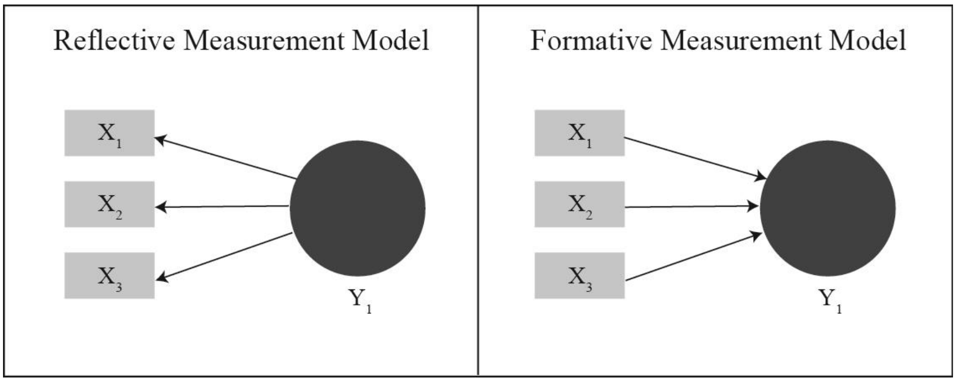
Structural Model

Source: Adapted from Hair et al. (2017, p. 12)

- Measurement Model

The relationships between variables and measurement items were displayed via measurement models that used an arrow to indicate the direction of causes. There are two types of measurement models: reflective measurement models and formative measurement models. Reflective measurement items provide a representative sample of all the possible items within one construct. Items should be interchangeable, and it should be possible to delete any single item without changing the meaning of the variable. The variable should have sufficient reliability. Formative measurements form the variable through linear combination. Formative measurement items are not interchangeable, because they contain specific aspects of the construct. Figure 3-5 gives an example of a reflective model and a formative model.

Figure 3-5: Example of Measurement Model

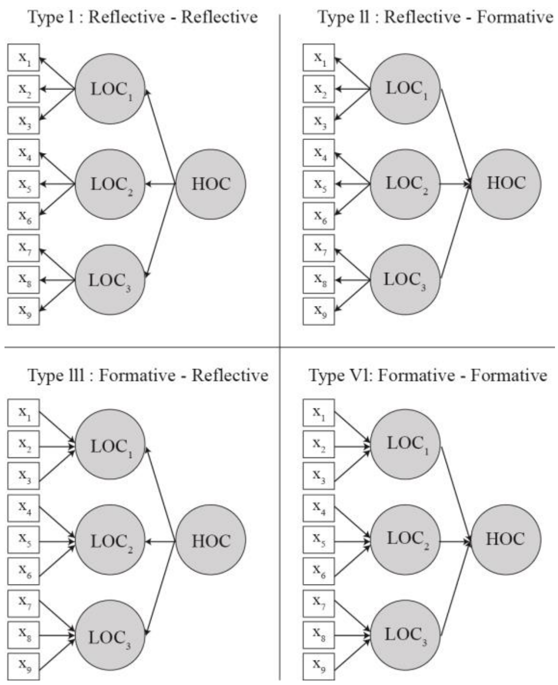


Source: Adapted from Hair et al. (2017, p. 65)

- Hierarchical Component Model (HCM)

Hierarchical component models (HCMs) are model that test second-order structure and contain two layers of components. Utilizing HCMs leads to more parsimony and reduces model complexity (Hair et al., 2017). HCMs have two layers of variables: lower-order construct (LOC) and higher-order construct (HOC) variables. There are four types of HCM: (1) reflective-reflective HCM, (2) reflective-reflective HCM, (3) formative-reflective HCM, and (4) formative-formative HCM, as shown in Figure 3-6. This research adopted reflective-formative HCMs in testing of hypotheses.

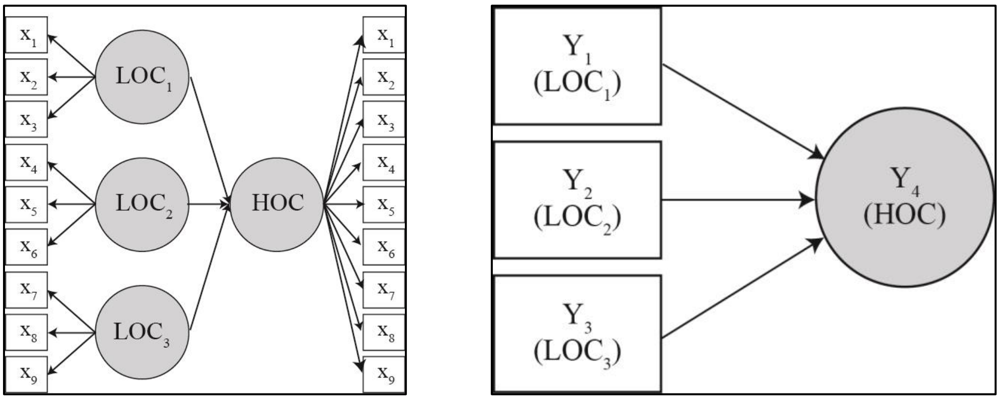
Figure 3-6: Types of Hierarchical Component Models



Source: Hair et al.(2018, p. 44)

For the reflective-formative HCM analysis, this research adopted the two-stage approach for estimation of the model. The two-stage approach can handle the errors of reflective-formative HCMs (Becker et al., 2012). In the first stage, all measurement items of the LOCs were assigned to the measurement model of the HOC to obtain the LOCs' scores. Then these scores were saved and used for the analysis in the second stage (Hair et al., 2018). Figure 3-7 shows an example of the HCMs produced using the two-stage approach.

Figure 3-7: HCM Using the Two Stage Approach

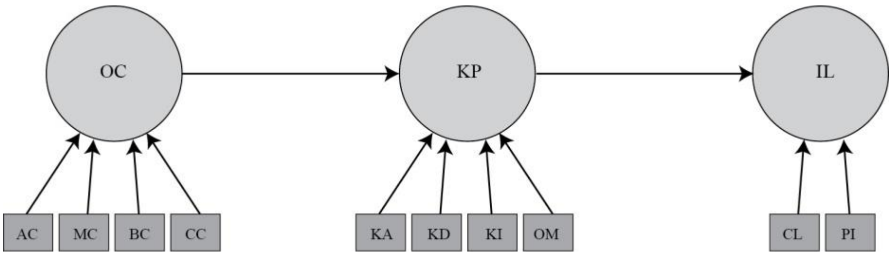


Source: Adapted from Hair et al.(2018, p. 48, 53)

- Research Model

A hierarchical component model (HCM), which summarizes the lower-order components into a single multidimensional higher-order construct (HOC) (Hair et al., 2017), was employed for this study. Adaptive culture (AC), mission culture (MC), bureaucratic culture (BC), and clan culture (CC) were designed as the component factors of the higher–order construct of organizational culture (OC). Similarly, knowledge acquisition (KA), knowledge distribution (KD), knowledge interpretation (KI), and organizational memory (OM) were assigned as the component factors of the higher-order construct of knowledge process (KP). Individual learning (IL) was conceptualized as a higher-order construct consisting of continuous learning opportunities (CL) and promoting inquiries and dialogues (PI). The research framework for studying the relationship between organizational culture, knowledge process, and individual learning is illustrated in Figure 3-8.

Figure 3-8: Research Model



Note. OC = Organizational Culture, AC = Adaptive Culture, MC = Mission Culture
BC = Bureaucratic Culture, CC = Clan Culture
KP = Knowledge Process, KA = Knowledge Acquisition,
KD = Knowledge Distribution, KI = Knowledge Interpretation,
OM = Organizational Memory
IL = Individual Learning, CL = Continuous learning Opportunities,
PI = Promotion of dialogues and inquiries

ii. Assessing Reflective Measurement Model

For SEM, the measurement model is evaluated by the outer loading and outer weight, composite reliability (CR), and the average variance extracted (AVE). The details of each measurement are as follows.

- Outer Loading and Outer Weight

The value of outer loading and outer weight was calculated by the PLS-SEM algorithm. First the data matrix was created. Table 3-6 shows the data matrix for the PLS path model in Figure 3-9. The seven measured items were identified as X_1 to X_7, and the three variables were identified as Y_1 to Y_3. The x measurement items were used as raw data for input to estimate Y_1 to Y_3. The relationship between the measurement items of the formative constructs Y_1 and Y_2 was outer weight and labeled as W_{11}, W_{12}, W_{23}, and W_{24}. The relationship between the measurement items of the reflective constructs Y_3 was outer loading and labeled as l_{35}, l_{36}, and l_{37}. Then the partial regression models were calculated by the PLS-SEM algorithm's iterative procedures in two stages. In the first stage, the construct score was calculated; in the second stage, the outer weights, outer loadings, and path coefficients were calculated (Hair et al., 2017).

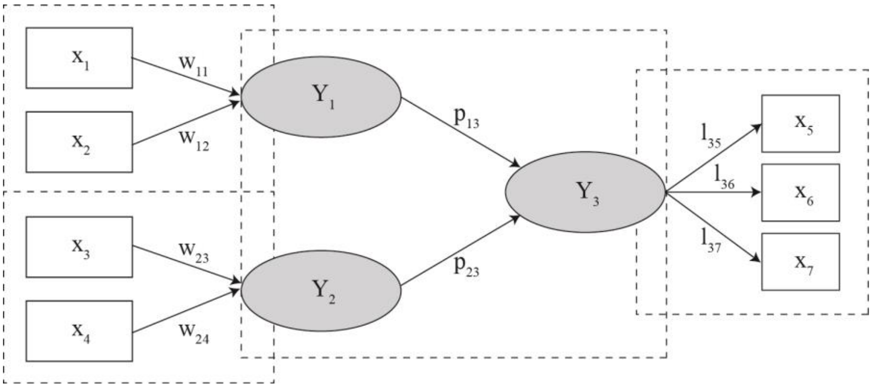
The recommendations for indicator deletion were based on outer loadings. First, any indicators with an outer loading < 0.40 were deleted, and any indicators with an outer loading > 0.70 were retained. Further, any indicators with an outer loading > 0.40 but < 0.70 whose deletion could increase the CR or AVE were deleted (Hair et al., 2017). The deletion of outer weights went as follows. First, significant outer weights were retained. Insignificant outer weights, which had an outer loading ≥ 0.50, were retained. Insignificant outer weights, which had an outer loading < 0.40, were deleted (Hair et al., 2017).

Table 3-6: Data Matrix for PLS-SEM Algorithm

Case	X_1	X_2	X_3	X_4	X_5	X_6	X_7	Y_1	Y_2	Y_3
1	$X_{1,1}$	$X_{2,1}$	$X_{3,1}$	$X_{4,1}$	$X_{5,1}$	$X_{6,1}$	$X_{7,1}$	$Y_{1,1}$	$Y_{2,1}$	$Y_{3,1}$
…	…	…	…	…	…	…	…	…	…	…
89	$X_{1,89}$	$X_{2,89}$	$X_{3,89}$	$X_{4,89}$	$X_{5,89}$	$X_{6,89}$	$X_{7,89}$	$Y_{1,89}$	$Y_{2,89}$	$Y_{3,89}$

Source: Adapted from Hair et al. (2017, p.82)

Figure 3-9: Example of PLS-SEM and Data



Source: Adapted from Hair et al. (2017, p. 85)

- Composite Reliability (CR)

The internal consistency reliability was evaluated by the composite reliability (CR). The CR took into account the different outer loadings of the measurement items. CR value varies between 0 and 1 and should be above 0.80. The formula used to calculate the CR is as follows (Hair et al., 2017).

$$P_c = \frac{\left[\sum_{i=1}^{M} l_i\right]^2}{\left[\sum_{i=1}^{M} l_i\right]^2 + \sum_{i=1}^{M} var(e_i)}$$

l_i = Outer loading of the indicator variable i of a specific construct measured with M indicators

e_i = Measurement error of indicator variable i

$var(e_i)$ = Variance of the measurement error defined as 1-l_i^2

- Average Variance Extracted (AVE)

Convergent validity measures the correlation between different measurement items of the same variable. The average variance extracted (AVE) was the measurement for convergent validity. AVE should be higher than 0.50 (Hair et al., 2017). The formula used to calculate AVE is as follows.

$$\text{AVE} = \left[\frac{\sum_{i=1}^{M} l_i^2}{M}\right]$$

l_i = Outer loading of the indicator variable i of a specific construct measured with M indicators

- Fornell-Larcker Criterion

Discriminant validity shows whether one variable is distinct from other variables. The Fornell-Larcker Criterion was the approach used for discriminant validity assessment. This approach compares the square root of the AVE values with the latent variable correlations. The square root of each AVE should higher than its highest correlation with any other variables (Hair et al., 2017). Table 3-7 shows an example of Fornell-Larcker Criterion analysis.

Table 3-7: Example of Fornell-Larcker Criterion Analysis

	Y_1	Y_2	Y_3
Y_1	$\sqrt{AVE_{Y_1}}$		
Y_2	$CORR_{Y_1Y_2}$	$\sqrt{AVE_{Y_2}}$	
Y_3	$CORR_{Y_1Y_3}$	$CORR_{Y_2Y_3}$	$\sqrt{AVE_{Y_2}}$

Source: Hair et al. (2017, p.117)

iii. Assessing Formative Measurement Model (Hair et al. 2017)

The Variance Inflation Factor (VIF) is the value for assessment of formative measurement models. First, it was required to calculate level of collinearity by computing the tolerance (TOL). The formula used to calculate TOL is as follows.

$$TOL_{xs} = 1 - R^2_{x_s}$$

$R^2_{x_s}$ = Regression of indicator x_s and other indicators in the same block

Then the VIF could be retrieved by the following formula. The VIF values should be less than 5.

$$VIF_{xs} = 1/TOL_{xs}$$

iv. Assessing Structural Model (Hair et al. 2017)

The structural model was formed through the following procedure of assessment.

- Level of Collinearity

Level of collinearity was assessed via the calculation of VIF, as in the assessment of the formative measurement model. The VIF was also used for checking the collinearity of the variables in the structural model.

- Bootstrapping

The bootstrapping approach was used to test whether a path coefficient was significantly different from zero. The approach uses sampling with replacement. Then mean value is calculated from each bootstrap sample. The result provides an estimate of the shape of the distribution of the mean; or, in other words, the result estimates how much the mean varies. Estimation of standard errors (standard deviations above and below the actual value) and confidence intervals (the range within which the true population parameter will fall assuming a certain level of confidence) was also retrieved. Lastly, a t-test was conducted to test whether the path value was significant from zero. The formula used to calculate t value is as follows (Sakamoto, 2016).

$$\mathrm{t} = \frac{\mathrm{w}_1}{se_{w_1}}$$

se = Standard of error

- Coefficient of Determination (R^2 value) (Hair et al, 2017)

The coefficient of determination shows predictive power. It represents the amount of variance in the endogenous constructs. The value is explained by the entire exogenous constructs linked to it. The R^2 is the squared correlation of actual and predicted value. The R^2 ranges from 0 to 1, and a higher R^2 means a higher level of predictive accuracy.

v. Mediating Effect

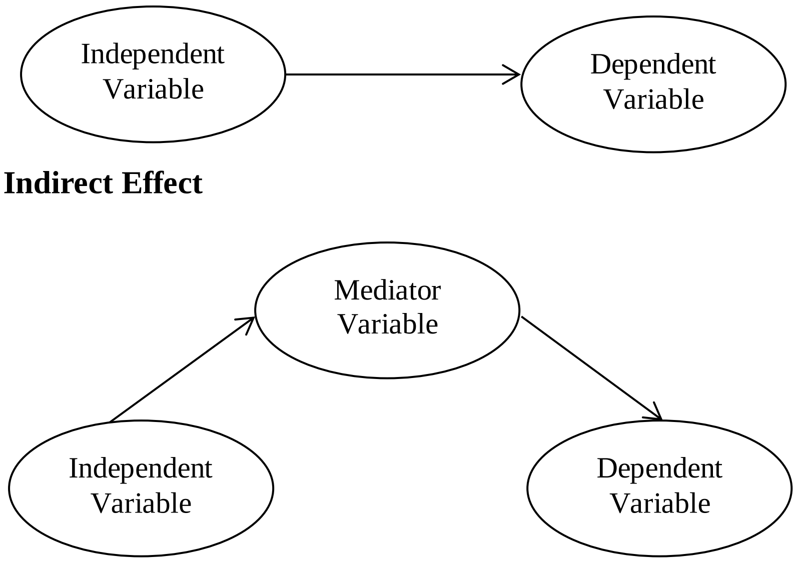
In this research, the mediating effect was used to test the hypothesis about the influence of knowledge process on the relationship between organizational culture and individual learning.

A mediating effect is created when a third variable intervenes between two other related variables. The role of the mediator variable is to reveal the true relationship between an independent and a dependent construct. The mediating effect is considered in terms of direct effects and indirect effects. Figure 3-10 details the mediation effect calculation. A direct effect is depicted with a single arrow between two variables (a). An indirect effect involves a sequence of relationships with at least one intervening variable (b) (Nitzl et al., 2017).

Figure 3-10: Mediation Effect Model

(a) Direct Effect

(b) Indirect Effect



Source: Adapted from Nitzl et al.(2017)

Hair et al. (2017) suggest that first the significance of the indirect effect should be calculated. If the indirect effect is not significant, it means that the intervening variable does not play a mediation role in the relationship. If the indirect effect is significant then the significance of the direct effect is considered. The types of meditation are as follows.

- Complementary mediation – The indirect effect and the direct effect both are significant and point in the same direction.
- Competitive mediation – The indirect effect and the direct effect both are significant and point in opposite directions.
- Indirect-only mediation – The indirect effect is significant, but the direct effect is not.

3.4 Qualitative Approach

This section explains the interviews' question design and procedure for data analysis.

3.4.1 Interview's Questions Design

The interviews aimed to add explanation to the relationships calculated by the quantitative method about the conducted knowledge process and the perceived organizational culture. Therefore, the interview questions were designed based on the research framework and questionnaire measurement items about knowledge process and organizational culture. The interviews were designed to be semi-structured interviews, so the questions were used as guidelines and interviewees were free to talk about the topics. In addition, the interviewers were free to ask for more detail in order to clarify the answers given by the interviewees.

The interview questions first asked for basic demographic details of interviewees in order to create a relaxed atmosphere and clarify the interviewees' background. Then opinions about the conducted knowledge process were elicited. Finally, the perceived organizational culture was discussed by asking about the atmosphere in the workplace. For the Thai interviewees, the questions were translated from English to Thai and checked by the staff of the museums who are bilingual and translation experts. The interview questions are provided in Appendix 2.

To recruit the interviewees, the researcher first selected the sections and positions of the interviewees with the aim of gathering opinions from each science museum. Therefore, interviewees are managers and staff covering a cross-section of job roles. Then the staff or managers who are the coordinators at each museum selected the person to be the interviewees. The interviewees were asked to read through all the questions, and their inquiries were answered before the interview started. Each interview took about 1 hour per interviewee.

3.4.2 Qualitative Data Analysis Procedure

The responses were tape-recorded with the consent of the interviewees to avoid losing important information. In addition, detailed notes were taken by the researcher. The records were subsequently transcribed by professional transcriptionists and checked by the researcher for correction. The interview transcripts were analyzed using NVivo Version 11 to create the coding frame. The coding frame was developed on the basis of the research framework and questionnaire measurement items.

3.5 Survey Respondents

The questionnaire respondents and interviewees from the three research sites are detailed as follows.

3.5.1 Number of Questionnaire Respondents

Questionnaires were distributed to every full-time and permanent staff at the NSM (TH) (257 staff) and SCE (TH) (69 staff) by hand. In addition, questionnaires were sent to members of the SCS (SG) (239 staff) by e-mail. The distribution was done with assistance from staff of each institution. Table 3-8 breaks down the number of questionnaire respondents per museum. There were 152 respondents from the NSM (TH) (59.1%), 66 respondents from the SCE (TH) (95.7%), and 61 respondents from the SCS (SG) (25.5%). The final sample size reached a higher number than that specified in the criteria recommended by Hair et al. (2017), who calculate ten times the maximum number of arrowheads pointing at a construct (four in this study).

Table 3-8: Number of Questionnaire Respondents

Detail	NSM (TH)	SCE (TH)	SCS (SG)
Total staff	257	69	239
No. of respondents	152	66	61
Percentage of respondents	59.1%	95.7%	25.5%

Note. NSM (TH) = National Science Museum, Thailand
SCE (TH) = Science Centre for Education, Thailand
SCS (SG) = Science Centre Singapore

3.5.2 Characteristics of Questionnaire Respondents

The demographics of the questionnaire respondents from each science museum are provided in Tables 3-9, 3-10, and 3-11. In the three museums, more than 60% of respondents were staff (i.e., not managers or senior managers), and more than 50% were in jobs related to visitor services. At the NSM (TH) and SCE (TH), more than 70% of respondents had been employed for at least 6 years, but at the SCS (SG), the number of respondents who were employed less than 6 years and those who were employed more than 6 years were almost equal. Furthermore, at the NSM (TH) and SCS (SG), most respondents were younger than 40 years old, but at the SCE (TH), most respondents were between 51 and 60 years old.

Table 3-9: Characteristics of Questionnaire Survey Respondents at the NSM (TH)

Detail	NSM (TH)	
Position	Senior Manager/Manager	10.5%
	Staff	89.5%
Function	Top management	2.0%
	Administration	40.8%
	Visitor Service	57.2%
Length of Employment	Less than 3 years	1.3%
	3-5 years	24.3%
	6-10 years	13.8%
	11-20 years	25.0%
	More than 20 years	33.6%
	Not mentioned	2.0%
Age Group	Under 31	23.7%
	31-40	49.3%
	41-50	20.4%
	51-60	6.6%
	More than 60	0.0%

Note. NSM (TH) = National Science Museum, Thailand

Table 3-10: Characteristics of Questionnaire Survey Respondents at the SCE (TH)

Detail	SCE (TH)	
Position	Senior Manager/Manager	28.8%
	Staff	68.2%
	Not mentioned	3.0%
Function	Top management	1.6%
	Administration	43.9%
	Visitor Service	54.5%
Length of Employment	Less than 3 years	7.6%
	3-5 years	7.6%
	6-10 years	18.2%
	11-20 years	25.8%
	More than 20 years	36.4%
	Not mentioned	4.5%
Age Group	Under 31	1.5%
	31-40	25.8%
	41-50	18.2%
	51-60	53.0%
	More than 60	1.5%

Note. SCE (TH) = Science Centre for Education, Thailand

Table 3-11: Characteristics of Questionnaire Survey Respondents at the SCS (SG)

Detail	SCS (SG)	
Position	Chief Executive/Senior Manager/Manager	31.1%
	Staff	68.9%
Function	Top management	1.6%
	Administration	26.2%
	Visitor Service	72.1%
Length of Employment	Less than 3 years	44.3%
	3-5 years	13.1%
	6-10 years	14.8%
	11-20 years	14.8%
	More than 20 years	13.1%
Age Group	Under 31	26.2%
	31-40	36.1%
	41-50	13.1%
	51-60	19.7%
	More than 60	4.9%

Note. SCS (SG) = Science Centre Singapore

3.5.3 Details of Interviewees

There were 12 interviewees from the NSM (TH), 10 interviewees from the SCE (TH), and 9 interviewees from the SCS (SG). Table 3-12 breaks down the interviewees per museum and job category.

Table 3-12: Number of Interviewees

Detail	NSM (TH)	SCE (TH)	SCS (SG)
Senior Manager	5	8	5
Staff	7	2	5
Total	12	10	10

Note. NSM (TH) = National Science Museum, Thailand
SCE (TH) = Science Centre for Education, Thailand
SCS (SG) = Science Centre Singapore

3.6 Test of Measurement Model

The measurement model and construct discriminants used in this study were tested for reliability. The reliability of the measures was calculated by retrieving the outer loading, composite scale reliability (CR), and average variance extracted (AVE). The recommendations made by Hair et al. (2017) were followed for measurement items deletion based on outer loadings. First, any measurement items with an outer loading < 0.40 were deleted, and any measurement items with an outer loading > 0.70 were retained. Further, measurement items with an outer loading > 0.40 but < 0.70 whose deletion could increase the CR or AVE were deleted (Hair et al., 2017). In addition, the criteria for judging CR required a minimum value of 0.80, and the AVE required a minimum value of 0.50, as proposed by Fornell and Larcker (1981).

3.6.1 Measurement Model Values – Knowledge Process Variable (KP)

At the NSM (TH), all the measurement items for knowledge acquisition (KA), knowledge interpretation (KI), and organizational memory (OM) had outer loadings higher than 0.70. However, one measurement item for knowledge distribution (KD_1) had outer loading = 0.66, which was lower than 0.70. In addition, the deletion of this measurement item increased the AVE values, so this measurement item was deleted for the structural model analysis. Details of measurement item values for the KP variable at the NSM (TH) are shown in Table 3-13.

At the SCE (TH), all the measurement items for knowledge distribution (KD) and knowledge interpretation (KI) had outer loadings higher than 0.70. For knowledge acquisition (KA), three measurement items had an outer loading lower than 0.70, namely KA_1 = 0.61, KA_4 = 0.68, and KA_5 = 0.64. In addition, the knowledge interpretation (KI) had one measurement item that had outer loading lower than 0.70, namely KI_2 = 0.57. Therefore, KA_1, KA_4, KA_5, and KI_2 were deleted. However, for KI, when KI_2 was deleted, the outer loading of KI_1 = 0.68, which is lower than 0.70. Therefore, KI_1 was also deleted from the measurement model. Then every measurement item met the criteria for the structural model calculation. Details of measurement item values for the KP variable at the SCE (TH) are shown in Table 3-14.

At the SCS (SG), all the measurement items for knowledge interpretation (KI) and organizational memory (OM) had outer loadings higher than 0.70. However, two measurement items for knowledge acquisition (KA) had an outer loading lower than 0.70, namely KA_1 = 0.64 and KA_3 = 0.60. One measurement item for knowledge distribution (KD_3) had outer loading = 0.67. The deletion of KA_1 and KA_3 increased the CR and AVE values. The deletion of KD_3 increased the AVE value but decreased CR value from 0.89 to 0.88; nonetheless, the criteria were still met after deletion. Therefore, these measurement items were deleted for the structural model analysis. Details of measurement item values for the KP variable at the SCS (SG) are shown in Table 3-15.

Table 3-13: Measurement Model Values – KP Variable at the NSM (TH)

Variables	Measurement Items	1st Calculation			2nd Calculation		
		Outer Loadings	CR	AVE	Outer Loadings	CR	AVE
KP - KA	KA_1	0.73	0.86	0.55	0.73	0.86	0.55
	KA_2	0.71			0.71		
	KA_3	0.76			0.76		
	KA_4	0.76			0.76		
	KA_5	0.76			0.76		
KP - KD	KD_1	0.66	0.87	0.57		0.87	0.63
	KD_2	0.73			0.73		
	KD_3	0.76			0.79		
	KD_4	0.83			0.84		
	KD_5	0.78			0.81		
KP - KI	KI_1	0.75	0.87	0.57	0.75	0.87	0.57
	KI_2	0.81			0.81		
	KI_3	0.73			0.73		
	KI_4	0.75			0.75		
	KI_5	0.73			0.73		
KP - OM	OM_1	0.76	0.92	0.71	0.76	0.92	0.71
	OM_2	0.87			0.87		
	OM_3	0.91			0.91		
	OM_4	0.87			0.87		
	OM_5	0.78			0.78		

Note. NSM (TH) = National Science Museum, Thailand,
KP = Knowledge Process, KA = Knowledge Acquisition, KD = Knowledge Distribution,
KI = Knowledge Interpretation, OM = Organizational Memory

Table 3-14: Measurement Model Values – KP Variable at the SCE (TH)

Variables	Measurement Items	1st Calculation			2nd Calculation			3rd Calculation		
		Outer Loadings	CR	AVE	Outer Loadings	CR	AVE	Outer Loadings	CR	AVE
KP - KA	KA_1	0.61	0.81	0.46		0.85	0.73		0.85	0.73
	KA_2	0.70			0.82			0.82		
	KA_3	0.75			0.89			0.89		
	KA_4	0.68								
	KA_5	0.64								
KP - KD	KD_1	0.84	0.90	0.64	0.84	0.90	0.64	0.84	0.90	0.64
	KD_2	0.78			0.78			0.78		
	KD_3	0.83			0.83			0.83		
	KD_4	0.79			0.79			0.79		
	KD_5	0.77			0.77			0.77		
KP - KI	KI_1	0.74	0.85	0.54	0.68	0.87	0.62		0.89	0.72
	KI_2	0.57								
	KI_3	0.83			0.85			0.83		
	KI_4	0.78			0.84			0.89		
	KI_5	0.73			0.77			0.82		
KP - OM	OM_1	0.76	0.92	0.69	0.76	0.92	0.69	0.76	0.92	0.69
	OM_2	0.77			0.77			0.77		
	OM_3	0.86			0.86			0.86		
	OM_4	0.89			0.89			0.89		
	OM_5	0.86			0.86			0.86		

Note. SCE (TH) = Science Centre for Education, Thailand
KP = Knowledge Process, KA = Knowledge Acquisition, KD = Knowledge Distribution,
KI = Knowledge Interpretation, OM = Organizational Memory

Table 3-15: Measurement Model Values – KP Variable at the SCS (SG)

Variables	Measurement Items	1st Calculation			2nd Calculation		
		Outer Loadings	CR	AVE	Outer Loadings	CR	AVE
KP - KA	KA_1	0.64	0.85	0.73		0.88	0.72
	KA_2	0.86			0.83		
	KA_3	0.60					
	KA_4	0.81			0.83		
	KA_5	0.81			0.88		
KP - KD	KD_1	0.76	0.90	0.64	0.80	0.90	0.68
	KD_2	0.86			0.85		
	KD_3	0.67					
	KD_4	0.82			0.84		
	KD_5	0.79			0.81		
KP - KI	KI_1	0.77	0.91	0.66	0.77	0.91	0.66
	KI_2	0.85			0.85		
	KI_3	0.79			0.79		
	KI_4	0.78			0.78		
	KI_5	0.87			0.87		
KP - OM	OM_1	0.88	0.94	0.74	0.88	0.94	0.74
	OM_2	0.90			0.90		
	OM_3	0.92			0.92		
	OM_4	0.85			0.85		
	OM_5	0.76			0.76		

Note. SCS (SG) =Science Centre Singapore
KP = Knowledge Process, KA = Knowledge Acquisition, KD = Knowledge Distribution, KI = Knowledge Interpretation, OM = Organizational Memory

3.6.2 Measurement Model Values – Organizational Culture Variable (OC)

At the NSM (TH), all the measurement items for clan culture (CC) had outer loadings higher than 0.70. However, one measurement item for adaptive culture (AC_1) had outer loading = 0.64. For mission culture (MC), two measurement items had an outer loading lower than 0.70, namely MC_2 = -0.02 and MC_4 = -0.13. The bureaucratic culture (BC) had two measurement items with an outer loading lower than 0.70, namely BC_1 = 0.59 and BC_4 = 0.60. Therefore, AC_1, MC_2, MC_4, BC_1, and BC_4 were deleted and the deletion increased the CR and AVE values, so this measurement item was also deleted for the structural model analysis. Details of measurement item values for the OC variable at the NSM (TH) are shown in Table 3-16.

At the SCE (TH), all the measurement items for adaptive culture (AC) and clan culture (CC) had outer loadings higher than 0.70. For mission culture (MC), two measurement items had an outer loading lower than 0.70, namely MC_2 = 0.60 and MC_4 = 0.62. The bureaucratic culture (BC) had one measurement item that had an outer loading lower than 0.70, namely BC_1 = 0.67. Therefore, MC_2, MC_4, and BC_1 were deleted, which increased CR and AVE values. Even though BC_3 and BC_4 had outer loading values below 0.70, these measurement items were kept for BC in order to maintain content validity. Furthermore, the single-item measures did not allow for the removal of measurement error, and they were only suited to sample sizes smaller than 50 (Hair et al. 2017). This study had a sample size bigger than 50, so the single-item measure was not applied. Details of measurement item values for the OC variable at the SCE (TH) are shown in Table 3-17.

At the SCS (SG), all the measurement items for clan culture (CC) had outer loadings higher than 0.70. However, one measurement item for adaptive culture had an outer loading lower than 0.70, namely AC_4 = 0.68. Two measurement items for mission culture (MC) had an outer loading lower than 0.70, namely MC_2 = -0.37 and MC_4 = -0.26. For bureaucratic culture (BC), one measurement item had an outer loading lower than 0.70, namely BC_2 = -0.08. Deletion of this measurement item increased the CR and AVE values, so BC_2 was deleted for the structural model analysis. Details of measurement item values for the OC variable at the SCS (SG) are shown in Table 3-18.

Table 3-16: Measurement Model Values – OC Variable at the NSM (TH)

Variables	Measurement Items	1st Calculation			2nd Calculation		
		Outer Loadings	CR	AVE	Outer Loadings	CR	AVE
OC – AC	AC_1	0.64	0.86	0.60		0.88	0.71
	AC_2	0.84			0.86		
	AC_3	0.84			0.89		
	AC_4	0.76			0.78		
OC – MC	MC_1	0.90	0.50	0.38	0.91	0.88	0.78
	MC_2	-0.02					
	MC_3	0.83			0.85		
	MC_4	-0.13					
OC – BC	BC_1	0.59	0.80	0.51		0.87	0.77
	BC_2	079			0.85		
	BC_3	0.84			0.91		
	BC_4	0.60					
OC – CC	CC_1	0.83	0.90	0.70	0.83	0.90	0.70
	CC_2	0.81			0.81		
	CC_3	0.83			0.83		
	CC_4	0.87			0.87		

Note. NSM (TH) = National Science Museum, Thailand
OC = Overall Organizational Culture, AC = Adaptive Culture, MC = Mission Culture, BC = Bureaucratic Culture, CC = Clan Culture

Table 3-17: Measurement Model Values – OC Variable at the SCE (TH)

Variables	Measurement Items	1st Calculation			2nd Calculation		
		Outer Loadings	CR	AVE	Outer Loadings	CR	AVE
OC – AC	AC_1	0.73	0.88	0.64	0.73	0.88	0.64
	AC_2	0.81			0.81		
	AC_3	0.88			0.88		
	AC_4	0.77			0.77		
OC – MC	MC_1	0.80	0.79	0.49	0.90	0.85	0.75
	MC_2	0.60					
	MC_3	0.76			0.83		
	MC_4	0.62					
OC – BC	BC_1	0.67	0.87	0.62		0.89	0.73
	BC_2	0.83			0.84		
	BC_3	0.88			0.90		
	BC_4	0.76			0.81		
OC – CC	CC_1	0.88	0.90	0.69	0.88	0.90	0.69
	CC_2	0.85			0.85		
	CC_3	0.83			0.83		
	CC_4	0.77			0.77		

Note. SCE (TH) = Science Centre for Education, Thailand
OC = Overall Organizational Culture, AC = Adaptive Culture, MC = Mission Culture, BC = Bureaucratic Culture, CC = Clan Culture

Table 3-18: Measurement Model Values – OC Variable at the SCS (SG)

Variables	Measurement Items	1st Calculation			2nd Calculation		
		Outer Loadings	CR	AVE	Outer Loadings	CR	AVE
OC – AC	AC_1	0.74	0.85	0.59	0.76	0.86	0.68
	AC_2	0.80			0.83		
	AC_3	0.84			0.87		
	AC_4	0.68					
OC – MC	MC_1	0.80	0.29	0.38	0.82	0.85	0.74
	MC_2	-0.37					
	MC_3	0.83			0.90		
	MC_4	-0.26					
OC – BC	BC_1	0.90	0.60	0.37	0.89	0.74	0.50
	BC_2	-0.08					
	BC_3	0.63			0.63		
	BC_4	0.50			0.56		
OC – CC	CC_1	0.92	0.94	0.79	0.92	0.94	0.79
	CC_2	0.91			0.91		
	CC_3	0.88			0.88		
	CC_4	0.84			0.84		

Note. SCS (SG) =Science Centre Singapore
OC = Overall Organizational Culture, AC = Adaptive Culture, MC = Mission Culture,
BC = Bureaucratic Culture, CC = Clan Culture

3.6.3 Measurement Model Values – Individual Learning (IL)

At the NSM (TH), all the measurement items for continuous learning (CL) and promotion of dialogues and inquiries (PI) had outer loadings higher than 0.70. However, the CR value of CL = 0.79, so the measurement item had to be deleted to increase the CR value to at least 0.80. Therefore, CL_2, which had the lowest outer loading, was deleted. Deletion of this measurement item increased the CR and AVE values enough to meet the criteria. Details of measurement item values for the IL variable at the NSM (TH) are shown in Table 3-19.

At the SCE (TH), all the measurement items for continuous learning (CL) and promotion of dialogues and inquiries (PI) had outer loadings higher than 0.70. The CR and AVE values met the criteria. Details of measurement item values for the IL variable at the SCE (TH) are shown in Table 3-20.

At the SCS (SG), all the measurement items for promotion of dialogues and inquiries (PI) had outer loadings higher than 0.70. However, one measurement item for continuous learning (CL) had an outer loading lower than 0.70, namely CL_2 = 0.69. Deletion of this measurement item increased the CR and AVE values, so CL_2 was deleted for the structural model analysis. Details of measurement item values for the IL variable at the SCS (SG) are shown in Table 3-21.

Table 3-19: Measurement Model Values – IL Variable at the NSM (TH)

Variables	Measurement Items	1st Calculation			2nd Calculation		
		Outer Loadings	CR	AVE	Outer Loadings	CR	AVE
IL – CL	CL_1	0.77	0.80	0.66	0.82	0.80	0.66
	CL_2	0.72					
	CL_3	0.73			0.81		
IL – PI	PI_1	0.91	0.88	0.71	0.91	0.88	0.71
	PI_2	0.82			0.82		
	PI_3	0.78			0.78		

Note. NSM (TH) = National Science Museum, Thailand
IL = Individual Learning, CL = Continuous learning, PI = Promotion of dialogues and inquiries

Table 3-20: Measurement Model Values – IL Variable at the SCE (TH)

Variables	Measurement Items	1st Calculation		
		Outer Loadings	CR	AVE
IL – CL	CL_1	0.85	0.87	0.69
	CL_2	0.80		
	CL_3	0.84		
IL – PI	PI_1	0.90	0.84	0.64
	PI_2	0.76		
	PI_3	0.73		

Note. SCE (TH) = Science Centre for Education, Thailand
IL = Individual Learning, CL = Continuous learning,
PI = Promotion of dialogues and inquiries

Table 3-21: Measurement Model Values – IL Variable at the SCS (SG)

Variables	Measurement Items	1st Calculation			2nd Calculation		
		Outer Loadings	CR	AVE	Outer Loadings	CR	AVE
IL – CL	CL_1	0.87	0.84	0.64	0.89	0.94	0.74
	CL_2	0.69					
	CL_3	0.83			0.90		
IL – PI	PI_1	0.84	0.88	0.71	0.84	0.88	0.71
	PI_2	0.82			0.82		
	PI_3	0.86			0.86		

Note. SCS (SG) =Science Centre Singapore
IL = Individual Learning, CL = Continuous learning opportunities,
PI = Promotion of dialogues and inquiries

3.6.4 Measurement Model Values – Discriminant Validity

The discriminant validity was achieved by the calculation of the square root of the AVE. The discriminant validity was considered sufficient when the square root of the AVE of each variable was higher than the variable's correlation with any other variables (Fornell and Larcker, 1981; Hair et al., 2017; Wetzels et al., 2009). In this study, the square root of the AVE of the variable in each science museum was higher than the correlation with other variables. These values confirmed the distinctness of the variables from each other and indicated sufficient discriminant validity for the hypothesis testing. The square root of the AVE at each science museum is shown in Tables 3-22, 3-23 and 3-24.

Table 3-22: Intercorrelations of the Latent Variables for First-Order Variables at the NSM (TH)

Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1. AC	0.84									
2. MC	0.51	0.88								
3. BC	0.46	0.44	0.88							
4. CC	0.53	0.37	0.36	0.84						
5. KA	0.49	0.31	0.32	0.53	0.74					
6. KD	0.45	0.14	0.28	0.58	0.62	0.79				
7. KI	0.55	0.30	0.31	0.65	0.65	0.66	0.75			
8. OM	0.52	0.18	0.23	0.52	0.51	0.58	0.63	0.84		
9. CL	0.52	0.30	0.31	0.60	0.46	0.52	0.54	0.45	0.82	
10. PI	0.51	0.28	0.28	0.63	0.44	0.49	0.59	0.48	0.71	0.84

Note. AC=Adaptive Culture, MC=Mission Culture, BC=Bureaucratic Culture, CC=Clan Culture
KA=Knowledge Acquisition, KD=Knowledge Distribution, KI=Knowledge Interpretation, OM=Organizational Memory
CL=Continuous learning opportunities, PI=Promotion of dialogues and inquiries
** Square root of the AVE on the diagonal

Table 3-23: Intercorrelations of the Latent Variables for First-Order Variables at the SCE (TH)

Variables	1	2	3	4	5	6	7	8	9	10
1. AC	0.80									
2. MC	0.65	0.86								
3. BC	0.47	0.39	0.85							
4. CC	0.64	0.51	0.64	0.83						
5. KA	0.36	0.36	0.31	0.54	0.86					
6. KD	0.54	0.31	0.33	0.55	0.41	0.80				
7. KI	0.50	0.33	0.36	0.55	0.51	0.71	0.85			
8. OM	0.50	0.33	0.35	0.50	0.29	0.67	0.64	0.83		
9. CL	0.58	0.32	0.33	0.51	0.25	0.65	0.49	0.64	0.83	
10. PI	0.61	0.40	0.32	0.57	0.34	0.53	0.57	0.57	0.77	0.80

Note. AC=Adaptive Culture, MC=Mission Culture, BC=Bureaucratic Culture, CC=Clan Culture
KA=Knowledge Acquisition, KD=Knowledge Distribution, KI=Knowledge Interpretation, OM=Organizational Memory
CL=Continuous learning opportunities, PI=Promotion of dialogues and inquiries
** Square root of the AVE on the diagonal

Table 3-24: Intercorrelations of the Latent Variables for First-Order Variables at the SCS (SG)

Variables	1	2	3	4	5	6	7	8	9	10
1. AC	0.82									
2. MC	0.71	0.86								
3. BC	0.56	0.65	0.71							
4. CC	0.55	0.47	0.47	0.89						
5. KA	0.44	0.33	0.43	0.58	0.85					
6. KD	0.35	0.27	0.34	0.47	0.67	0.83				
7. KI	0.46	0.44	0.51	0.58	0.69	0.72	0.81			
8. OM	0.32	0.28	0.39	0.53	0.61	0.64	0.78	0.86		
9. CL	0.42	0.42	0.24	0.58	0.50	0.46	0.53	0.64	0.89	
10. PI	0.52	0.41	0.38	0.70	0.59	0.42	0.61	0.60	0.67	0.84

Note. AC=Adaptive Culture, MC=Mission Culture, BC=Bureaucratic Culture, CC=Clan Culture
KA=Knowledge Acquisition, KD=Knowledge Distribution, KI=Knowledge Interpretation, OM=Organizational Memory
CL=Continuous learning opportunities, PI=Promotion of dialogues and inquiries
** Square root of the AVE on the diagonal

3.7 Test of Formative Model

The assessment of the formative model of the HOC models of OC, KP, and IL was done using a two-stage approach as suggested by Becker et al. (2012). First, each model was estimated with the lower-order variables linked to the final endogenous variable (i.e., individual learning). Then, the latent variable scores of each lower-order variable were saved. The latent variable scores from the first stage as formative indicators were used for the second-order variables.

An assessment of the formative model examined the collinearity of the indicators and the variance inflation factor (VIF) and the significance of the statistical contribution of each indicator to the main construct. VIF values below the critical value of 5 indicated that no multicollinearity existed among the indicators. The outer weight values of all formative indicators showed evidence of relative contributions to the main construct, as the values were not equal to zero. According to Hair et al. (2017), even if some outer weights are not significant at the 1% level, if the outer loadings are significant at the 1% level, these indicators are still relatively important to the construct and should be retained. However, the outer weights with negative values show high collinearity of the indicators, which can cause a false interpretation of the results and a misleading conclusion.

At the NSM (TH), MC had a negative value for its outer weights = -0.09. Therefore, MC was deleted from the formative indicators for OC. At the SCE (TH), MC and BC had a negative value for their outer weight, with MC = -0.11 and BC = -0.07. Therefore, MC and BC were deleted for the case of the SCE (TH). At the SCS (SG), KD had a negative value (KD = -0.15), so it was deleted for the case of the SCS (SG).

Tables 3-25, 3-26, and 3-27 show the values for the formative model test at each science museum.

Table 3-25: Variance Inflation Factor (VIF) and Formative Indicators Significance Testing Results at the NSM (TH)

Formative Variables	Formative Indicators	VIF	Outer Weights	Outer Loadings
OC	AC	1.76	0.45***	0.79***
	MC	1.46	-0.09	0.41***
	BC	1.39	0.02	0.45***
	CC	1.44	0.73***	0.93***
KP	KA	1.94	0.14	0.76***
	KD	2.12	0.26**	0.82***
	KI	2.44	0.52***	0.93***
	OM	1.81	0.24**	0.78***
IL	CL	2.04	0.49***	0.91***
	PI	2.04	0.59***	0.94***

Note. *** Significance level $p < 0.01$, ** Significance level $p < 0.05$, VIF = Variance Inflation Factor
NSM (TH) = National Science Museum, Thailand
OC = Overall Organizational Culture, AC = Adaptive Culture, MC = Mission Culture,
BC = Bureaucratic Culture, CC = Clan Culture
KP = Knowledge Process, KA = Knowledge Acquisition, KD = Knowledge Distribution,
KI = Knowledge Interpretation, OM = Organizational Memory
IL = Individual Learning, CL = Continuous learning, PI = Promotion of dialogues and inquiries

Table 3-26: Variance Inflation Factor (VIF) and Formative Indicators Significance Testing Results at the SCE (TH)

Formative Variables	Formative Indicators	VIF	Outer Weights	Outer Loadings
OC	AC	2.23	0.64***	0.91***
	MC	1.79	-0.11	0.58***
	BC	1.71	-0.07	0.56***
	CC	2.28	0.59***	0.89***
KP	KA	1.37	0.21**	0.58***
	KD	2.44	0.43	0.90***
	KI	2.52	0.15	0.83***
	OM	2.03	0.43**	0.87***
IL	CL	2.47	0.55**	0.95***
	PI	2.47	0.51**	0.94***

Note. *** Significance level $p < 0.01$, ** Significance level $p < 0.05$, VIF = Variance Inflation Factor
SCE (TH) = Science Centre for Education, Thailand
OC = Overall Organizational Culture, AC = Adaptive Culture, MC = Mission Culture,
BC = Bureaucratic Culture, CC = Clan Culture
KP = Knowledge Process, KA = Knowledge Acquisition, KD = Knowledge Distribution,
KI = Knowledge Interpretation, OM = Organizational Memory
IL = Individual Learning, CL = Continuous learning, PI = Promotion of dialogues and inquiries

Table 3-27: Variance Inflation Factor (VIF) and Formative Indicators Significance Testing Results at the SCS (SG)

Formative Variables	Formative Indicators	VIF	Outer Weights	Outer Loadings
OC	AC	2.35	0.19	0.71***
	MC	2.52	0.02	0.61***
	BC	1.87	0.12	0.62***
	CC	1.52	0.80***	0.97***
KP	KA	2.20	0.48***	0.88***
	KD	2.42	-0.15	0.69***
	KI	3.59	0.40	0.91***
	OM	2.68	0.37	0.87***
IL	CL	1.81	0.33	0.83***
	PI	1.81	0.75***	0.97***

Note. *** Significance level $p < 0.01$, ** Significance level $p < 0.05$, VIF = Variance Inflation Factor
(SG) = Science Centre Singapore
OC = Overall Organizational Culture, AC = Adaptive Culture, MC = Mission Culture,
BC = Bureaucratic Culture, CC = Clan Culture
KP = Knowledge Process, KA = Knowledge Acquisition, KD = Knowledge Distribution,
KI = Knowledge Interpretation, OM = Organizational Memory
IL = Individual Learning, CL = Continuous learning, PI = Promotion of dialogues and inquiries

3.8 Coding Frame with Results from Interviews

The coding frame was established by following the name of independent variables (OC and KP) and the measurement items of each variable used for the quantitative analysis. Items that measured each indicator of KP were separated into sub-items. The details of the coding frame and counts of interviewees' replies for each category are presented in Tables 3-28 and 3-29.

Table 3-28: Coding Frame and Counts of Interviewees' Replies about Knowledge Process

Variables	Dimensions	Counts		
		NSM (TH)	SCE (TH)	SCS (SG)
KP	KA			
	• Policy and resources for R&D and testing ideas	46	50	51
	• Collect information about museums and trends	58	49	41
	• Join events	23	18	33
	• Cooperation with other organizations	8	8	9
	KD			
	• Meeting and sharing idea	32	31	40
	• Knowledge transfer by different sources	31	22	20
	• Coordinator	16	11	14
	• Sharing best practices	3	4	4
	KI			
	• Staff work, discuss together to solve problems	26	14	34
	• Utilize previous experiences to solve problems	10	12	16
	• Apply experience into rules, ways of working, and training material	10	11	8
	OM			
	• Existing of databases.	24	31	21
	• Database usage	26	15	17
	• Database updating	10	7	15
	• Access to database	7	4	9
	• Database is easy to use.	6	3	4

Note. NSM (TH) = National Science Museum, Thailand, SCE (TH) = Science Centre for Education, Thailand, SCS (SG) = Science Centre Singapore
KP = Knowledge Process, KA = Knowledge Acquisition, KD = Knowledge Distribution,
KI = Knowledge Interpretation, OM = Organizational Memory

Table 3-29: Coding Frame and Counts of Interviewees' Replies about Organizational Culture

Variables	Dimensions	Counts		
		NSM (TH)	SCE (TH)	SCS (SG)
OC	AC	15	12	14
	MC	10	5	4
	BC	11	6	5
	CC	11	16	9

Note. NSM (TH) = National Science Museum, Thailand,
SCE (TH) = Science Centre for Education, Thailand,
SCS (SG) = Science Centre Singapore
OC = Overall Organizational Culture, AC = Adaptive Culture, MC = Mission Culture,
BC = Bureaucratic Culture, CC = Clan Culture

Chapter 4

Knowledge Process and Individual Learning Development in the Staff of Science Museums

This chapter reports the results from the survey in order to test the following hypothesis about the influence of knowledge process on individual learning in science museum staff. The hypothesis is as follows:

H1: Knowledge process influences individual learning in science museum staff.

The analysis was conducted by using knowledge process as an independent variable and individual learning as a dependent variable. First, the results from the quantitative analysis are presented. Then the results from the qualitative method are analyzed to explain the causes of the relationships identified in the quantitative analysis.

4.1 Quantitative Analysis of the Influence of Knowledge Process on Individual Learning

The quantitative analysis was conducted by using PLS-SEM. In addition, the hierarchical component model (HCM) with two-stage approach was utilized to estimate the model. The details of the analysis are as follows.

4.1.1 Measurement Model

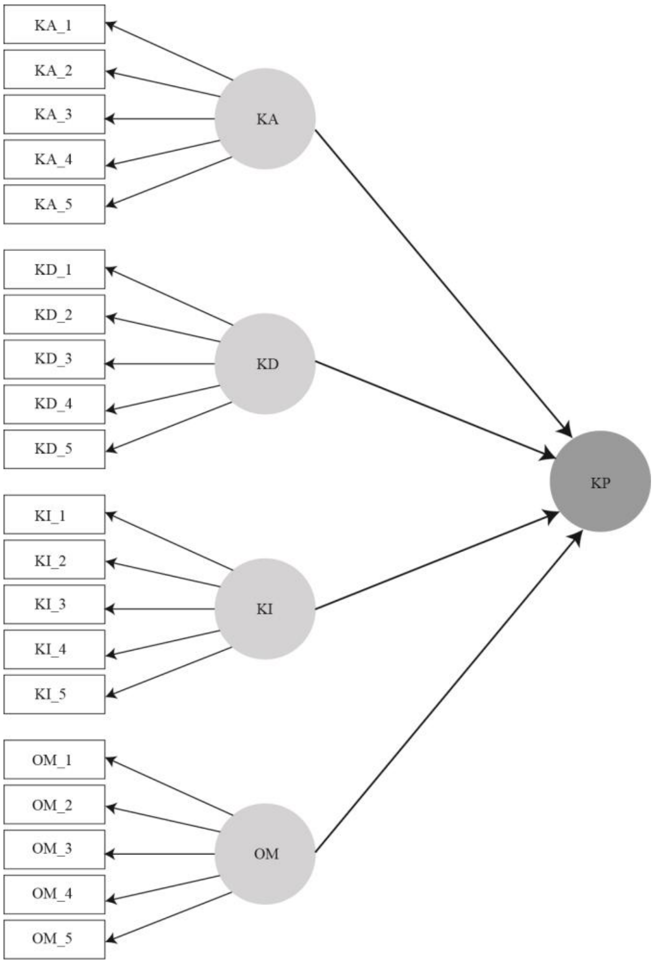
The knowledge process (KP) variable, which is the higher-order independent variable, was measured by four lower-order variables: knowledge acquisition (KA), knowledge dissemination (KD), knowledge interpretation (KI), and organizational memory (OM). Each lower-order variable was measured by five measurement items.

The individual learning (IL) variable, which is the higher-order dependent variable, was measured by two lower-order variables: create continuous learning opportunities (CL) and promote inquiries and dialogues (PI). There were three measurement items for each lower-order variable.

The details of the lower-order variables and measurement items used to measure the KP variable are shown in Figure 4-1, and the lower-order variables and measurement items used to measure the IL variable are shown in Figure 4-2.

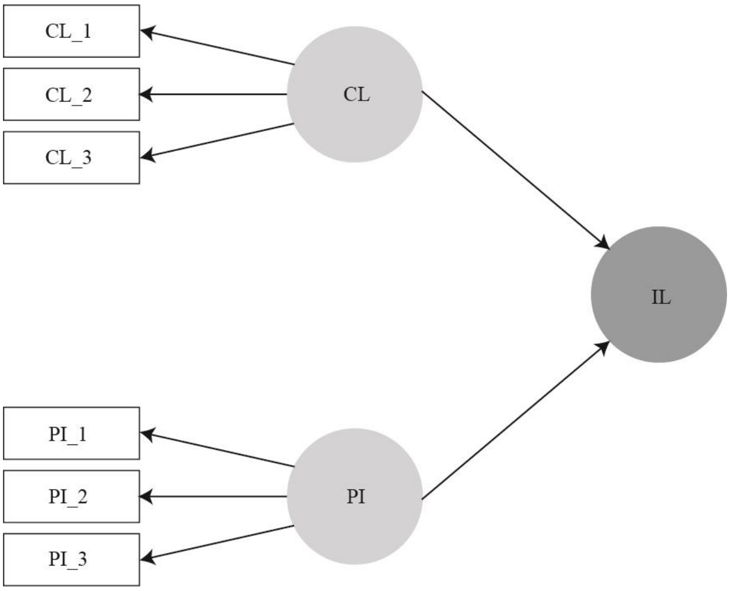
For the analysis of the KP variable, some additional measurement items were deleted according to the criteria for the measurement model. KD_1 was deleted for the analysis of NSM (TH). KA_1, KA_4, KA_5, KI_1, and KI_2 were deleted for the analysis of SCE (TH). KA_1, KA_3, and KD_3 were deleted for the analysis of the SCS (SG). For the analysis of IL, CL_2 was deleted for the analysis of the NSM (TH) and SCS (SG).

Figure 4-1: Details of Lower-Order Variables and Measurement Items to Measure Knowledge Process



Note. ** Some items were deleted for analysis in each science museum by referring to the measurement model testing results.
KP = Knowledge Process, KA = Knowledge Acquisition,
KD = Knowledge Distribution, KI = Knowledge Interpretation,
OM = Organizational Memory

Figure 4-2: Lower-Order Variables and Measurement Items to Measure Individual Learning



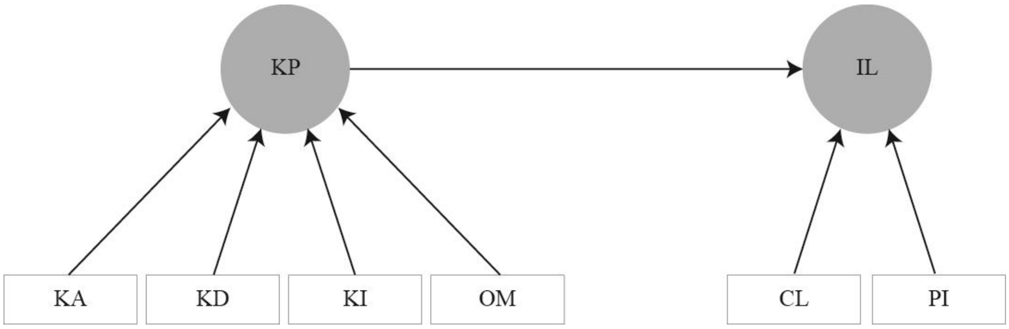
Note. ** Some items were deleted for analysis in each science museum by referring to the measurement model testing results.
IL = Individual Learning, CL = Continuous learning opportunities,
PI = Promotion of dialogues and inquiries

4.1.2 Structural Model

The reflective-formative HCM with two-stage approach was adopted for the analysis of the influence of knowledge process on individual learning. Knowledge process (KP) was observed through the measurement items of knowledge acquisition (KA), knowledge distribution (KD), knowledge interpretation (KI), and organizational memory (OM). Individual learning (IL) was observed through the measurement items of continuous learning (CL) and promotion of dialogues and inquiries (PI). At the first stage, the LOC values (KA, KD, KI, OM, CL, and PI) were calculated, and their influence on IL was tested. Then LOC values were used as the values to calculate the HOC values (KP and IL) in the second stage. The conceptual model for hypothesis testing is demonstrated in Figure 4-3.

At the SCS (SG), the LOC-KD had a negative value, which could cause a false interpretation of the results and a misleading conclusion, as suggested by Hair et al. (2017). Therefore, this LOC variable was not included for the analysis of the SCS (SG).

Figure 4-3: Conceptual Model to Test Hypothesis about Influence of Knowledge Process on Individual Learning



Note. KP = Knowledge Process, KA = Knowledge Acquisition, KD = Knowledge Distribution,
KI = Knowledge Interpretation, OM = Organizational Memory
IL = Individual Learning, CL = Continuous learning opportunities,
PI = Promotion of dialogues and inquiries

4.1.3 Influence by Knowledge Process on Individual Learning

Firstly, the influence of knowledge process on individual learning was analyzed by observing influence in terms of the individual activities within a knowledge process. Then the influence of knowledge process, as a variable including every activity, was analyzed.

i. Influence by Knowledge Process on Individual Learning at the NSM (TH)

The analysis of the influence of each knowledge process activity on individual learning at the NSM (TH) shows that none of the four activities (i.e. knowledge acquisition, knowledge distribution, knowledge interpretation, and organizational memory) significantly influenced individual learning at $p < 0.05$. However, knowledge process overall, including all four activities, significantly influenced individual learning at the NSM (TH) with the value of ß = 0.27, $p < 0.05$. Table 4-1 presents the results regarding the relationship between knowledge process and individual learning at the NSM (TH).

Table 4-1: Structural Model Analysis Results for Knowledge process and Individual Learning at the NSM (TH)

Relationships	Beta	SE	*t*-value	*p*-value
KA -> IL	0.00	0.09	0.03	0.97
KD -> IL	0.10	0.08	1.23	0.22
KI -> IL	0.17	0.10	1.77	0.08
OM -> IL	0.04	0.08	0.58	0.56
KP -> IL	0.27**	0.09	3.09	0.00

Note. ** Significance level $p < 0.05$
KP = Knowledge Process, KA = Knowledge Acquisition,
KD = Knowledge Distribution, KI = Knowledge Interpretation,
OM = Organizational Memory
IL = Individual Learning

ii. Influence by Knowledge Process on Individual Learning at the SCE (TH)

The analysis of the influence of each knowledge process activity on individual learning at the SCE (TH) shows that knowledge acquisition, knowledge distribution, and knowledge interpretation did not significantly influence individual learning. The only activity that significantly influenced individual learning was organizational memory. The influence had the value of ß = 0.32 at p < 0.05. In addition, knowledge process overall, including all four activities, influenced individual learning at the SCE (TH) with the value of ß = 0.45, p < 0.05. Table 4-2 presents the results regarding the relationship between knowledge process and individual learning at the NSM (TH).

Table 4-2: Structural Model Analysis Results for Knowledge process and Individual Learning at the SCE (TH)

Relationships	Beta	SE	*t*-value	*p*-value
KA -> IL	-0.08	0.13	0.61	0.54
KD -> IL	0.22	0.20	1.11	0.27
KI -> IL	0.02	0.19	0.10	0.92
OM -> IL	0.32**	0.13	2.58	0.01
KP -> IL	0.45**	0.14	3.14	0.00

Note. ** Significance level $p < 0.05$
KP = Knowledge Process, KA = Knowledge Acquisition,
KD = Knowledge Distribution, KI = Knowledge Interpretation,
OM = Organizational Memory
IL = Individual Learning

iii. Influence by Knowledge Process on Individual Learning at the SCS (SG)

The analysis of the influence of each knowledge process activity on individual learning at the SCS (SG) shows that knowledge acquisition, knowledge distribution, and knowledge interpretation did not significantly influence individual learning. The only activity that significantly influenced individual learning was organizational memory. The influence had the value of ß = 0.38 at $p < 0.05$. In addition, knowledge process overall, including all four activities, influenced individual learning at the SCE (TH) with the value of ß = 0.41, $p < 0.05$. Table 4-3 presents the results regarding the relationship between knowledge process and individual learning at the SCS (SG).

Table 4-3: Structural Model Analysis Results for Knowledge process and Individual Learning at the SCS (SG)

Relationships	Beta	SE	*t*-value	*p*-value
KA -> IL	0.16	0.13	1.25	0.21
KD -> IL	-0.11	0.17	0.68	0.50
KI -> IL	0.01	0.18	0.07	0.94
OM -> IL	0.38**	0.17	2.22	0.03
KP -> IL	0.41**	0.16	2.61	0.01

Note. ** Significance level $p < 0.05$
KP = Knowledge Process, KA = Knowledge Acquisition,
KD = Knowledge Distribution, KI = Knowledge Interpretation,
OM = Organizational Memory
IL = Individual Learning

4.2 Qualitative Analysis for the Influence of Knowledge Process on Individual Learning

The interview transcripts were analyzed by creating coding frames relating to different aspects of KA, KD, KI, and OM by referring to questionnaire questions. Then key points that were mentioned by interviewees regarding each knowledge activity were extracted. Details from interviewees that explain the different influences of knowledge process activities are provided in the following sub-sections.

4.2.1 Knowledge Acquisition

Interviewees were asked to share their opinions about different aspects that they perceived related to KA at their science museums. Generally, the interviewees mentioned using a variety of sources to retrieve knowledge. However, the interviewees also noted that sources that provide specific knowledge, such as training on topics relevant to work, study trips, or science museum conferences, are insufficient. Table 4-4 provides an overview of the knowledge acquisition perceived by staff at the three science museums. Details from the interview transcripts are provided afterward.

Table 4-4: Interviewees' Views of Knowledge Acquisition

Museum	Knowledge Acquisition	
	Variety of Knowledge Sources	Insufficient Opportunities to Achieve Relevant Knowledge
NSM (TH)	12/12	9/12
SCE (TH)	10/10	6/10
SCC (SG)	10/10	6/10

Note. NSM (TH) = National Science Museum, Thailand, SCE (TH) = Science Centre for Education, Thailand, SCS (SG) = Science Centre Singapore
n/N refers to 'N' = total interviewees, 'n' = the number of interviewees that mentioned about the topic

Interviewees at the three science museums expressed that their knowledge acquisition occurs through the following different sources:

> *I always search information from websites and discuss with visitors to apply their opinions to improve my work. (Interviewee 1 (NSM-TH))*

> *Internet is a quick channel where I can get information that I need urgently. I also talk to the teachers who accompany their students in our educational program. How do they feel about our activities? What should be improved? (Interviewee 4 (NSM-TH))*

> *Previously, the source I used most was textbooks, and journals were the second. Now I use internet, also meeting with experts. (Interviewee 1 (SCE-TH))*

> *I use the library because at our science museum we have a library and we have many books about [subject redacted]. Sometimes I discuss with experts, and I also use electronic sources. (Interviewee 5 (SCE-TH))*

So you can see there are books, there is internet. . . . You know, when I meet people, I try to see what the person is doing, so I gain knowledge also at that time. (Interviewee 8 (SCS-SG))

I go through a lot of research beforehand. So, for example, if I get the topic that I'm supposed to do, and that is on dinosaurs, then I will refer first to Google, Wikipedia, and then I will cross reference that [information] with proper books. We have a lot of references in the science center, so I get books from there, and then I look for those who are more experienced in the topic. (Interviewee 9 (SCS-SG))

Examples of interviewees' opinions about the insufficient opportunities to access relevant knowledge are as follows:

We had chances to go for study trips, but not so often. We would like to go, but there was no opportunity. So sad, right? If we can see how other science museums work by ourselves, we can understand, and we can tell other staff in our department about [subject redacted], [we can tell them] clearly how we should do it. But we understand that it costs a lot. (Interviewee 7 (NSM-TH))

I don't have training regularly, and the relevant trainings were not very frequent. I need to look for the course that is related to my work and send a request for participation. (Interviewee 10 (NSM-TH))

We have little training. I observed during these 2 years there were not many training sessions arranged, not within our museum or with sending staff to have external training. (Interviewee 7 (SCE-TH))

So far, we have not done much training because we are very busy, also we lack budget. We need to maintain our exhibitions and other activities, so we do not have much budget left for training. But we have plans for our training course. (Interviewee 2 (SCE-TH))

Not often, as in [name of department]. We do not have the chance to go because we do have a network of science centers and museums where we have conferences, annual conferences, and the topics are usually on science, but not on [subject]. So [name of department] has few opportunities to go oversea for learning from them. (Interviewee 3 (SCS-SG))

If we have time, we may even try to go for any interesting courses, but finding relevant courses to what I'm doing is not so easy. (Interviewee 7 (SCS-SG))

4.2.2 Knowledge Distribution

Knowledge distribution was also found to have an insignificant influence in all three science museums. The results from the interviews demonstrate that there were events (e.g., meetings, sharing sessions) that allowed staff to occasionally discuss their experience. However, staff members mentioned that there was a lack of personnel with an explicit role in collecting and distributing knowledge within the department or between different units. Some interviewees stated that there was no coordinator, and others stated that there was a coordinator, but that this individual's main duty was not knowledge distribution. Table 4-5 provides an overview of the knowledge distribution perceived by staff at the three science museums. Details from the interview transcripts are provided afterward.

Table 4-5: Interviewees' Views of Knowledge Distribution

Museum	Knowledge Distribution	
	Events for Discussion	Lack of Explicit Knowledge Coordinator
NSM (TH)	12/12	12/12
SCE (TH)	10/10	8/10
SCC (SG)	10/10	7/10

Note. NSM (TH) = National Science Museum, Thailand, SCE (TH) = Science Centre for Education, Thailand, SCS (SG) = Science Centre Singapore
n/N refers to 'N' = total interviewees, 'n' = the number of interviewees that mentioned about the topic

Interviewees at the three science museums described opportunities for knowledge distribution via discussion as follows:

> *I always have meetings. Like, for [name of subject], we meet at least once a week. And we also have monthly department meetings. In these meetings, we can talk about, discuss, or share what we know. We also discuss new activity in these meetings. (Interviewee 8 (NSM-TH))*

> *We have regular meetings for different events. Organization wide, we meet every two or three months, but in our department, we meet every week to exchange information about our work and the progress we have made. (Interviewee 9 (NSM-TH))*

> *Usually we have meetings once a month or sometimes two months. Each time we will assign the staff to present their new ideas or new knowledge that they have received. (Interviewee 2 (SCE-TH))*

> *Every month we have meetings that everyone at our museum will attend. But we meet quite often with the group that we work with, sometimes 2-4 times a month. (Interviewee 10 (SCE-TH))*

> *The main one would be management meetings, so once a month, we have it. We also have a planning committee that comes together, and we update each other. There are varieties of meetings. (Interviewee 1 (SCS-SG))*

> *Our team is very small. If we are talking about [name of subject], we've got five or six of us. We do get together and discuss our ideas together, and we work closely with our team. (Interviewee 3 (SCS-SG))*

Examples of interviewees' opinions about the lack of an explicit knowledge coordinator are as follows:

> *No we don't have a coordinator between different departments of our museum. It's a good question. It seems like we have this kind of staff, but not a clear and regular role. (Interviewee 7 (NSM-TH))*

I think if we had a coordinator it would be easier to manage our works and we could work faster. The coordinator would know that it's their job to distribute knowledge to other staff, and staff who want knowledge would also know who they should contact to receive knowledge. So it would be good for both sides. (Interviewee 8 (NSM-TH))

It would be good if we could have staff who coordinated between different sections, but I know that it is difficult to do that. Now the staff of the [name of section] seem to act as coordinators. (Interviewee 8 (SCE-TH))

At our museum we have meetings and discuss different things at the meetings. It's only that. We don't have staff who coordinate with different sections and gather knowledge for us. (Interviewee 2 (SCE-TH))

There is no such role explicitly. I think it really depends on specific questions or specific issues. There will be a team coordinating, but center wide there is not. (Interviewee 1 (SCS-SG))

I think managers are not concerned as coordinator. There are managers. They are bridges. . . . So the managers are the bridge to collect information and then feed in who is suitable for that area. (Interviewee 9 (SCS-SG))

4.2.3 Knowledge Interpretation

Knowledge interpretation had an insignificant influence on individual learning in all three science museums. Staff members said that including different expertise in work is important and routinely conducted. However, most of the interviewees reported that turning their knowledge or experiences into material or making use of the materials are rare in science museums. Table 4-6 provides an overview of the knowledge interpretation perceived by staff at the three science museums. Details from the interview transcripts are provided afterward.

Table 4-6: Interviewees' Views of Knowledge Interpretation

Museum	Knowledge Interpretation	
	Inclusion of Different Expertise to Work	Lack of Turning Knowledge into Materials or Making Use of Materials
NSM (TH)	11/12	7/12
SCE (TH)	9/10	7/10
SCC (SG)	9/10	6/10

Note. NSM (TH) = National Science Museum, Thailand, SCE (TH) = Science Centre for Education, Thailand, SCS (SG) = Science Centre Singapore
n/N refers to 'N' = total interviewees, 'n' = the number of interviewees that mentioned about the topic

Interviewees at the three science museums described the importance of including different expertise in their work for knowledge interpretation as follows:

> *It's very useful to work with others. Different people have different ideas, and we can learn from them. It's also fun because we have to deal with people who have different working styles. (Interviewee 3 (NSM-TH))*

> *I can't work by myself. I know that by myself I don't have good ideas to work. When I work with others, I can learn from them and create good ideas for my work. When I have to think by myself, I feel really dull. (Interviewee 8 (NSM-TH))*

> *When we start a new project, at the beginning we have staff from different departments come discuss their ideas with us. Then we try to make the prototype, and we invite them to test it and give us comments. We always have different staff involved in this process. (Interviewee 2 (SCE-TH))*

> *Working with others is very helpful because I don't know everything. We learn from them, and they also learn from me. Actually, it also helps us to maintain a close relationship. Sometimes we have arguments or think differently, but it is a general thing when we work together. (Interviewee 8 (SCE-TH))*

When we do our new [name of product], we actually call for nominees. We call for brainstorming first, with people from [name of department], but we also call our staff from [name of department], [name of department]. We get different ideas, and then that's really when we take on and develop it. (Interviewee 3 (SCS-SG))

When we are doing a new project, sometimes we talk to a project officer who's doing a similar project to understand what are the pitfalls that they have faced. We ask about what learning points they can share with us. (Interviewee 6 (SCS-SG))

Examples of interviewees' opinions about problems with interpreting knowledge into material or making use of knowledge material are as follows:

We have many training materials, which is a part of knowledge management. Everyone does it because it is for annual performance evaluation. But do we really make use of the materials or not, that's my question? (Interviewee 4 (NSM-TH))

By knowledge management policy, we produce many materials. I think more than ten that we have. But for the real use we need to consider about that. It could be motivation for our works. Now it depends on the management when they ask staff in some departments to review they will do it. (Interviewee 8 (NSM-TH))

Per knowledge management policy, we produce many materials. I can think of more than ten manuals that we have. But for the real use, we need to consider about that. It could be motivation for our work. Now it depends on the management, when they ask staff in some departments to review, they will do it. (Interviewee 8 (NSM-TH))

We have few staff in our section. It's our dream to produce training material, but we don't have time to do it. Our daily jobs already take all of our time. (Interviewee 6 (SCE-TH))

That's one of the weaknesses that we have for the science center, our record of previous exercises like that. About 7 years ago, we went to this before exploring, moving to the same location as well, which eventually did not materialize because of budget. So having access to all the documents that then it's not centralized system need to get it from individual. Some of them have left so fortunately they left behinds some of the records. So I need to get together these things. (Interviewee 1 (SCS-SG))

I don't think we exactly document our knowledge or experience, but we do set certain procedures in place. And we do exercise the procedures, and across the broad organization what everybody knows about these procedures. (Interviewee 6 (SCS-SG))

4.2.4 Organizational Memory

Regarding organizational memory, there was significant influence at the SCE (TH) and SCS (SG). Staff mentioned usage of databases in their work. On the contrary, there was insignificant influence at the NSM (TH). The staff indicated that technical problems made them distrustful of storing knowledge in the database. In addition, some staff mentioned lack of awareness of the existing database. Table 4-7 provides an overview of the organizational memory perceived by staff at the three science museums. Details from the interview transcripts are provided below.

Table 4-7: Interviewees' Views of Organizational Memory

Museum	Organizational Memory	
	Awareness and Usage of Database	Reliable Technology
NSM (TH)	3/12	2/12
SCE (TH)	9/10	7/10
SCC (SG)	7/10	7/10

Note. NSM (TH) = National Science Museum, Thailand, SCE (TH) = Science Centre for Education, Thailand, SCS (SG) = Science Centre Singapore
n/N refers to 'N' = total interviewees, 'n' = the number of interviewees that mentioned about the topic

Interviewees at the three science museums expressed their opinions about organizational memory in terms of awareness and usage of a database as follows:

> *I tell you, frankly, I don't know about our database. I don't know how our staff upload information or whether there are staff who take care of the system that supports the database of our museum. (Interviewee 3 (NSM-TH))*

> *I would say that it's in the middle of have and don't have a database. While we are informed that we have a database for organization-wide usage, it doesn't link among different sections, so I don't know. There could be a database or there might not be. (Interviewee 10 (NSM-TH))*

> *The database is very useful, actually, but it depends on how often our staff use it. What we do is, after we upload the knowledge on the database, we also inform others about the uploading. I think it's a good channel for distributing knowledge. (Interviewee 7 (SCE-TH))*

> *We have a shared folder for our science museum. I always check out knowledge or information from other departments and use it for my work. I also upload data on this shared folder. (Interviewee 8 (SCE-TH))*

> *For our documents, we've got our document management system. So it's an online thing that we deposit all the relevant documents from the projects into. So if any new officers, whenever they want to find out how a thing has been done, all documents are in there. They can find out. (Interviewee 3 (SCS-SG))*

> *In terms of this knowledge management policy, because we have document sharing system, it's a shared platform across all the staff, so if you want to share things, you can actually store them there. And we can always retrieve things from that system, so that is more of open platform whereby you can access certain things. (Interviewee 6 (SCS-SG))*

The following are examples of interviewees' opinions about how reliable database systems are:

> *The system of our database really has problems. We were attacked by a virus, and the system was demolished. All the information that I had uploaded was lost, so I think we should not keep anything there. (Interviewee 6 (NSM-TH))*

> *Our database is quite convenient to use, but recently the system was collapsing, and we were frightened by that. We need to back up information and update what we have, but it's not easy. (Interviewee 7 (NSM-TH))*

> *We have shared data, and it is safe from viruses. We can download information from the system. We don't need to bring flash drives to save data from other sources, which is quite risky with virus infection. (Interviewee 3 (SCE-TH))*

> *Our ICT department has already set up a good system for everyone. Sometimes we don't use it so often, and they will send us a notice to make us more active in using the database. (Interviewee 2 (SCE-TH))*

> *Yes, the storage facility is easy because we create our own folders. I co-share the permission with a few people including [names of people]. . . . So far, it's ok. It's a storage and retrieval system. (Interviewee 4 (SCS-SG))*

> *So, in terms of this information, because we already have the existing system, so we actually put the record out for the system. In terms of initial understanding of the system, there is always a domain expert that we will always refer to. In case we encounter any issues, we check with the domain expert. (Interviewee 6 (SCS-SG))*

4.3 Hypothesis Testing

This chapter has discussed the results from the quantitative and qualitative analyses about the influence of knowledge process on individual learning. The results from this chapter provide a response to RQ 1: Can knowledge process lead to learning in science museum staff? The hypothesis for testing the research question is as follows:

H1: Knowledge process influences individual learning in science museum staff.

H1 is supported. There are two main points raised by the results.

Firstly, the results from the quantitative analysis showed that knowledge process overall, including all four knowledge activities, had a significant influence on every science museum in this study. Therefore, *knowledge process influences individual learning in science museum staff*.

Secondly, the results from the quantitative analysis demonstrate that not every knowledge activity, when tested independently, can lead to learning in science museum staff. Three activities had an insignificant influence on individual learning in every science museum: knowledge acquisition, knowledge distribution, and knowledge interpretation. Only organizational memory had a significant influence in two science museums, namely the SCE (TH) and SCC (SG). In addition, the results from the qualitative analysis suggest some reasons behind the insignificant and significant influences of each activity. For knowledge acquisition, the insufficient opportunities to receive relevant knowledge are the cause of insignificant influence, and the lack of a knowledge coordinator is the reason for the insignificant influence of knowledge distribution. Failure to interpret knowledge into materials and failure to use knowledge materials caused the insignificant influence of knowledge interpretation. Awareness of databases and perceived reliability of database systems caused the significant influence on learning in science museum staff.

Chapter 5

The Influence of Knowledge Process on the Relationship Between Organizational Culture and Individual Learning

The results relating to the influence of knowledge process on the relationship between organizational culture and individual learning are explained in this chapter. The hypothesis for this relationship is set as follows:

> *H2: Knowledge process influences the relationship between organizational culture and individual learning in science museum staff.*

Three variables related to hypothesis testing: organizational culture as an independent variable, knowledge process as a mediation variable, and individual learning as a dependent variable. Firstly, the relationships were tested by quantitative analysis. Then the qualitative analysis was conducted in order to help explain the relationships identified by quantitative analysis.

5.1 Quantitative Analysis of the Influence of Knowledge Process on the Relationship between Organizational Culture and Individual Learning

The quantitative analysis was conducted by using PLS-SEM and the hierarchical model with two-stage approach. In addition, a mediation analysis was conducted to test the influence of knowledge process as a mediation variable in the relationship between organizational culture and individual learning. The details of analysis are as follows.

5.1.1 Measurement Model

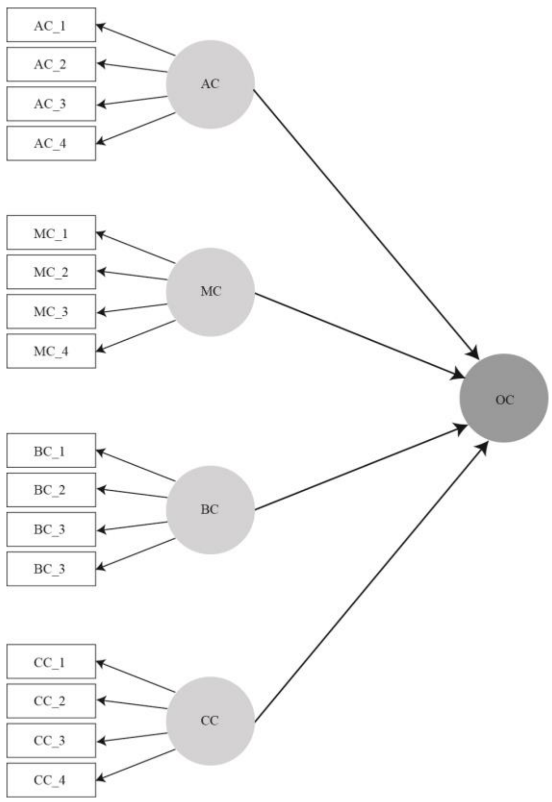
The organizational culture (OC) variable, which is the higher-order independent variable, was measured by four lower-order variables: adaptive culture (AC), mission culture (MC), bureaucratic culture (BC), and clan culture (CC). Each lower-order variable was measured by four measurement items.

The knowledge process (KP) variable, which is the higher-order mediation variable, was measured by four lower-order variables: knowledge acquisition (KA), knowledge dissemination (KD), knowledge interpretation (KI), and organizational memory (OM). Each lower-order variable was measured by five measurement items.

The individual learning (IL) variable, which is the higher-order dependent variable, was measured by two lower-order variables: create continuous learning opportunities (CL) and promote inquiries and dialogues (PI). There were three measurement items for each lower-order variable.

The details of the lower-order variables and measurement items used to measure the OC variable are shown in Figure 5-1. The lower-order variables and measurement items used to measure the KP variable are shown in Figure 4-1 (Chapter 4), and the lower-order variables and measurement items used to measure the IL variable are shown in Figure 4-2 (Chapter 4).

Figure 5-1: Details of Lower-Order Variables and Measurement Items to Measure Organizational Culture



Note. ** Some items were deleted for analysis in each science museum
by referring to the measurement model testing results.
OC = Organizational Culture, AC = Adaptive Culture, MC = Mission Culture,
BC = Bureaucratic Culture, CC = Clan Culture

After the analysis, some measurement items were deleted according to the criteria for the measurement model. For the analysis of the OC variable, AC_1, MC_2, MC_4, BC_1, and BC_4 were deleted for the analysis of the NSM (TH). MC_2, MC_4, and BC_1 were deleted for the analysis of the SCE (TH). AC_4, MC_2, MC_4, and BC_2 were deleted for the analysis of the SCS (SG). For the analysis of the KP variable, KD_1 was deleted for the analysis of the NSM (TH). KA_1, KA_4, KA_5, KI_1, and KI_2 were deleted for the analysis of the SCE (TH). KA_1, KA_3, and KD_3 were deleted for the analysis of the SCS (SG). For the analysis of IL, CL_2 was deleted for the analysis of the NSM (TH) and SCS (SG).

5.1.2 Structural Model

The influence of knowledge process on the relationship between organizational culture and individual learning was analyzed by the mediation analysis. Mediation occurs when a third mediator variable intervenes between two other related variables. In other words, a change in the independent variable causes a change in the mediator variable and results in a change in the dependent variable (Hair et al., 2017). Hence, for this study, the mediation analysis tested whether a change in organizational culture causes a change in knowledge process and results in a change in individual learning. The mediation effect can be retrieved by calculation of (1) the indirect effect of the independent construct (OC) through the mediating construct (KP) on the dependent construct (IL) and (2) the direct effect between the independent construct (OC) and dependent construct (IL). Type of mediation effect is decided by the significance of the indirect effect and the direct effect.

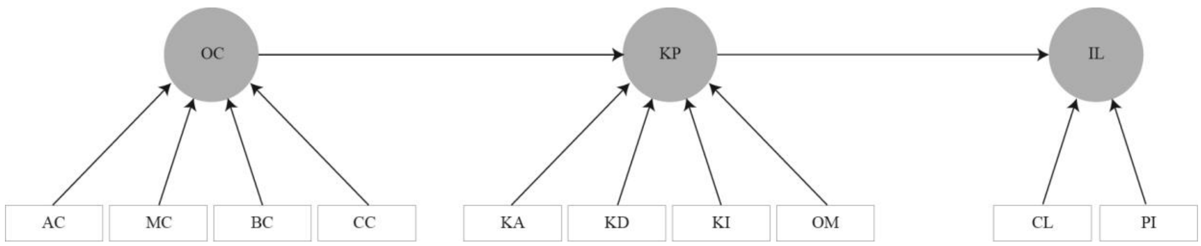
5.1.3 Influence of Knowledge Process on the Relationship between Organizational Culture and Individual Learning

Firstly, the indirect effects of organizational cultures on individual learning were analyzed by adding knowledge process to the relationship between organizational culture and individual learning. Then, any relationships that had a significant indirect effect were analyzed for the significance of the direct effects. Finally the type of mediation effect was identified.

i. Indirect Effects by Organizational Cultures on Individual Learning

The reflective-formative HCM with two-stage approach was adopted for the analysis of the indirect effect of organizational culture on individual learning with knowledge process as a mediation variable. Organizational culture (OC) was observed by the measurement items of adaptive culture (AC), mission culture (MC), bureaucratic culture (BC), and clan culture (CC). Knowledge process (KP) was observed by the measurement items of knowledge acquisition (KA), knowledge distribution (KD), knowledge interpretation (KI), and organizational memory (OM). Individual learning (IL) was observed by the measurement items of continuous learning opportunities (CL) and promotion of dialogues and inquiries (PI). At the first stage, the LOC values (AC, MC, BC, CC, KA, KD, KI, OM, CL, and PI) were calculated and their influence on IL was tested. Then the LOC values were used as the values to calculate the HOC values (KP and IL) in the second stage. The conceptual model for hypothesis testing is demonstrated in Figure 5-2.

Figure 5-2: Conceptual Model to Test the Indirect Effect of Organizational Culture on Individual Learning with Knowledge Process as a Mediation Variable



Note.
KP = Knowledge Process, KA = Knowledge Acquisition, KD = Knowledge Distribution,
KI = Knowledge Interpretation, OM = Organizational Memory
OC = Organizational Culture, AC = Adaptive Culture, MC = Mission Culture, BC = Bureaucratic Culture,
CC = Clan Culture
IL = Individual Learning, CL = Continuous learning opportunities, PI = Promotion of dialogues and inquiries

- Indirect Effect of Organizational Culture on Individual Learning with Knowledge Process as a Mediation Variable at the NSM (TH)

The analysis of indirect effect by each organizational culture type on individual learning with knowledge process as a mediation variable at the NSM (TH) shows that mission culture and bureaucratic culture had an insignificant indirect effect on individual learning. The two organizational culture types that had a significant indirect effect on individual learning were adaptive culture with the value of ß = 0.09, $p < 0.05$ and clan culture with the value of ß = 0.14, $p < 0.05$. For the analysis of the indirect effect of overall organizational culture, the LOC-MC had a negative value, which could cause a false interpretation of the results and a misleading conclusion, as suggested by Hair et al. (2017). Therefore, this LOC variable was not included for the analysis of the NSM (TH). The overall organizational culture had a significant direct influence on individual learning at the NSM (TH) with the value of ß = 0.20, $p < 0.05$. Table 5-1 presents the results regarding the indirect effect by organizational culture on individual learning at the NSM (TH).

Table 5-1: Indirect Effect of Organizational Culture on Individual Learning with Knowledge Process as a Mediation Variable at the NSM (TH)

Relationships	Indirect Effect	95% Confidence Interval of the Indirect Effect	*t*-value	*p*-value
AC->KP->IL	0.09**	(0.02,0.18)	2.25	0.02
MC->KP->IL	-0.03	(-0.09,0.02)	1.02	0.31
BC->KP->IL	0.01	(-0.04,0.05)	0.38	0.70
CC->KP ->IL	0.14**	(0.04,0.25)	2.67	0.01
OC->KP ->IL	0.20**	(0.06,0.34)	2.90	0.00

Note. ** Significance level $p < 0.05$, SCE (TH) = Science Centre for Education, Thailand
OC = Overall Organizational Culture, AC = Adaptive Culture, MC = Mission Culture,
BC = Bureaucratic Culture, CC = Clan Culture, IL = Individual Learning

- Indirect Effect by Organizational Culture on Individual Learning with Knowledge Process as a Mediation Variable at SCE (TH)

The analysis of the indirect effect of each organizational culture type on individual learning with knowledge process as a mediation variable at the SCE (TH) shows that no organizational culture type has a significant indirect effect on individual learning. However, in the analysis of the indirect effect of overall organizational culture, the LOC-MC and LOC-BC had negative values, which could cause a false interpretation of the results and a misleading conclusion, as suggested by Hair et al. (2017). Therefore, these LOC variables were not included for the analysis of the SCE (TH). The overall organizational culture had a significant direct influence on individual learning at the SCE (TH) with the value of ß = 0.30, $p < 0.05$. Table 5-2 presents the results regarding the indirect effect of organizational culture on individual learning at the SCE (TH).

Table 5-2: Indirect Effect by Organizational Culture on Individual Learning with Knowledge Process as a Mediation Variable at the SCE (TH)

Relationships	**Indirect Effect**	**95% Confidence Interval of the Indirect Effect**	***t*-value**	***p*-value**
AC->KP->IL	0.16	(0.10,0.24)	1.55	0.12
MC->KP->IL	-0.03	(-0.09,0.00)	0.45	0.65
BC->KP->IL	-0.01	(-0.05,0.02)	0.19	0.85
CC->KP ->IL	0.21	(0.15,0.28)	1.96	0.05
OC->KP ->IL	0.30**	(0.11,0.53)	2.77	0.01

Note. ** Significance level $p < 0.05$, SCE (TH) = Science Centre for Education, Thailand,
OC = Overall Organizational Culture, AC = Adaptive Culture, MC = Mission Culture,
BC = Bureaucratic Culture, CC = Clan Culture, IL = Individual Learning

- Indirect Effect of Organizational Culture on Individual Learning with Knowledge Process as a Mediation Variable at the SCS (SG)

The analysis of the indirect effect of each organizational culture type on individual learning with knowledge process as a mediation variable at the SCS (SG) shows that adaptive culture, mission culture, and bureaucratic culture had an insignificant indirect effect on individual learning. The only organizational culture type that had a significant indirect effect on individual learning was clan culture with the value of ß = 0.23, $p < 0.05$. For the analysis of the indirect effect of overall organizational culture, the LOC-MC had a negative value, which could cause a false interpretation of the results and a misleading conclusion, as suggested by Hair et al. (2017). Therefore, this LOC variable was not included for the analysis of the SCS (SG). The overall organizational culture had a significant direct influence on individual learning at the SCS (SG) with the value of ß = 0.27, $p < 0.05$. Table 5-3 presents the results regarding the indirect effect of organizational culture on individual learning at the SCS (SG).

Table 5-3: Indirect Effect by Organizational Culture on Individual Learning with Knowledge Process as a Mediation Variable at the SCS (SG)

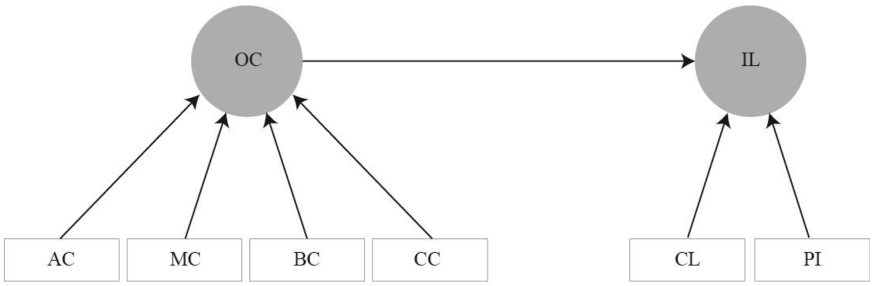
Relationships	Indirect Effect	95% Confidence Interval of the Indirect Effect	*t*-value	*p*-value
AC->KP->IL	0.05	(-0.08,0.23)	0.62	0.54
MC->KP->IL	-0.03	(-0.20,0.11)	0.46	0.65
BC->KP->IL	0.12	(-0.04,0.28)	1.46	0.14
CC->KP ->IL	0.23**	(0.05,0.46)	2.13	0.03
OC->KP ->IL	0.27**	(0.04,0.48)	2.39	0.02

Note. ** Significance level $p < 0.05$, SCE (TH) = Science Centre for Education, Thailand
OC = Overall Organizational Culture, AC = Adaptive Culture, MC = Mission Culture,
BC = Bureaucratic Culture, CC = Clan Culture, IL = Individual Learning

ii. Direct Effects by Organizational Cultures on Individual Learning

The reflective-formative HCM with two-stage approach was adopted for the analysis of the direct effect of organizational culture on individual learning. Organizational culture (OC) was observed by the measurement items of adaptive culture (AC), mission culture (MC), bureaucratic culture (BC), and clan culture (CC). Individual learning (IL) was observed by the measurement items of continuous learning opportunities (CL) and promotion of dialogues and inquiries (PI). At the first stage, the LOC values (AC, MC, BC, CC, CL, and PI) were calculated and their influence on IL was tested. Then the LOC values were used as the values to calculate the HOC values (KP and IL) in the second stage. The conceptual model for testing the direct effect of organizational culture on individual learning is demonstrated in Figure 5-3.

Figure 5-3: Conceptual Model to Test the Direct Effect by Organizational Culture on Individual Learning



Note. OC = Organizational Culture, AC = Adaptive Culture, MC = Mission Culture, BC = Bureaucratic Culture, CC = Clan Culture, IL = Individual Learning, CL = Continuous learning opportunities, PI = Promotion of dialogues and inquiries

- Direct Effect of Organizational Culture on Individual Learning at the NSM (TH)

At the NSM (TH), there were significant indirect effects when knowledge process (KP) was added to the relationship between adaptive culture (AC), clan culture (CC), and overall organizational culture (OC) and individual learning (IL). Therefore, an analysis of the direct effect of these three aspects of organizational culture on individual learning was conducted. The results show that these three aspects had a significant direct effect on individual learning. Adaptive culture had a value of $ß = 0.22$, $p < 0.01$, and clan culture had a value of $ß = 0.37$, $p < 0.01$. For the analysis of the direct effect of overall organizational culture, the LOC-BC had a negative value, which could cause a false interpretation of the results and a misleading conclusion, as suggested by Hair et al. (2017). Therefore, this LOC variable was not included for the analysis of the NSM (TH). The overall organizational culture had a significant direct influence on individual learning at the NSM (TH) with the value of ß = 0.50, $p < 0.01$. Table 5-4 presents the results regarding the direct effect by organizational culture on individual learning at the NSM (TH).

Table 5-4: Direct Effect by Organizational Culture on Individual Learning at the NSM (TH)

Relationships	Direct Effect	95% Confidence Interval of the Direct Effect	*t*-value	*p*-value
AC->IL	0.22***	(0.08,0.36)	2.95	0.00
CC->IL	0.37***	(0.22,0.54)	4.55	0.00
OC->IL	0.50***	(0.34,0.66)	6.29	0.00

Note. *** Significance level $p < 0.01$, NSM (TH) = National Science Museum, Thailand
OC = Overall Organizational Culture, AC = Adaptive Culture, MC = Mission Culture,
BC = Bureaucratic Culture, CC = Clan Culture, IL = Individual Learning

- Direct Effect by Organizational Culture on Individual Learning at the SCE (TH)

At the SCE (TH), the only significant indirect effect was achieved when knowledge process (KP) was added to the relationship between overall organizational culture (OC) and individual learning (IL). Therefore, an analysis of the direct effect of overall organizational culture on individual learning was conducted. For the analysis of the direct effect of overall organizational culture, the LOC-BC and LOC-MC had negative values, which could cause a false interpretation of the results and a misleading conclusion, as suggested by Hair et al. (2017). Therefore, these LOC variables were not included for the analysis of the SCE (TH). The overall organizational culture had a significant direct influence on individual learning at the SCE (TH) with the value of ß = 0.36, $p < 0.05$. Table 5-5 presents the results regarding the direct effect of organizational culture on individual learning at the SCE (TH).

Table 5-5: Direct Effect by Organizational Culture on Individual Learning at the SCE (TH)

Relationships	Direct Effect	95% Confidence Interval of the Direct Effect	*t*-value	*p*-value
OC->IL	0.36**	(0.07,0.62)	2.55	0.01

Note. ** Significance level $p < 0.05$, SCE (TH) = Science Centre for Education, Thailand
OC = Overall Organizational Culture, AC = Adaptive Culture, MC = Mission Culture,
BC = Bureaucratic Culture, CC = Clan Culture, IL = Individual Learning

- Direct Effect by Organizational Culture on Individual Learning at the SCS (SG)

At the SCS (SG), adding knowledge process (KP) to the relationship between clan culture (CC) and individual learning (IL) and between overall organizational culture (OC) and individual learning (IL) produced significant indirect effects. Therefore, the analysis of the direct effect of these two aspects of organizational culture on individual learning was conducted. The significant direct effect on individual learning by clan culture had the value of ß = 0.39, $p < 0.01$. For the analysis of the direct effect by overall organizational culture, the LOC-BC had a negative value, which could cause a false interpretation of the results and a misleading conclusion, as suggested by Hair et al. (2017). Therefore, this LOC variable was not included for the analysis of the SCS (SG). The overall organizational culture had a significant direct influence on individual learning at the SCS (SG) with the value of ß = 0.46, $p < 0.01$. Table 5-6 presents the results regarding the direct effect by organizational culture on individual learning at the SCS (SG).

Table 5-6: Direct Effect by Organizational Culture on Individual Learning at the SCS (SG)

Relationships	**Direct Effect**	**95% Confidence Interval of the Direct Effect**	***t*-value**	***p*-value**
CC->IL	0.39***	(0.16,0.63)	3.28	0.00
OC->IL	0.46***	(0.20,0.73)	3.33	0.00

Note. *** Significance level $p < 0.01$, SCS (SG) = Science Centre Singapore
OC = Overall Organizational Culture, AC = Adaptive Culture, MC = Mission Culture,
BC = Bureaucratic Culture, CC = Clan Culture, IL = Individual Learning

iv. Type of Mediation Effect of Knowledge Process on the Relationship between Organizational Culture on Individual Learning

The mediation effect characteristics were suggested by Hair et al. (2017) as follows.

(1) Complementary mediation – The indirect effect and the direct effect both are significant and point in the same direction.

(2) Competitive mediation – The indirect effect and the direct effect both are significant and point in opposite directions.

(3) Indirect-only mediation – The indirect effect is significant, but the direct effect is not.

Therefore, the type of mediation effect by knowledge process on the relationship between organizational cultures on individual learning was analyzed according to these categories.

- Type of Mediation Effect at the NSM (TH)

The results show that at the NSM (TH), adaptive culture and clan culture had a significant positive direct influence on individual learning. In addition, these two organizational culture types had a significant positive indirect influence on individual learning with adding knowledge process as a mediation variable. Furthermore, the overall organizational culture had a significant positive direct influence on individual learning and a significant positive indirect influence on individual leaning with adding knowledge process as a mediation variable. Therefore, at the NSM (TH), adaptive culture, clan culture, and overall organizational culture had complementary partial mediation. Table 5-7 details the mediation effect of knowledge process at the NSM (TH).

Table 5-7: Analysis Results for the Mediating Effect of Knowledge Process at the NSM (TH)

Relationships	Indirect Effect	Relationships	Direct Effect	Mediation
AC->KP->IL	Positive Significant	AC->IL	Positive Significant	Complementary Partial Mediation
CC->KP ->IL	Positive Significant	CC->IL	Positive Significant	Complementary Partial Mediation
OC->KP ->IL	Positive Significant	CC->IL	Positive Significant	Complementary Partial Mediation

Note. OC = Overall Organizational Culture, AC = Adaptive Culture, MC = Mission Culture, BC = Bureaucratic Culture, CC = Clan Culture, KP = Knowledge Process, IL = Individual Learning

- Type of Mediation Effect at the SCE (TH)

The results show that at the SCE (TH), the overall organizational culture had a significant positive direct influence on individual learning and a significant positive indirect influence on individual learning with adding knowledge process as a mediation variable. Therefore, at the

SCE (TH), overall organizational culture had complementary partial mediation. Table 5-8 details the mediation effect of knowledge process at the SCE (TH).

Table 5-8: Analysis Results for the Mediating Effect of Knowledge Process at the SCE (TH)

Relationships	Indirect Effect	Relationships	Direct Effect	Mediation
OC->KP ->IL	Positive Significant	CC->IL	Positive Significant	Complementary Partial Mediation

Note. OC = Overall Organizational Culture, AC = Adaptive Culture, MC = Mission Culture,
BC = Bureaucratic Culture, CC = Clan Culture,
KP = Knowledge Process, IL = Individual Learning

- Type of Mediation Effect at the SCS (SG)

The results show that at the SCS (SG), only clan culture had a significant positive direct influence on individual learning and a significant positive indirect influence on individual learning with adding knowledge process as a mediation variable. Furthermore, the overall organizational culture had a significant positive direct influence on individual learning and a significant positive indirect influence on individual learning with adding knowledge process as a mediation variable. Therefore, at the SCS (SG), clan culture and overall organizational culture had complementary partial mediation. Table 5-9 details the mediation effect of knowledge process at the SCS (SG).

Table 5-9: Analysis Results for the Mediating Effect of Knowledge Process at the SCS (SG)

Relationships	Indirect Effect	Relationships	Direct Effect	Mediation
CC->KP ->IL	Positive Significant	CC->IL	Positive Significant	Complementary Partial Mediation
OC->KP ->IL	Positive Significant	CC->IL	Positive Significant	Complementary Partial Mediation

Note. OC = Overall Organizational Culture, AC = Adaptive Culture, MC = Mission Culture,
BC = Bureaucratic Culture, CC = Clan Culture,
KP = Knowledge Process, IL = Individual Learning

5.2 Qualitative Analysis for the Influence of Organizational Culture on Knowledge Process and Individual Learning

Coding frames were created from analysis of the interview transcripts relating to perception of four types of organizational culture in staff of the three science museums. The interviewees were asked which culture type that they perceived as an important working environment in each science museums with referring to the details of questionnaire questions. Then key points that were mentioned by interviewees about each organizational culture were extracted. Details from interviewees that explain the different influence of organizational cultures are provided as follows.

5.2.1 Adaptive Culture

At the NSM (TH), half of the interviewees perceived adaptive culture as the most important organizational culture. They mentioned that an adaptive culture gives them opportunities to perform different jobs, and they were able to gain new experiences from such opportunities. In addition, only two interviewees, both at the SCE (TH), perceived that an adaptive culture is important. They mentioned that it is important for having work progress and development. However, at the SCS (SG), an adaptive culture was noted as good when completing new projects with partners, but interviewees added that working on many new projects at the same time could cause time constraints and afford less time for revision.

Furthermore, there is the possibility that length of employment has an influence in an adaptive culture. At the NSM (TH) and SCE (TH), more than 70% of respondents had been employed for at least 6 years, but at the SCS (SG), the number of respondents employed for less than 6 years and the number employed for more than 6 years were almost equal. The interview results demonstrate that staff at the SCS (SG) mentioned time constraints caused by working on new projects. It is possible that employees working with the museums for many years could have experience in dealing with different projects at the same time, and they thus saw adaptive culture as challenging. Table 5-10 provides an overview of adaptive culture perceived by staff at the three science museums.

Table 5-10: Interviewees' Views of Adaptive Culture

Museum	Adaptive Culture	
	Provide Opportunities to Do New Jobs or Challenges	Cause Time Constraint
NSM (TH)	6/12	-
SCE (TH)	2/10	-
SCC (SG)	2/10	2/10

Note. NSM (TH) = National Science Museum, Thailand,
SCE (TH) = Science Centre for Education, Thailand, SCS (SG) = Science Centre Singapore
n/N refers to 'N' = total interviewees, 'n' = the number of interviewees that mentioned about the topic
'-' = not mentioned

The opinions of interviewees at the three science museums about adaptive culture are as follows:

> *I think developing new things is important for working in this museum. Here, we don't have fixed plans of what we want to do when you have new ideas. I like to find new knowledge, and I can develop what we can communicate with our visitors. Even though I didn't do it by myself, I can share my ideas with other staff of our museum or other museums. (Interviewee 4 (NSM-TH))*

> *I like to find new knowledge, and I can develop what we can communicate with our visitors. Even though I didn't do it by myself, I can share my ideas with other staff of our museum or other museums. (Interviewee 11 (NSM-TH))*

> *It is important for us to update our knowledge. Without that we can't have any progress of development in our work. (Interviewee 4 (SCE-TH))*

> *What can I say when you ask me this question? I can only say having new knowledge comes first to my mind. I don't need to think about other choices. (Interviewee 6 (SCE-TH))*

> *We know that we're gonna get less and less budget. We know we can't extend our manpower significantly. So we know that we are very stretched on a day to day basis. We and our people are really stressed and tired. But when it comes to new partnership or new event . . . we can do that, we can do that. (Interviewee 1 (SCS-SG))*

We are an attraction industry, and in the industry of the science center especially, the attraction is moving very fast. . . . So it's important that staff can understand that and realize that they also have to change, look for new ways of doing things, being very open and flexible. . . . It takes a lot of time, a lot of energy, actually a lot of energy, mental energy, and a lot of motivation. (Interviewee 4 (SCS-SG))

5.2.2 Mission Culture

At the three science museums, only a few interviewees mentioned that mission culture is important because they understand their jobs must be finished on time. Therefore, this culture was perceived as a mandate by some of the science museum staff. This perception could be a reason why mission culture showed an insignificant influence in relationship to knowledge process and individual learning at all three science museums. Table 5-11 provides an overview of mission culture perceived by staff at the three science museums.

Table 5-11: Interviewees' Views of Mission Culture

Museum	Mission Culture
	Mandate for Their Jobs
NSM (TH)	2/12
SCE (TH)	2/10
SCC (SG)	1/10

Note. NSM (TH) = National Science Museum, Thailand,
SCE (TH) = Science Centre for Education, Thailand, SCS (SG) = Science Centre Singapore
n/N refers to 'N' = total interviewees,
'n' = the number of interviewees that mentioned about the topic

The opinions of interviewees at the three science museums about mission culture are as follows:

My work is mainly about the organization report. So I need to finish it with accuracy and punctuality. (Interviewee 6 (NSM-TH))

Most of my work is rush ordered, so I need to keep at my work to be finished by the time I am requested. (Interviewee 9 (NSM-TH))

I think the most important aspect to work at this museum is to finish my job in time. I believe in that. (Interviewee 2 (SCE-TH))

I always get urgent job orders. Sometimes I need to finish within 15 days. So I have to do it. I can't put off doing it. (Interviewee 5 (SCE-TH))

I actually got some time to finish [name of job]. Also it's important for me to get ready like when [name of visitors] come, and I must get ready for that. (Interviewee 5 (SCS-SG))

5.2.3 Bureaucratic Culture

Bureaucratic culture demonstrated an insignificant influence in all three science museums. The few interviewees who mentioned that bureaucratic culture is important noted that their jobs must follow rules and regulations. Table 5-12 provides an overview of bureaucratic culture perceived by staff at the three science museums.

Table 5-12: Interviewees' Views of Bureaucratic Culture

Museum	Bureaucratic Culture
	Rules and Regulations is Compulsory
NSM (TH)	3/12
SCE (TH)	3/10
SCC (SG)	1/10

Note. NSM (TH) = National Science Museum, Thailand,
SCE (TH) = Science Centre for Education, Thailand, SCS (SG) = Science Centre Singapore
n/N refers to 'N' = total interviewees,
'n' = the number of interviewees that mentioned about the topic

The opinions of interviewees at the three science museums about bureaucratic culture are as follows:

I think if we work without following rules and regulations then there will be many problems afterwards. So I think it's important to think about rules and regulations. (Interviewee 5 (NSM-TH))

Rules and regulations are compulsory to my work, so I need to make sure that I follow them, and it is the most important culture for me. (Interviewee 10 (NSM-TH))

We are a government organization, so there are rules and regulations that control our work. We need to follow them. (Interviewee 8 (SCE-TH))

My work is related to rules and regulations. Therefore, for me, following rules and regulations are very important. (Interviewee 10 (SCE-TH))

I suppose following established rules and regulations, that is important, because mine is more on government. So if anything that goes wrong, the auditor will come after us or the government will come after us. (Interviewee 2 (SCS-SG))

5.2.4 Clan Culture

Staff of the three science museums perceived clan culture as a culture that assists them to work successfully. They mentioned that workers in a science museum need to coordinate. Their jobs could not be accomplished by working individually. However, at the SCE (TH), on the one hand a clan culture is important. On the other hand, an age gap problem was blocking communication between young and senior staff members, even though they were working together. Table 5-13 provides an overview of clan culture perceived by staff at the three science museums.

Table 5-13: Interviewees' Views of Clan Culture

Museum	Clan Culture	
	Importance of Working as a Team	Age Gap
NSM (TH)	6/12	-
SCE (TH)	5/10	4/10
SCC (SG)	6/10	-

Note. NSM (TH) = National Science Museum, Thailand,
SCE (TH) = Science Centre for Education, Thailand, SCS (SG) = Science Centre Singapore
n/N refers to 'N' = total interviewees,
'n' = the number of interviewees that mentioned about the topic, '-' = not mentioned

The opinions of interviewees at the three science museums about importance of clan culture are as follows:

> *I think coordinating with other staff is the heart of working at this museum. We need teamwork, so without coordination, we can't be successful. (Interviewee 2 (NSM-TH))*

> *I find that having a good relationship with other staff can help me to work smoothly. When I have problems, a colleague can help me. (Interviewee 4 (NSM-TH))*

> *Everyone has the goal of completing their own job, but we also need to consider our colleagues. We should work as a team, and our work can develop in the right direction. It's better not to work individually because we can't be 100% right by ourselves. It's not our own job, but a job of our museum. (Interviewee 8 (SCE-TH))*

> *It's very helpful when we coordinate with other staff or other departments. We know only some parts of our jobs. We can't finish everything within our own section. Instead we need help from other sections. (Interviewee 7 (SCE-TH))*

> *I think over here it is very difficult to work as an individual because you can't be the only one doing things. You may be the only conceptualizer, but you are not the person to carry it through. . . . So we definitely work as a team, and we will need to gather feedback, understand what they went through, and think of how to refine the process or to make sure to smooth out the issue that they faced. (Interviewee 6 (SCS-SG))*

> *I think most important is also team communication, teamwork. Best part about working in a science center is that everybody knows everybody. We communicate well from the top management all the way to the bottom, the security guards and the cleaners. So it's the most important part. It really frustrates you when you are not communicating well and then things go wrong. (Interviewee 9 (SCS-SG))*

In addition, the problems of age gap at the SCE (TH) are mentioned as follows:

> *The age gap is an issue at this museum. There are different views between staff who are older than 50 years and staff who are younger than 50 years. I won't say which group is right or wrong. They only have different frames of reference for working together. If we can find a balance between these two groups, we could develop fast. (Interviewee 3 (SCE-TH))*
>
> *Sometimes I have problems with senior staff. They have their own experience and they don't see the importance of what I think is important. What I want to do is the excessive work for them, but I think we should have it as prevention. (Interviewee 7 (SCE-TH))*

Considering the ages of the respondents in the three science museums, the results concerning significant organizational types were also supported. Most respondents at the NSM (TH) and SCS (SG) were below 40 years old, and at the SCE (TH), most of the respondents were more than 50 years old. The interview results underscore the difficulty of young and senior staff at the SCE (TH) in communicating and working together. Therefore, this result suggests that overcoming any age gaps is important for a clan culture to have an influence on learning in science museum staff.

5.3 Hypothesis Testing

This chapter discussed the results from the quantitative and qualitative analyses on the influence of knowledge process on the relationship between organizational culture and individual learning. The results from this chapter responded to RQ 2: Do science museum staff require both organizational culture and knowledge process to promote their individual learning? The hypothesis for testing this research question is as follows:

> *H2: Knowledge process influences the relationship between organizational culture and individual learning in science museum staff.*

H2 is supported. Firstly, the results from the quantitative analysis showed that in all three science museums, organizational culture, which includes every organizational culture type, influences knowledge process, which then influences individual learning. Therefore, these three variables have a significant relationship. In addition, knowledge process shows partial mediation on the relationship between overall organizational culture and individual learning. Consequently, both knowledge process and individual learning have a beneficial influence on individual learning; in other words, individual learning depends on both knowledge process and organizational culture. Therefore, *knowledge process influences the relationship between organizational culture and individual learning in science museum staff*.

Secondly, the results from the quantitative analysis demonstrate that clan culture, knowledge process, and individual learning are related in science museums. In addition, knowledge process has a partial mediation role in the relationship between clan culture and individual learning, which means that clan culture and knowledge process together influence individual learning in science museums. In addition, the results from the qualitative analysis help explain why clan culture is perceived by science museum staff as a culture that promotes teamwork, which is in turn important to successful work in science museums. Notably, clan culture can have an age gap problem which influences individual learning even when working together with knowledge process. Furthermore, mission culture is perceived as a significant culture within the staff that have time limits as mandatory criteria for their work. Bureaucratic culture is important only for staff whose work needs to follow rules and regulations. Therefore, these two cultures—mission culture and bureaucratic culture—did not show a relationship with knowledge process and individual learning. Adaptive culture can influence individual learning together with knowledge process when staff perceive it as an important culture. However, when staff did not view adaptive culture as important, or when they viewed it as important but accompanied by another constraint, the adaptive culture did not show a relationship with knowledge process and individual learning.

Chapter 6

Key Findings

The aim of this study was to explore the factors that promote individual learning in science museum staff. There were two research questions established to find out these success factors:

RQ 1: Can knowledge process lead to individual learning in science museum staff?

RQ 2: Do science museum staff require both organizational culture and knowledge process to promote individual learning?

In chapter 4 the influence by knowledge process on individual learning in science museum staff were explored to answer RQ 1. In addition, chapter 5 presents the influence by organizational culture on individual learning with adding knowledge process in order to answer RQ 2. By conducting research based on theoretical framework that has been proposed and adopted by different studies in this area, this study has answered the two research questions that are established and can identify success factors that can promote learning in science museum staff. An overview of the significant findings of this study is discussed as following.

6.1 Knowledge Process as an Instrument for Individual Learning in Science Museum Staff

Results from the surveys in three science museums demonstrate the ability of knowledge process as an instrument for individual learning in science museum staff. However, the analysis of different knowledge activities demonstrates that each activity of knowledge process had factor that enhance or prohibit its influence on individual learning. Details are shown in Table 6-1.

Table 6-1: Ability of Knowledge Process as an Instrument for Learning in Science Museum Staff

	NSM (TH)	SCE (TH)	SCS (SG)
KA –> IL	X	X	X
KD –> IL	X	X	X
KI –> IL	X	X	X
OM –> IL	X	O	O
KP –> IL	O	O	O

Note. O = Significant, X = Insignificant
NSM (TH) = National Science Museum, Thailand,
SCE (TH) = Science Centre for Education, Thailand, SCS (SG) = Science Centre Singapore
KP = Knowledge Process, KA = Knowledge Acquisition, KD = Knowledge Distribution,
KI = Knowledge Interpretation, OM = Organizational Memory
IL = Individual Learning

6.1.1 Knowledge Process Leads to Individual Learning in Science Museum Staff

Knowledge process is theoretically suggested to be the factor that can enhance individual learning and organizational learning (Fiol and Lyles, 1985; Nonaka and Takeuchi, 1995; Bennet and Bennet, 2003). In addition, the empirical studies in different industries (Edmondson and Joshi, 2011; Karkoulian et al., 2013; Ngah et al., 2016) demonstrate that knowledge process has significant influence on learning within the organizations. However, there is none of the empirical studies of the influence by knowledge process on learning in science museum context. By conducting of this study can fulfill this gap and the results from the three science museums indicate that individual learning in science museum staff can be increased by knowledge process. Therefore, this finding added the practicability and significance of applying knowledge management in science museum section.

6.1.2 Activities of Knowledge Process that Lead to Individual Learning in Science Museums

On the one hand, the results from this research show that knowledge process that includes every knowledge activity can enhance learning in science museum staff. On the other hand, the analysis of single activity of knowledge process demonstrates that some activities could not promote learning in science museum staff. The proposed four knowledge activities that lead to learning are knowledge acquisition, knowledge dissemination, knowledge interpretation, and organizational memory (Huber, 1991; O'Brien, 2015). Therefore, this study displays that the evaluation of knowledge management should not only done in the big picture. However, it is important to have the evaluation of each knowledge activity which can tell the real effectiveness of conducting knowledge management.

From the quantitative analysis, this study demonstrates that organizational memory is the only one activity that has the tendency to enhance learning in science museum staff. Organizational memory is the existing of knowledge storage which staff can access and utilize the deposited knowledge to their works. Huber (1991) suggests that the effectiveness of organizational memory depends on involvement of staff. In addition, Bennet and Bennet (2003) mentions about technology that can facilitate the use of organizational memory. Referring to the interviews' results, this study also reveals that the effectiveness of organizational memory depends on the known of the depository and the stability of the technology that are used. Staff in science museums mentioned that they use the organizational memory because they know that it is the platform where they can both deposit and retrieve knowledge. In addition, staff use it because the technology is provided and can be trusted to support their works. Therefore, science museums should insure that their staff know about the organizational memory and realize the benefit of using this platform. Additionally, the technology should be reliable and can prevent the loss of knowledge storage.

Furthermore, the results show that knowledge acquisition, knowledge distribution, and knowledge interpretation are ineffective in leading to learning in science museum staff. This condition means that science museums cannot get benefit from these three activities that they are conducting. In addition, these results imply the causes of low success of knowledge activities that are currently conducted in science museums. Even though they have the policy to conduct knowledge management but without the evaluation of these activities, they could not understand what actually occurred and what they should improve for their knowledge activities. Therefore, evaluation of knowledge activities can ensure the success of knowledge management in science museums.

However, the causes of ineffective knowledge activities can give lesson learn for science museums in conducting their knowledge activities. About knowledge acquisition, which is the activity involved in accumulating knowledge by gathering, collaborating, observing, or learning from past experiences (Huber 1991; Aksu and Ozdemir 2005; Ngah et al., 2016; Chang and Lin 2015). Results from this study show that variety of knowledge sources is not the important issue for science museum staff. However, opportunities to retrieve relevant knowledge should be the success factor for knowledge acquisition in science museum staff. They mentioned about the insufficient opportunities to retrieve relevant knowledge with different reasons. Some staff mentioned that there were many training courses arranged in their museums but the content rarely relevant to their works. In addition, some staff mentioned their museums are lack of budget so they rarely have training courses or having study trips. Therefore, science museums should consider about arranging activities that can provide relevant knowledge to their staff.

For Knowledge distribution which creates knowledge flow within the organization (Lai and Lee 2007). Learning in the organization occurs when knowledge can move laterally and vertically (Garvin 2000). Although update meetings are held regularly in science museums to exchange knowledge or information but staff raised that the knowledge flow in science museums demand staff who link and circulate knowledge between different sections. With the assistance of knowledge coordinators, knowledge distribution can enhance the learning of science museum staff. Therefore, in science museums a distribution cannot occur only by staff but there is the need of activators who staff realize about their roles in gathering and distributing knowledge among different units.

About knowledge interpretation which is the activity that allows for developing new knowledge by comparing and matching existing knowledge (Aksu and Ozdemir 2005; Lai and Lee 2007; Chang and Lin 2015). In science museums, staff mentioned that working as a team is routine for them. When there is new project they always bring together different staff who have expertise in various subjects and then they can create new knowledge. However, they accused about lack of interpreting knowledge into material or staff are not motivated to use the knowledge that are interpreted. Therefore, science museum staff see that explicit knowledge which is the knowledge that is transformed into different forms and can be systematically accessed (Nonaka and Takeuchi, 1995) is important. In addition, staff should realize that advantage of utilizing the interpreted explicit knowledge in their works.

6.2 Mutual Beneficial by Organizational Culture and Knowledge Process on Individual Learning in Science Museum Staff

Results from the surveys in three science museums demonstrate the relationship between organizational culture, knowledge process, and individual learning. Therefore, science museums require both organizational culture and knowledge process to promote learning in their staff. However, the analysis of organizational culture type shows that science museums require specific organizational culture type combined with knowledge activities for staff learning. Details are shown in Table 6-2.

Table 6-2: Mediating Effect by Knowledge Process on the Relationship between Organizational Culture and Individual Learning in Science Museum Staff

	NSM (TH)	SCE (TH)	SCS (SG)
AC–>KP–>IL	O	X	X
AC–>IL	O	-	-
MC–>KP–>IL	X	X	X
MC–>IL	-	-	-
BC–>KP–>IL	X	X	X
BC–>IL	-	-	-
CC–>KP–>IL	O	X	O
CC–>IL	O	-	O
OC–>KP–>IL	O	O	O
OC–>IL	O	O	O

Note. O = Significant, X = Insignificant, **-** = Not analyzed
NSM (TH) = National Science Museum, Thailand,
SCE (TH) = Science Centre for Education, Thailand, SCS (SG) = Science Centre Singapore
KP = Knowledge Process, KA = Knowledge Acquisition, KD = Knowledge Distribution,
KI = Knowledge Interpretation, OM = Organizational Memory
IL = Individual Learning

6.2.1 Importance of Promoting both Organizational Culture and Knowledge Process for Individual Learning in Science Museum Staff

This study empirically proves the proposal by Argote and Miron-Spektor (2011) that organizations should consider both organizational culture and knowledge process in creating learning in staff. The existing empirical studies did not analyze these three components in conjunction. Therefore, this study can fill the gap of previous analysis. Gupta et al. (2000) suggest that organizational knowledge can be leveraged through supportive organizational learning and good knowledge management. This shows that a combination of organizational culture and knowledge activities is required for learning. In science museums, knowledge process can enhance the influences of the overall organizational culture. Therefore, for staff to effectively communicate knowledge to visitors, science museums should build a learning-supportive culture and promote a set of knowledge activities in their management.

6.2.2 Organizational Culture Types with Knowledge Process for Learning in Science Museum Staff

Organizational culture influences the thoughts and reactions of staff (Schein 1996, 2010). Therefore, it also influences the working behavior of staff (Mahler, 1997). Learning among individuals is influenced by an organizational climate that encourages knowledge management (Alavi and Leidner, 2001; Janz and Prasarnphanich, 2003).

In this study, the results demonstrate that only clan culture in combination with knowledge process has the efficiency to increase learning in science museum staff. Communication and learning are enhanced by dissolving of boundaries between different units and teamwork (Allard, 2003; Lopez et al., 2004; Chang and Lee, 2007; Janz and Prasarnphanich, 2003). Science museums offer educational services to visitors as their main role. The works of science museums are mostly created through teamwork, involving staff across units. Therefore, science museums must be supported by a culture that promotes staff involvement and collaboration. Then clan culture should be the most required for the science museum context. Consequently, clan culture is important for staff learning. Nevertheless, this study demonstrates that clan culture failed to enhance the learning of staff when age gap is a problem. Without good communication, a true team cannot develop. Learning activities can be supported by practicing interpersonal skills, to learn to negotiate during a disagreement with the aim of understanding the topic at hand, and rethinking to devise solutions to problems. A critical success factor is that team members maintain high levels of communication and tight coordination (Edmondson, 2012). Therefore, science museums should aware about this problem whether the clan culture is truly occurred within the organization.

Humphrey and Yochim (2000) propose that to reach a level of maturity where knowledge activities are promoted, museums need to foster a clan culture and an adaptive culture. Jung (2016) suggests that if the museums promote a collaborative and supportive workplace culture, their staff will have more of a human relations approach and organizational learning will be promoted. However, in this study, when exploring a single organizational culture typology, it is found that knowledge process can enhance the learning of staff only in a clan culture. Experimentation, risk taking, and failure tolerance are important for individual learning (Ortenblad and Koris, 2014; Lopez et al., 2004; Chang and Lee, 2017). In addition, Maden (2012) suggests the importance of provision of time to review knowledge. To provide effective services to visitors and remain in tune with trends relating to science museum visitation, it is important for science museums to create new exhibitions and other offerings. Therefore, an adaptive culture should enhance individual learning in staff of science museums. However, the results reveal that in promoting an adaptive culture, museums should remain aware of incorporating too many activities, as staff mentioned that it may cause time constraints for learning development. In addition, science museum staff should realize the importance of adaptive culture in their works.

Furthermore, in this study finds that most of science museum staff has tolerance to mission culture which emphasizes getting the job done and focusing on work more than communication and the bureaucratic culture which organized and systematic administration are significant. Even though they are public organization where bureaucratic culture should prevail highly (Yeo, 2007) but this culture is perceived as important culture only within some staff who have to follow rules and regulations. Similarly to mission culture which staff mention that it is the culture that they cannot deny so they do not perceive it as important culture typology.

Therefore, clan culture should be supported and developed while knowledge management is practiced as an enhancement tool for individual learning. Then, individual learning within an organizational culture in a science museum can be enhanced by knowledge process.

Chapter 7

Conclusions

This chapter discusses the achievement of the aim of this research with the conclusions of the key results. In addition, the contributions from this study to theories in this area and the practice in science museums and other organizations are explained. Lastly, the limitations and suggestions for future research are provided.

7.1 Summary of the Key Findings

The objective of this study was to identify the factors that can enhance individual learning in science museum staff. The study was accomplished by investigating the role of knowledge process and the role of knowledge process in combination with organizational culture. The objective of this study has been achieved by identifying the success factors for science museum staff learning. The conclusions based on the key results are as follows.

- Knowledge process can be a management instrument that increases learning in science museum staff. In addition, analysis of a single knowledge activity can reveal the effectiveness of the activity. In this study, organizational memory was found to be an activity that can increase learning in science museum staff. Furthermore, exploring the other three activities demonstrated the weaknesses of conducting those activities, which yielded only a low success in conducting knowledge management in science museums.

- Organizational culture, knowledge process, and individual learning are relevant. Therefore, science museums require both organizational culture and knowledge process to enhance the learning of their staff. In addition, the most important culture typology for science museums of the types tested is clan culture. The combination of clan culture and knowledge process can enhance learning in science museum staff.

7.2 Contributions

The key findings in this research make theoretical contributions and practical contributions as follows.

7.2.1 Contributions to Theory

This research makes three main contributions to theories about knowledge management and staff learning.

First, this research provides empirical evidence that can contribute to the study of relationships between knowledge management and staff learning. It was found that practicing knowledge process can improve the learning of science museum staff. Therefore, the applicability of knowledge management is proved in the science museum sector, which was a sector that had not been empirically studied previously. In addition, the results can enrich the discussion about the improvement of staff learning in other types of museums or other knowledge-oriented non-profit and government organizations that are seeking ways to leveraging staff learning through knowledge activities.

Second, the empirical analysis shows that a relationship exists among organizational culture, knowledge process, and individual learning. The results show that discussions about individual learning should not separate knowledge management from organizational culture. Previous studies have not explored these factors in this way. Therefore, the framework adopted in this study could be a useful tool for investigating the role of knowledge management and organizational culture in other organizations.

Third, it is important to analyze the influence of individual knowledge activities and of each organizational culture typology on individual learning. In this study on how certain factors influence individual learning, the analysis of knowledge process included four knowledge activities, and the analysis of organizational culture included four culture typologies. However, analysis of each activity and each culture typology showed a different influence per individual aspect. Therefore, this study recommends conducting analysis of each unit. An organization could thereby identify which aspects should be improved to enhance learning in their staff.

7.2.2 Contributions to Practice

This study aimed to determine the practices for science museums to improve learning of their staff. In addition, as the research is based on the philosophy of non-profit organizations aiming at education provision, this study also applies to other knowledge-oriented non-profit and government organizations.

First, the results reveal the importance of knowledge management practice for science museums, as knowledge management can improve the learning of science museum staff. When staff are learning, they can create effective tools to communicate science and technology to visitors. Therefore, any science museums that do not have policy for conducting knowledge management should consider implementing this management tool. In addition, science museums where knowledge management is conducted, such as the three cases in this study, should consider evaluation of their practice. Without evaluation, science museums cannot identify empirically what are the causes of low success of their knowledge management practice. The two science museums in Thailand, for example, had realized that they were not having high success with their knowledge activities, but they had not identified the reasons why. Consequently, this study can show them the barriers of their knowledge management practice.

Second, the results of this study identified that organizational memory is the knowledge activity that has the highest potential to enhance learning in science museum staff. An organizational memory allows staff to access and use knowledge that has been stored by staff from different units within the organization (Griffiths and Morse, 2009). The study revealed three important issues related to organizational memory. Science museums should consider these three issues for improvement of their knowledge depository.

(1) Awareness of the depository –This study found that even though knowledge storage is provided, science museums could fail to make the storage known organization wide. In that case, there is no benefit to having knowledge storage. Making the knowledge storage known also involves teaching staff how to deposit the knowledge. Some staff mentioned that they know about the system but do not know how to upload data into the system. In addition, policy to raise the interest of the staff in using the knowledge storage is also important. When the science museums make the knowledge storage known, the benefits of using the storage should also be communicated.

(2) Usage of the depository – Usage means both accessing and updating knowledge in the depository. This study shows that the access should be easy. A complicated process for accessing knowledge can discourage the staff from knowledge storage. In addition, the knowledge should be updated regularly. Some staff mentioned that they accessed the storage, but when they found no updates, they lost interest

in using the storage. In addition, sharing updated knowledge or new features about the storage system could raise interest in the staff.

(3) Reliable technology of the depository – The science museums' staff revealed the problem of a vulnerable system, which caused lack of confidence when using the system. Therefore, science museums should establish stable functioning to build trust in their staff.

Lastly, this study revealed that in parallel with knowledge activities, science museums should create a clan culture within the organization. Clan culture is a culture in which staff feel like family and there is collaboration and cooperation between different units. In addition, there is a close relationship between management and staff (Cameron and Quinn, 2011). The results show that many of the science museum staff perceived this culture typology as important in their organizations. In science museums, staff have to work in teams to accomplish their work. Hence clan culture is a foundation culture in science museum staff. Science museums should therefore arrange activities that can strengthen this culture within their staff regularly. These activities should bring staff across units and position to participate across section boundaries or beyond position hierarchies. These activities can be either related or unrelated to work. Some staff mentioned that they can talk with and understand other people best when people talk about other issues like hobbies or interests unrelated to work. Afterward, staff feel closer, and they can have better discussions about their work.

7.3 Research Limitations

The major limitation in this study is the small number of research sites. Only three science museums were included in the survey. In addition, every museum is located in the same geographic location, namely Southeast Asia. Even though the study sample was valid, the generalizability of the findings of this study could be improved by including more museums in different geographical locations.

In addition, the research was conducted only in science museums that serve at the national scale. Small-scale science museums were excluded. Therefore, a comparative study between small-scale and large-scale science museums might reveal interesting findings.

7.4 Suggestions for Future Research

This study has provided a theoretical framework for further research that aims to identify the success factors in promoting learning in staff. The research is also a pioneer contribution to the science museum sector. Although the science museum is only one type of institution in the museum sector, every type of museum holds the same philosophy of providing education to visitors. In addition, science museums, like other museums, are non-profit organizations that have knowledge-oriented service. Therefore, suggestions for future research are as follows.

(1) Conduct a comparative study among different types of museums to disclose whether the success factors for staff learning are similar.

(2) Explore the success factors in other non-profit organizations or government organizations that also aim to provide education to the public.

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Appendices

Appendix 1: Survey Questionnaire

Questionnaire for the Survey of Knowledge Management for Promoting Learning Actions in Staff of Science Museums/Centers

Dear Respondents,

My name is Nopparat Thepthepa. I am a Head of the Exhibition Development Division at the National Science Museum, Thailand. At present, I am on study leave to complete the Ph.D. course at the Graduate School of Technology Management, Ritsumeikan University. My research aims to identify knowledge management practices capable of effectively training science museum/centre staff about how to do their jobs within the existing work environment.

Please take just 15 minutes to answer this questionnaire. Your information will be confidential and used solely in my academic papers and dissertation. If you have any further inquiries about this questionnaire feel free to contact me by e-mail: gr0224hp@ed.ritsumei.ac.jp.

Thank you very much in advance for your kind participation.

Best regards,

Nopparat Thepthepa

PhD Student, Graduate School of Technology Management, Ritsumeikan University

2-150 Iwakura-cho, Ibarakishi, Osaka, Japan 567-8570

<u>Part 1</u> About you (5 questions)

<u>Please tick the correct box.</u>

1. Which department are you in?

☐ Top Management ☐ Administration ☐ Visitor Service

*<u>Note</u>

Details were varied by referring to different section at each science museum.

2. What is your functional position?

☐ Head of Department ☐ Manager/Supervisor ☐ Staff ☐ Other

3. How long have you worked at the museum?

☐ Less than 3 years ☐ 3-5 years ☐ 6-10 years ☐ 11-20 years

☐ More than 20 years

5. What age group are you in?

☐ Under 31 ☐ 31-40 ☐ 41-50 ☐ 51-60 ☐ 60+

<u>Please tick the box which is closer to what occurs in your organization.</u>

<u>Part 2</u> Knowledge management in your organization (20 questions)

1. Your organization actively promotes cooperation with other science museums/centers, universities, professionals and experts.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

2. Staff are encouraged to join events and/or exhibitions that are arranged both within and outside the organization.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

3. Your organization collects information on other science museums/centers, visitors, economic and social trends, or scientific and technological trends.

☐ Almost never true ☐ Usually not true ☐ Occasionally true
☐ Usually true ☐ Almost always true

4. Your organization has clear policy and sufficient resources for R&D activities.

☐ Almost never true ☐ Usually not true ☐ Occasionally true
☐ Usually true ☐ Almost always true

5. New ideas and approaches for doing jobs are tested continuously.

☐ Almost never true ☐ Usually not true ☐ Occasionally true
☐ Usually true ☐ Almost always true

6. Meetings are periodically held to inform all the staff about the latest ideas and work processes.

☐ Almost never true ☐ Usually not true ☐ Occasionally true
☐ Usually true ☐ Almost always true

7. Best practices among different jobs are shared.

☐ Almost never true ☐ Usually not true ☐ Occasionally true
☐ Usually true ☐ Almost always true

8. Your organization has staff members who are in several teams or divisions and also act as links between them.

☐ Almost never true ☐ Usually not true ☐ Occasionally true
☐ Usually true ☐ Almost always true

9. Your organization has staff members responsible internally for collecting, assembling and distributing the employees' opinions about doing jobs.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

10. Knowledge for doing jobs is transferred by internal publications, job rotation, informal networks etc.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

11. Approaches from successful projects have been turned into standardized rules or ways of doing similar jobs.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

12. Approaches from successful projects have been integrated into training materials.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

13. Staff with different expertise are often brought together to solve a problem.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

14. Problems are solved through discussions and other social interactions.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

15. Problems are solved by applying previous lessons learned or best practices.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

16. Your division has a system for organizing data about problems, solutions and lesson learned.

☐ Almost never true ☐ Usually not true ☐ Occasionally true
☐ Usually true ☐ Almost always true

17. In your division, data is collected systematically and is kept up to date.

☐ Almost never true ☐ Usually not true ☐ Occasionally true
☐ Usually true ☐ Almost always true

18. You can easily access and use data that are collected.

☐ Almost never true ☐ Usually not true ☐ Occasionally true
☐ Usually true ☐ Almost always true

19. You often consult data that are collected.

☐ Almost never true ☐ Usually not true ☐ Occasionally true
☐ Usually true ☐ Almost always true

20. You have access to get required data from other divisions.

☐ Almost never true ☐ Usually not true ☐ Occasionally true
☐ Usually true ☐ Almost always true

<u>Part 3</u> Actions supporting staff education in your organization (12 questions)

1. Staff in each division help each other to learn how to do their job.

☐ Almost never true ☐ Usually not true ☐ Occasionally true
☐ Usually true ☐ Almost always true

2. Staff in each division are rewarded when they apply what they have learnt to their jobs.

☐ Almost never true ☐ Usually not true ☐ Occasionally true
☐ Usually true ☐ Almost always true

3. Staff in each division give open and honest feedback to each other.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

4. Whenever staff state their views, they also ask what others think.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

5. Staff in each division are given the time to learn about doing their jobs.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

6. Staff in each division spend time to learn about work together.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

7. Teams/groups have the freedom to adapt their goals for projects as needed.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

8. Teams/groups revise their thinking as a result of group discussions or information collected.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

9. Teams/groups are confident that the organization will act on their recommendations.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

10. Systems are in place to measure gaps between current and expected performance.

☐ Almost never true ☐ Usually not true ☐ Occasionally true
☐ Usually true ☐ Almost always true

11. Your organization measures the results of the time and resources spent on learning.

☐ Almost never true ☐ Usually not true ☐ Occasionally true
☐ Usually true ☐ Almost always true

12. Your organization encourages staff to think from a global perspective.

☐ Almost never true ☐ Usually not true ☐ Occasionally true
☐ Usually true ☐ Almost always true

<u>Part 4</u> Work environment (16 questions)

1. Your organization considers change to be natural and necessary.

☐ Almost never true ☐ Usually not true ☐ Occasionally true
☐ Usually true ☐ Almost always true

2. Staff are aware of visitors/clients' satisfaction.

☐ Almost never true ☐ Usually not true ☐ Occasionally true
☐ Usually true ☐ Almost always true

3. Readiness to meet new challenges is important.

☐ Almost never true ☐ Usually not true ☐ Occasionally true
☐ Usually true ☐ Almost always true

4. There is an emphasis on being ahead of other science museums/centers.

☐ Almost never true ☐ Usually not true ☐ Occasionally true
☐ Usually true ☐ Almost always true

5. Your organization prioritizes getting the job done.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

6. Staff are not very socially involved amongst each other.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

7. Schedule is important for doing tasks.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

8. Staff are too busy to spend time for improvement.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

9. Formal rules and policies. Maintaining a smooth-running organization is important here.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

10. Your organization has a focus on hierarchy and fixed organization structure.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

11. Established procedures generally govern what staff do.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

12. Administrative operations are prioritized.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

13. Your organization treats every staff like a large family.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

14. Collaboration and co-operation among the different duties and departments are encouraged.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

15. There is a lot of warmth in the relationships between management and staff.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

16. Promotion of employees is to create bonds with, and dedication to the organization.

☐ Almost never true ☐ Usually not true ☐ Occasionally true

☐ Usually true ☐ Almost always true

End – To confirm again, the results of this survey are 100% confidential. Thank you for your kind cooperation.

Appendix 2: Semi-Structured Interview Questions

Interview Sheet

For the study titled "Knowledge Management for Promoting Learning Actions in Staff of Science Museums/Centers"

by Nopparat Thepthepa, PhD Student, Graduate School of Technology Management, Ritsumeikan University, Japan

Date: ………………………..………… Time : ……………………………………………

Name of interviewee: …………………………………………… Institution ………………..

Section: ……………………………………… Position: ………………………..…………….

e-mail: ……………………………………………………………………………....…………

Dear interviewees,

This interview will remain 'in confidence'. All results will be used for educational use only and your names will not be used in any publications. Name and contact details asked for are in case I need to ask you questions in the future.

Thank you very much.

1. How long have been working at this center?

2. What are your major responsibilities?

3. Where do you get information, knowledge, or consultation from, that you need for your work? Why you choose it? How often do you use it? (For example management staff, experts, colleagues, friends from other museums/centers, events, training course, internet etc.)

4. Do you often explore other science museums/centers/educational organizations? If yes, what do you explore? How often? If not, why?

5. Is it important to investigate economic and social trends, and scientific and technological trend? Why or why not?

6. In your institute when you have new ideas for your work or other people's work, is it easy to experiment your ideas?

7. What are the meetings you have to attend regularly? How often? What are discussed? How much you can share your ideas, experiences or good practices?

8. What channels are used for communicating amongst staff? Do you think they are effective? (For example internal publications, intranet, social media etc.)

9. Have you ever been rotated to other functions? How do you feel about it?

10. How do you record what you get from work that you have done? Is it known by other staff? Do you apply it for your new projects?

11. Is there any staff who work as coordinators among different units? (Collecting ideas, opinions and practices)

12. Do you often work with other staff? (Problem solving, completing task etc.) What makes you work with other staff? Do you think it is better to work as a team than individual? (Giving/receiving feedback, helping each other to learn, spending time together etc.)

13. Do you often use databases provided by your center? Do you have any comments about the existing databases? (Updated information, easy access)

14. Have you ever been rewarded by your center? If so, what kind of reward did you receive? Do you think it is important to have reward system? Why/why not?

15. What are the most important aspects for working at this center? Being update and innovative, getting jobs done in time, following established rules and regulations or coordinating with others?

16. Does this center have knowledge management policy? If so, what do you do to follow it?

19. Do you have any additional comments?

Time ended ………………………..