Doctoral Dissertation

The Dynamic Mechanism of Co-Creation: Application to Relationship Design and Management

Akane Matsumae

Supervisor: Professor Yukari Nagai, Ph.D

School of Knowledge Science

Japan Advanced Institute of Science and Technology

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Akane MATSUMAE
School of Knowledge Science, Japan Advanced Institute of Science and Technology

In the past few decades, increased global mobility led by remarkable developments and the extension of public infrastructure has brought about not only the possibility of further conventional static design management, but the importance of dynamic design management as well. Every type of organization— regardless of industrial sector, size, or profit status— is faced with the need to manage a newly dynamic environment based on an understanding of the context and factors of co-creation as well as the need to engage in its process. The importance of co-creation has been recognized for decades, but at the same time, the difficulties in its implementation have also been recognized. Simply gathering people from various organizations in one place and letting them introduce themselves is not enough to form a basis for sustainable collaborative innovation: developing methodology to flexibly design, implement, and manage the relationships that structure a society has become a broader need.

While the term co-creation has become widely used, it has not been clearly defined, nor has a common understanding of it yet been reached. As a result, it is natural that it is often confused with "collaboration" or "co-operation." Furthermore, studies on co-creation tend to take static approaches focusing on its partial and external aspects, referring to studies on collaboration (Taura et al., 2012); a focus on the challenge in capturing its particular nature as an integrated dynamic system is necessary in developing a practical methodology for co-creative relationship design and management. In addition, studies on co-creation have mainly focused on the usefulness of co-created values or on efficient collaborative processes creating these values. Few studies exist that take into consideration the fragile and dynamic nature of forming and sustaining co-creation subjectivity among individuals (Leigh Star, 2010).

In this regard, studies focused not only on co-created value but also on the subjectivity of co-creation are essential, particularly on their inner aspects. Studies on collaboration need to pay sufficient attention to distinguishing the fundamental differences between collaboration based on individual creativity and co-creation. Therefore, this study aims to elucidate co-creation mechanisms among individuals as dynamic systems by focusing on their fundamental factors and how the design process affects the formation of co-creative subjectivity and co-creativity among the individuals involved.

For this purpose, we have defined *co-creation* and proposed methodologies to evaluate these fundamental factors; *intersubjectivity* for a subjectivity of co-creation, *context* for a process of co-creation, and *co-creativity* for a consequence of co-creation. To examine them, an experimental study was then conducted concerning the types of collaborative design process: co-creative collaboration and co-operative collaboration. Theoretical and practical implications are discussed based on the knowledges obtained from the experiment in order to apply it to a design and management methodology for relationships that is deployable in an innovation ecosystem. Finally, the dynamic mechanism of co-creation is modelized as Inverted Vortex Model, an integrated dynamic system representing the results of experiments with a fluid dynamics analogy. The IVM is applied to case studies in the context of generating an innovation ecosystem, in which the establishment of new relationships throughout the co-creation process was recognized.

This study takes on the challenge of elucidating a dynamic mechanism of co-creation related to the formation process of co-creation subjectivity in its gestation phase (Reynolds & Miller, 1992) and of contributing to the methodology for the design and management of flexible relationships facilitating autonomous and horizontal collaborations not only within but also among organizations. Changing the emphasized aspect of co-creation phenomena from the co-created knowledge to the subjectivities of co-creation, its human-centric system is given an opportunity to be focused as the other hidden side of a knowledge creating system. A shift on what is focused can lead the shift of both measurements and principle for optimization from productivity to well-being.

Keywords: Co-Creation, Intersubjectivity, Dynamic Modelling, Relationship Design and Management, Well-Being

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Chapter 1

Introduction

1.1 Background

In the past few decades, increased global mobility led by remarkable developments and the extension of public infrastructure has brought about not only the possibility of further conventional static design management, but the importance of dynamic design management as well. Operating on the assumption that this neutral environmental change will occur in the form of increased mobility, every type of organization— regardless of industrial sector, size, or profit status— is faced with the need to manage a newly dynamic environment based on an understanding of the context and factors of co-creation as well as the need to engage in its process.

Following the German government advocating the importance of connected society as the industrial policy called Industry 4.0, which has become widespread globally (Bartodziej, 2017; Oesterreich & Teuteberg, 2016), the Japanese government now also emphasizes its importance in governmental policies represented by the term "connected industries" or the phrase "society 5.0 based on industry 4.0" (Cabinet Office, 2016). Thus, the importance of co-creation has been recognized for decades, but at the same time, the difficulties in its implementation have also been recognized. Simply gathering people from various organizations in one place and letting them introduce themselves is not enough to form a basis for sustainable collaborative innovation: developing methodology to flexibly design, implement, and manage the relationships that structure a society has become a broader need.

Under these circumstances, studies on co-creation are being actively conducted: 40,400 articles under the keyword “co-creation” are specified in Google Scholar as of April 20, 2018. Figure 1-1 shows the number of articles published in each year. It displays the rapid increase of research interest in co-creation that started in the latter half of the 2000s and accelerated through the 2010s (Figure 1.1).

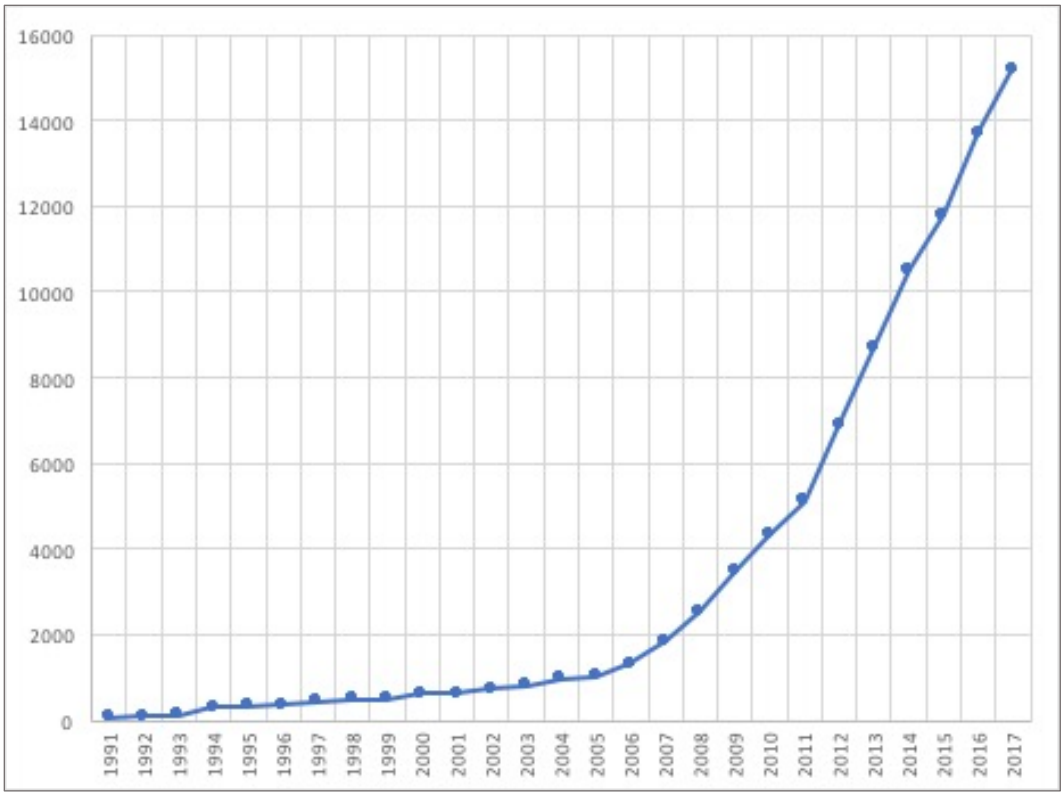

Figure 1.1 Number of Research Articles Searched by *Co-Creation* in Google Scholar

As exemplified in Figure 1.1, while the term co-creation has become widely used, it has not been clearly defined, nor has a common understanding of it yet been reached (Alford, 2016; Minkiewicz, Evans, & Bridson, 2013; Ramaswamy & Ozcan, 2018; Sanders & Stappers, 2008). As a result, it is natural that it is often confused with “collaboration” or “co-operation.” Furthermore, as shown in Chapter 2, studies on co-creation tend to take static approaches focusing on its partial and external aspects, referring to studies on collaboration (Taura et al., 2012); a focus on the challenge in capturing its particular nature as an integrated dynamic system is necessary in developing a practical methodology for co-creative relationship design and management.

1.2 Research Objectives

This study aims to elucidate co-creation mechanisms among individuals as dynamic systems by focusing on their fundamental factors (the subjectivity of co-creation, the process of co-creation, and co-creativity) and how the design process affects the formation of co-creative subjectivity and co-creativity among the individuals involved.

For this purpose, we have defined key terms and proposed methodologies to evaluate these fundamental factors. To examine them, an experimental study was then conducted concerning the types of collaborative design process: co-creative collaboration and co-operative collaboration.

We emphasize the importance of capturing co-creation mechanism as a dynamic system containing major factors, rather than focusing on a specific major factor. A dynamic model is proposed to represent the relationships between the formation of co-creation subjectivity and the co-creative process, based on the knowledge obtained from the experiment.

1.3 Research Significance

Studies on co-creation have mainly focused on the usefulness of co-created values or on efficient collaborative processes creating these values. Few studies exist that take into consideration the fragile and dynamic nature of forming and sustaining co-creation subjectivity among individuals (Leigh Star, 2010). Studies on collaboration need to pay sufficient attention to distinguishing the fundamental differences between collaboration based on individual creativity and co-creation. In this regard, studies focused not only on co-created value but also on the subjectivity of co-creation are essential, particularly on their inner aspects as well as in reference to existing literature based on individual collaboration or creativity.

On the other hand, this perspective is also significant in terms of knowledge science. First, since knowledge-enabling conditions and the SECI model have mainly been developed empirically within established larger companies (Krogh, Ichijo, & Nonaka, 2000; Nonaka & Takeuchi, 1995), it should be carefully examined using

evidence from experiments to expand its theoretical scope to the formation phase of new business entities on which we focus in this study. Little practical evidence has been demonstrated for the formation of quadruple knowledge clusters among organizations, although Nonaka and Konno have mentioned its theoretical possibility (Nonaka & Konno, 2012). Second, as Nonaka defines "organizational knowledge creation" as the process of making available and amplifying the knowledge created by individuals, as well as crystallizing and connecting it to an organization's knowledge system (Nonaka, Krogh, & Voelpel, 2006), knowledge science has focused on co-created knowledge rather than subjectively co-creating knowledge. In this context, as practitioners, we have often experienced and observed the secondary effect of co-creation, which has formed autonomous knowledge creation clusters among cross-contextual stakeholders (Matsumae, 2014b, 2014a; Matsumae & Burrow, 2016), and we have attempted to use them to design and manage an innovation ecosystem (Matsumae & Burrow, 2015; Matsumae & Nagai, 2016).

This study takes on the challenge of elucidating a dynamic mechanism of co-creation related to the formation process of co-creation subjectivity in its gestation phase (Reynolds & Miller, 1992) and of contributing to the methodology for the design and management of flexible relationships facilitating autonomous and horizontal collaborations not only within but also among organizations. It will empirically explore the limitations of these theories— whether they can be applied during the formation phase of organizations and whether the theories apply both within and among organizations.

1.4 Methodology

In this study, we took an experimental approach in referring to literature to understand the dynamic mechanisms of co-creation in relation to the formation process of co-creation subjectivity among individuals in various contexts during the gestation phase of autonomous and horizontal collaborations. Our methodology is characterized by the analogy of the research methodology of dynamics, which captures interactive and integrated systems quantitatively. This methodology is usually understood through five experimental approaches: 1) proposing a dynamic model simplifying research objects, 2)

indicating the measurements for evaluation, 3) conducting experiments based on the proposed model, 4) performing theoretical analysis on observed phenomena and the results of the experiments, and 5) engaging in discussion on modifications, improvements, or further development of the original model based on the findings, in consideration of the possibilities of practical application.

1.5 Thesis Structure

First, following the literature review, we summarize the concept of co-creation and its dynamic nature in comparison with creation and collaboration. We then define major factors of co-creation dynamics and evaluation methods for each factor, including co-creativity and the subject and context of co-creation. Second, experiments capture both the dynamic nature of and the relationships between these major factors based on the definitions and methods given above. Third, we modelize the dynamic mechanism of co-creation as an integrated dynamic system representing the results of experiments with a fluid dynamics analogy. We also apply it to case studies in the context of generating an innovation ecosystem using the proposed model, in which the establishment of new relationships throughout the co-creation process was recognized. Finally, we discuss theoretical and practical implications based on our findings in order to apply it to a design and management methodology for relationships that is deployable in an innovation ecosystem.

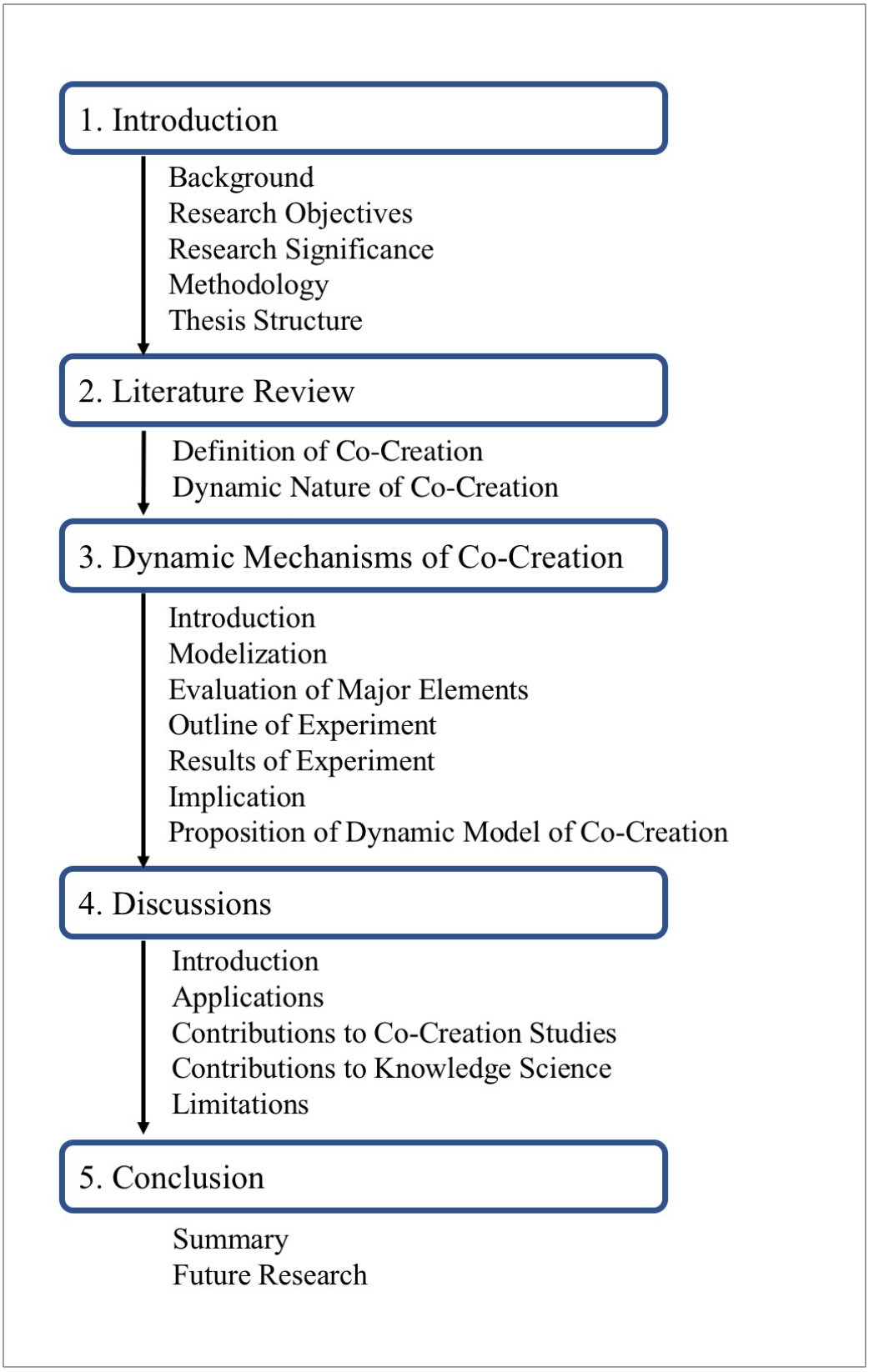

Figure 1.2 Thesis Structure

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Chapter 2

Literature

2.1 Definition of Co-Creation

The term co-creation is an important term widely used in various fields, including knowledge science. However, researchers admit that it has not reached a common definition; rather, the varieties of its definitions continue to increase (Alford, 2016; Minkiewicz, Evans, & Bridson, 2013; Ramaswamy & Ozcan, 2018; Sanders & Stappers, 2008).

From the perspective of participatory design, co-creation is defined as *any act of collective creativity*— creativity that is shared by two or more people. As a consequence, co-design as collective creativity is regarded as a specific instance of co-creation. The broader sense of co-designing subjectivity in collective creativity includes not only collaborating designers but also people who are not trained in design applying their unique points of view while working together in the design development process (Sanders & Stappers, 2008). In the context of Knowledge-Intensive Business Service (KIBS), co–creation between a service provider and a client is defined as " …*a joint process of service creation* which is based on the creativity of the partners; it involves the integration of complementary heterogeneous resources, the production of new knowledge and its application in solving a specific and even unique business problem and leads to the result of mutually beneficial value that is hardly foreseen in advance…" (Jokubauskiene, Patasiene, Bakanove, & Patasius, 2014). Meanwhile, Aarikka–Stenroos and Jaakkola defined it as "…*joint problem solving*, which involves supplier and customer resources integrated in a collaborative interaction process" in the same context (Aarikka-stenroos

& Jaakkola, 2012). Literature on co-creation has been accumulated mainly within the domain of *value co-creation*, where it is defined as a "*collaborative innovation process between stakeholders* that focuses on co-creation as a dynamic and interactive social process between co-creators both across co-creation environments and embedded within them" (Roser, DeFillippi, & Samson, 2013) in the context of a shift from a transactional to a collaboration-focused view of customer relations in marketing. In this sense, "co-creation involves an effort between multiple stakeholders to co-create value/an experience collaboratively" (Minkiewicz et al., 2013) in the other contexts of customer experience, particularly in service design.

As perspectives on co-creation studies have expanded from the business to the social, from the theoretical to the practical, and from the objective to the subjective, definitions of co-creation have become more varied to adopt to these situations. Stensæth, who studied co-creation from the perspective of promoting health and well-being, started with the simplest definition: the *act of co-creating together* and deployed various definitions of co-creation for each perspective, including interaction design, music and health, musicking, and relationships, to make them meaningful for each instance (Stensæth, 2013).

The challenge to derive a common definition of co-creation was taken on by Frow et al. who defined co-creation as "*an interactive process* involving at least two willing resource integrating actors which are engaged in specific form(s) of mutually beneficial collaboration, resulting in value creation for those actors based on the following analysis (Frow et al., 2015)." This was based on findings from his review on the literature of co-creation in various fields that co-creation includes (1) active involvement between at least two actors, (2) integration of resources that create mutually beneficial value, (3) willingness to interact, and (4) a spectrum of potential forms of collaboration (Skaržauskaitė, 2013). Moreover, the modified definition of that frequently cited definition is that co-creation is the *enactment of interactional creation* across interactive system-environments (afforded by interactive platforms), entailing agencing engagements and structuring organizations (Ramaswamy & Ozcan, 2018).

As seen above, the term “co-creation” has not reached a common definition. The distinction among collaboration, co-creation and co-operation has remained ambiguous. The definitions and discussions on co-creation in existing literature indicate that the aspect of focus in a study ought to be reflected in the definition: focused more on the “co” aspect and less on what is co-created. Therefore, for the purposes of this study, we define *co-creation* in this study as ”a collaboration to create something together sharing the phase of socialization among individuals,” referring to the SECI spiral in Figure 2.1 (Nonaka & Takeuchi, 1995). Sharing a clear common goal among individuals is not required at the beginning of the co-creation process, but the goal appears during the process of dynamically developed co-creation. In contrast, co-operation is distinctive from co-creation because it is collaboration performed to achieve a given common goal without a shared socialization phase among individuals. For co-operation, a stated clear goal must be central among individuals from the beginning (Figure. 2.2).

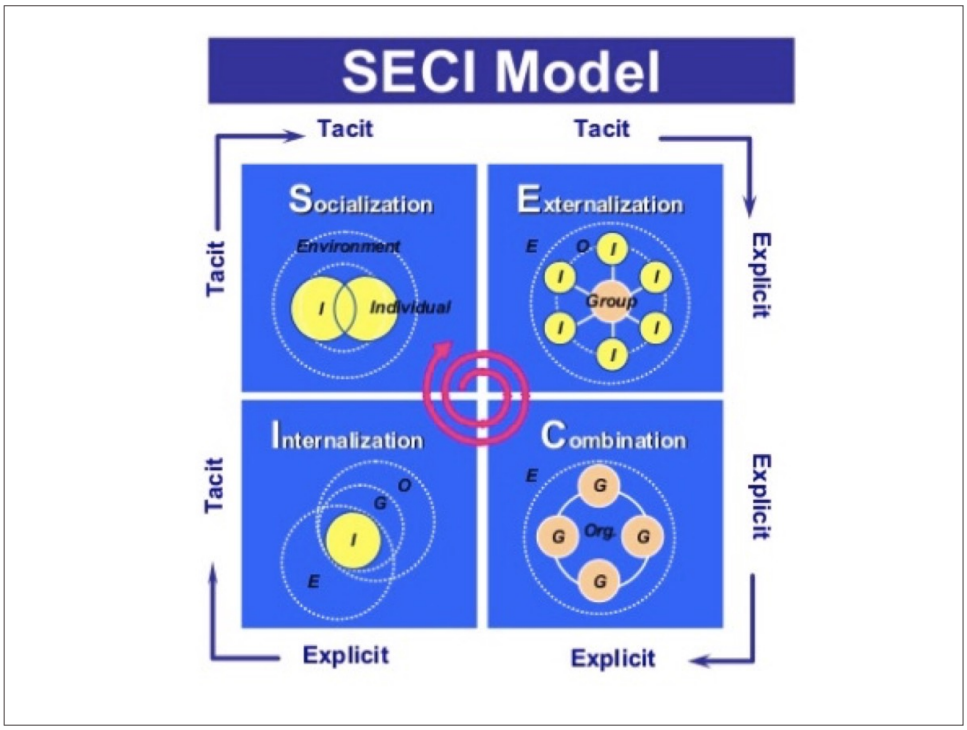

Figure 2.1. SECI Model (Nonaka, Takeuchi, & Konno, 2011)

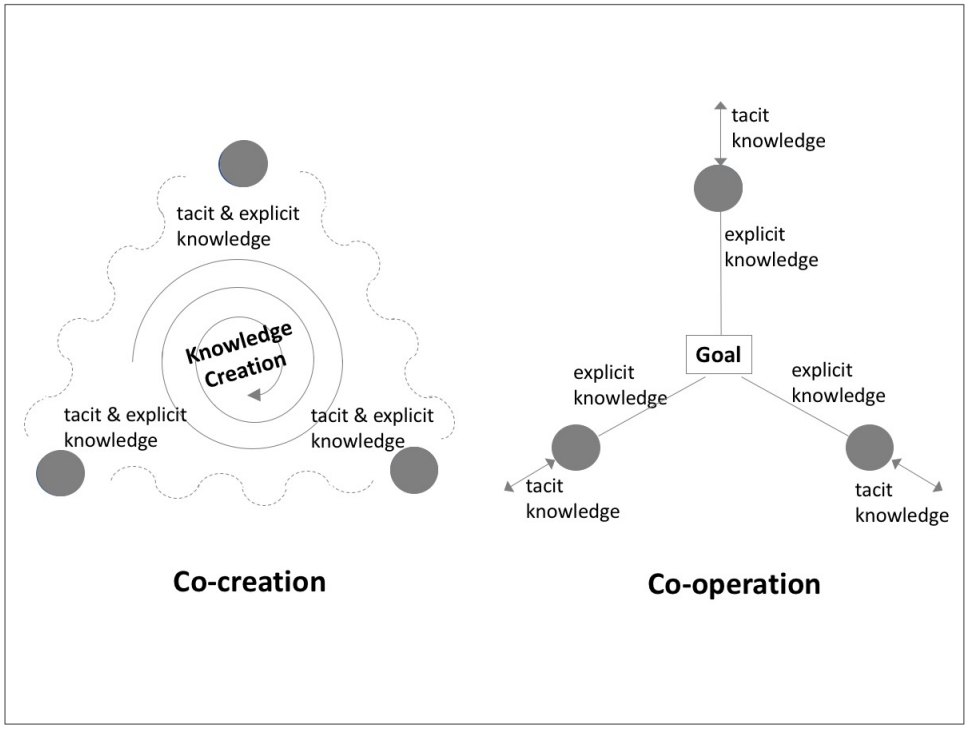

Figure 2.2 Comparison of Co-Creation and Co-Operation

2.2 Dynamic Nature of Co-Creation

2.2.1 Introduction

Studies on co-creation have mainly focused on the usefulness of co-created values or on efficient collaborative processes toward them. Few studies seem to exist that take into consideration the fragile and dynamic nature of the co-creation subjectivity that is formed and sustained among individuals (Leigh Star, 2010).

Studies on collaboration ought to pay sufficient attention to the distinction of the fundamental differences between collaboration based on individual creativity and co-creation based on co-creativity generated among individuals. It is necessary to conduct studies focused not only on co-created value, but also on the dynamic subjectivity of co-creation, particularly on its inner aspects. This should be performed with reference to existing literature on collaboration and creativity that is based on individuals. Individual creation differs from co-creativity in its subjectivity and process as well as in its dynamic nature.

In this study, the dynamic nature of co-creation is discussed from the points of view of three components of action: subjectivity, process, and co-creativity.

2.2.2 Subjectivity of Co-Creation

In the pursuit of innovation, the importance of collaboration among diverse individuals and/or organizations is often emphasized (Sawyer, 2011), but collaboration does not happen just by having individuals together in one place. It is also lamentable to see collaborative projects break up when part of their framework is taken away, for instance, when they face a loss of resources, become obsolete in dynamic circumstances, or experience the termination of a period of subsidy. Unframed subjectivities in collaboration are basically free, brittle, and dynamic enough to decimate the basis of collaboration. Therefore, it is important to understand the dynamics of the autonomic

subjectivity of collaboration for sustainable innovation. As for co-creative collaboration, in which the process includes sharing implicit knowledge, the importance of consideration on the subjectivity of co-creation is higher than that of co-operative collaboration, in which process by definition shares explicit knowledge that is only based on each individual.

The subjectivity of co-creation is formed among individuals as a basis for co-creation, which includes socialization, converting tacit knowledge to new tacit knowledge through shared experiences (Nonaka & Takeuchi, 1995). This is different from the collective subjectivities of each individual in collaboration. There is a recent experimental study on shared understanding among team members during collaboration (Cash, Dekoninck, & Ahmed-kristensen, 2017) that is not based on intersubjectivity among members but on each individual's independent subjectivity.

The subjectivity of co-creation has been argued by Benjamin to be intersubjectivity. Benjamin also has an interest in how we build relational systems. From his research interest on how we actually experience the other as a separate yet connected being with whom we are acting reciprocally, he defines intersubjectivity in terms of a relationship of mutual recognition a relationship in which each person experiences the other as a like subject, another mind with which things can be experienced, yet one that has a distinct, separate center of feeling and perception (Benjamin & Ph, 2004). In this context, with the idea that co-creation could be viewed as a social model that encompasses environmental factors ranging from the individual's most immediate environment to the general environment (including both social and institutional structures) (Stensæth, 2013), co-creation could be a means of forming micro relationships called intersubjectivity that could even act as a way of structuring society in the end.

The concept of intersubjectivity has its origins in Husserl's phenomenology and has been developed in several different directions based on its different aspects. The domain of intersubjectivity lies beneath the empathy of the Husserl's Fifth Cartesian Meditation (Donohoe, 2016; Zahavi, 2001). The basic idea of intersubjectivity is that subjects do not constitute a world alone, but jointly, together with other subjects. This world lies beneath the empathy of the Fifth Cartesian Meditation (Bower, 2014).

The importance of intersubjectivity in knowledge co-creation has been pointed to as a source of motive power for execution (Nonaka & Konno, 2012) expressed as the co-creativity explained in 2.2.4. Their intersubjectivity point of view is closer to Benjamin's empirical point of view, although it is difficult to find experimental research to support their indication in their literature because of the complexity of the phenomena of or difficulty in evaluating a human's inner state. Tomasello found that intersubjectivity is not only responsive to other subjects' goals but also the means employed in achieving those goals from their observation (Tomasello, 2008).

Thus, the subjectivity of co-creation has a dynamic nature, and it is expressed in literature by the term intersubjectivity. Hereafter, we use the term intersubjectivity to indicate the subjectivity of co-creation and propose a methodology to evaluate its dynamic nature formed among individuals in relation to its process and to co-creativity.

2.2.3 Process of Co-Creation

Regardless of the field of application, there have been substantial studies on the collaboration process regarding knowledge sharing, knowledge integration, and shared understanding in established teams (Cash et al., 2017; Gendron, Pourroy, Carron, & Marty, 2012; Kleinsmann, Deken, Dong, & Lauche, 2012; Maier, Kreimeyer, Lindemann, & Clarkson, 2009; Yang, Dong, & Helander, 2012). However, these studies on the co-operative collaborations that are supposed to be *well-managed*. They have a clear common goal from the beginning to achieve and are mainly discussed with regard to efficiency and/or usefulness in achieving that goal.

In contrast, this study focuses on co-creation, defined as a collaboration to create something together sharing a phase of socialization among individuals, requires different discussion on its process, since it does not have a clear common goal to achieve. Rather, it is a dynamic process that includes continuous interaction to search, define, modify, and form a common goal together in the course of creating. This dynamic process should be understood as deployment of research in the concept generation process with the aim of understanding the concept generation process of designers and, approached by modelling

and simulation based on real-life experiments (Nagai & Noguchi, 2003; Taura, Yamamoto, Yusof, & Fasiha, 2012) .

The dynamic nature of the co-creation process is explained in the literature. Co-creation is a highly contextual and interactive phenomenon (Tari Kasnakoglu, 2016) ; Creativity ("co-creation" in this study) is the interaction among aptitude, process, and environment through which an individual or a group produces a perceptible product that is both novel and useful as defined within a social context (Plucker & Dow, 2004). What we call creativity always involves a change in a symbolic system—a change that, in turn, will affect the thoughts and feelings of other members of the culture. A change that does not affect the way others think, feel, or act will not be creative. (Csikszentmihalyi, 1988). In knowledge creation, one cannot be free from one's own context, and context provides the basis for one to interpret information in order to create meaning (Nonaka & Toyama, 2003).

However, if the process of co-creation has a dynamic nature, then on what should we focus to grasp the dynamic process? In other words, what generates and drives the dynamic process of co-creation? In the literature on the co-creation process that discusses this point, there are likely to be two major terms mentioned as drivers of the co-creation process: creativity and context. It is also necessary to have both terms, creativity and context, to grasp the dynamic co-creation mechanism. According to the literature, we could organize these relationships as follows: it is individual creativity that generates and drives co-creation, and each individual's creativity is directed with its own context, since context is understood to be a meaningful aspect of the *phenomena*, in contrast with creativity, which is something that has impact on its own. Dynamic interactions among each individual's creativity, which mutually affect and alter one's context, mediated with *ba*, defined as "a shared context in motion" (Nonaka & Toyama, 2003).

Thus, the process of co-creation has a dynamic nature driven by individual creativity that is directed using varieties of contexts mediated with *ba*. In this study, we capture the dynamic process of co-creation using the concept of context vectors and

propose a methodology to evaluate its dynamic nature in relation with its process and with co-creativity.

2.2.4 Consequence of Co-Creation

The definition of co-creativity in this study can be understood as an inner consequence of co-creation, by referring to the recently published literature on creativity cited below. The standard definition of creativity has consistently required two attributes, originality and effectiveness, though they are paraphrased into different expressions by different researchers (Runco & Jaeger, 2012). Researchers have developed studies on creativity generated among individuals (Gilson, Lim, Litchfield, & Gilson, 2015; Sawyer, 2011). Research on group creativity can be seen in specific fields, such as music and drama (Chen, 2017; St. John, 2007). In a more general sense, organizational creativity was defined as the creation of a valuable, useful new product, service, idea, procedure, or process by individuals working together in a complex social system (Woodman, Sawyer, & Griffin, 1993).

However, these literatures, which assume a *stable* organization as a subjectivity of co-creation, overlook a fundamental difference between co-creativity and creativity: the *unstable* subjective basis of co-creativity. Substantial studies on creativity and its theoretical development provide reasonable clues to developing studies on co-creativity, as far as their fundamental differences are considered. Co-creativity is generated among individuals, in contrast with creativity, which is generated within an individual. This means that co-creativity is founded on a dynamic subjective basis. This point of view is especially important when we deal with either the fuzzy front-end phase in process development (Reid & Brentani, 2004) or the gestation phase in organization development (Reynolds & Miller, 1992; Sanders & Stappers, 2008). Which this study focused on for its dynamic phase in forming both its clear goal and its subjectivity. Considering that both the essential factors of creativity, effectiveness and novelty, can be approached through the continuous creative process, and that it is *motivation* which initiates and sustains the creative process (Amabile, 1983), the most essential factor of co-creativity can be said to maintain shared motivation based on dynamic intersubjectivity among individuals, not

within an established organization, to continue improving a project without a clear common goal.

Furthermore, discussing creativity in relation to the design category of co-creation as defined in this study, it is clearly categorized as *ideal pursing*, in which creativity should be evaluated by how close it is to the desired ideal figure. In this case, novelty is just a result of creativity as seen above, and if we started off by aiming at novelty, we would not be able to achieve our desired figure; instead, we would end up with a strange, unsuitable result (Taura & Nagai, 2009).

Thus, *co-creativity* in this study should also be a different concept from traditional creativity or organizational creativity in current studies conceptualized with a focus on the external consequences of co-creation in a logic of *value co-creation*, which is described by effectiveness, usefulness, novelty, or even productivity. Co-creativity in this study should be defined in a logic of *human well-being* as the inner consequence of co-creation. Relatedly, authors consider it significant to provide alternative definitions and measures in a logic of human well-being to grasp the consequences of co-creation, since we tend to pursue improvement along with the measures, once defined. What, then, should be the focus of the inner consequences of dynamic co-creation? Considering the fundamental nature of co-creation from an inner aspect—fragile and unstable subjectivity among individuals (intersubjectivity)—the intersubjectivity should generate and sustain the co-creative process until process realization.

Therefore, as the inner consequence of co-creation, *co-creativity* is defined in this study as *a shared motivation among individuals to develop and realize their concept* since it is *motivation* which initiates and sustains the creative process (Amabile, 1983)

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Chapter 3

Dynamic Mechanism of Co-Creation

3.1 Introduction

Modelization— which represents a mechanism of the modelled object's nature in order to design and manage a modelled object and develop a further understanding of it— has a useful role in developing and deploying theoretical knowledge into practical knowledge. It is applicable not only to physical phenomena but also to those that are conceptual. For example, modelling and blueprinting offer a system for marketers that can lead to the kind of experimentation and management necessary for service innovation and development (Shostack, 1982). Moreover, the first step towards rational service design is a system for visualizing this phenomenon, enabling services to be given the proper position and weight in a market entity context (Shostack, 1982). The significance of modelization can be even greater when the modelled object is a conceptual and/or dynamic phenomenon since it has unique necessity in terms of visualization and/or integration as a system.

This significance of modelization should be also applicable to the nature of co-creation, since the nature of co-creation is conceptual, and its factors interact with each other dynamically. In the following section, we determine methods for modelization and major factors of the model for the dynamic mechanism of co-creation, grasp the dynamic relationships among these factors, and finally, modelize the dynamic mechanism of co-creation as an integrated dynamic system based on the knowledge that has been obtained.

3.2 Modelization

3.2.1 Models of Co-Creation

The significance of systems modelling approaches to creativity has been argued and recognized as the theoretical foundation of the field (Plucker & Dow, 2004) . This could be basically expanded in its course into that for co-creation, because various kinds of co-creation models have recently been proposed from which the perspective of measuring value co-creation (Skaržauskaitė, 2013); evaluating co-creation possibilities (Jokubauskiene, Patasiene, Bakanove, & Patasius, 2014); knowledge-sharing risk management procedures (Banerjee & Sharma, 2015); understanding the consequences of co-creation among consumers, providers, and partners (Tari Kasnakoglu, 2016); and the co-creation process (Silva & Wright, 2016).

However, most of models of co-creation, including the ones above, represent only static and/or discrete relations, which only relate to and structure factors and/or phases focusing on input and output. As discussed in the previous chapter, co-creation has a dynamic nature. Therefore, a dynamic systems modelling approach can represent its fundamental nature more accurately by enabling it to describe its dynamic mechanisms as a dynamic integrated system using various factors. Several challenges in the development of dynamic systems modelling are found in literature on creativity. For example, the systems model is analogous to the model that scholars have used to describe the process of evolution (Csikszentmihalyi, 1988) and to the molecular model from behavioral perspectives (Shostack, 1982). The former model is based on whether creativity is worth both being included and assists in surviving in a particular field: it is incompatible to the definition of co-creativity in this study. The latter is discrete, and it cannot describe continuous and interactive behaviors of a co-creative nature. The book “Managing Flow” (Nonaka, Toyama, & Hirata, 2015) emphasizes the dynamic nature of firms within sustainable innovation might lead association to use fluid dynamics, and its ideas could be compatible with the definition of co-creation in our study, however, modelling using a fluid dynamics analogy cannot be found in that definition.

3.2.2 Dynamic Modelization

Following the consideration in the previous section (3.2.1), we will modelize the dynamic nature of co-creation in an analogy of fluid dynamics with respect to its advantages. This can describe interactive behaviors among factors of co-creation as an integrated dynamic systems model both in quality and in quantity.

As discussed in the previous chapter, the major factors of dynamic co-creation mechanisms we focus on in this study include intersubjectivity, context, and co-creativity; each of them reflects the subjectivity of co-creation, the process of co-creation, and the concept of co-creativity, which constitute co-creation dynamics. Each of these major factors is captured based on the dynamic inner state of individuals. Individual creativity can be resolved through scholar potential, individual property, and a vector potential, in an individual context, since context is understood as a meaningful aspect of individual creativity of the phenomena (Nonaka & Toyama, 2003). In contrast, creativity is something that has an impact. Individual property is represented as a mass point placed in fluid, individual creativity as a vector force at each mass, and co-creativity as a sum of vector forces within an integrated system, while *ba,* which mediates each factor as shared context in motion (Nonaka et al., 2015) can be represented with fluid. There are other factors that constitute dynamic co-creation mechanisms, but only the fundamental factors are considered in this study to capture fundamental behavior.

3.3 Evaluation of Major Factors

3.3.1 Introduction

Since design are activities arising from humans' inner state, it is essential to capture the dynamic nature of this inner state to understand the mechanism of co-creation which includes design process. The problem here is that it is difficult for individuals to observe their inner design processes by themselves while they are deeply engaged in their work,

since they are then fully immersed in their work in a mental state described as flow (Nakamura & Csikszentmihalyi, 2009); it is also difficult to capture the inner state of individuals creative process by external observation, because a designer's thinking is formulated internally (Nagai & Taura, 2010). As a result it is difficult to observe the design-thinking process objectively, whether externally or internally (Taura et al., 2012). Results can differ depending on who is evaluating, when measurements are taken concurrently or ex-post (Nagai, Taura, Sano, and Yasui, 2010).

However, co-creation requires action, not completed within the sense of individual, but in the sense of relating. Eventually, in co-creation, action exists on a co-action in joint attention and being actively engaged, face-to-face, in a live situation (Stensæth, 2013). In other word, co-creation could be comparatively advantageous than individual work to be captured inner state for its interactive nature; something somehow to be shared with other collaborators externally and less immersion to oneself to spare one's attention for interaction internally.

Admitting the difficulty of evaluation of inner state, it is also true that each externalized behavior reveals a portion of the major tendency of inner state. Inner state can be captured partly by observing a subject's external appearance and also by the self-description based on their own awareness. Therefore, a multi-pronged approach is taken in this study to capture the subject's inner state with higher precision, in the same way a court captures a case without its direct experience, along with its established law methodology, reasoning from duplicated indirect facts with evidence from different points of view.

At the same time, the authors regard it as important to choose the appropriate evaluation scale considering the complexity and the fluctuation of human nature and limitation of cognitive ability. To capture the dynamics of inner human nature, intersubjectivity (3.3.2), contexts (3.3.3) and co-creativity (3.3.4) were chosen as essential factors in this study and to be evaluated.

3.3.2 Intersubjectivity

In this study, the degree of intersubjectivity formation is evaluated both with the concordance degree among self-described dynamic emotional waves of each individual (Figure 3.1) and with the observation of external appearance in reasonably appropriate precision by experts. As described in 3.3.1, the concordance degree of emotional waves is only one of the viewpoints expected to be duplicated with others to pursue higher precision, and it is for future research to compare and examine validity among them.

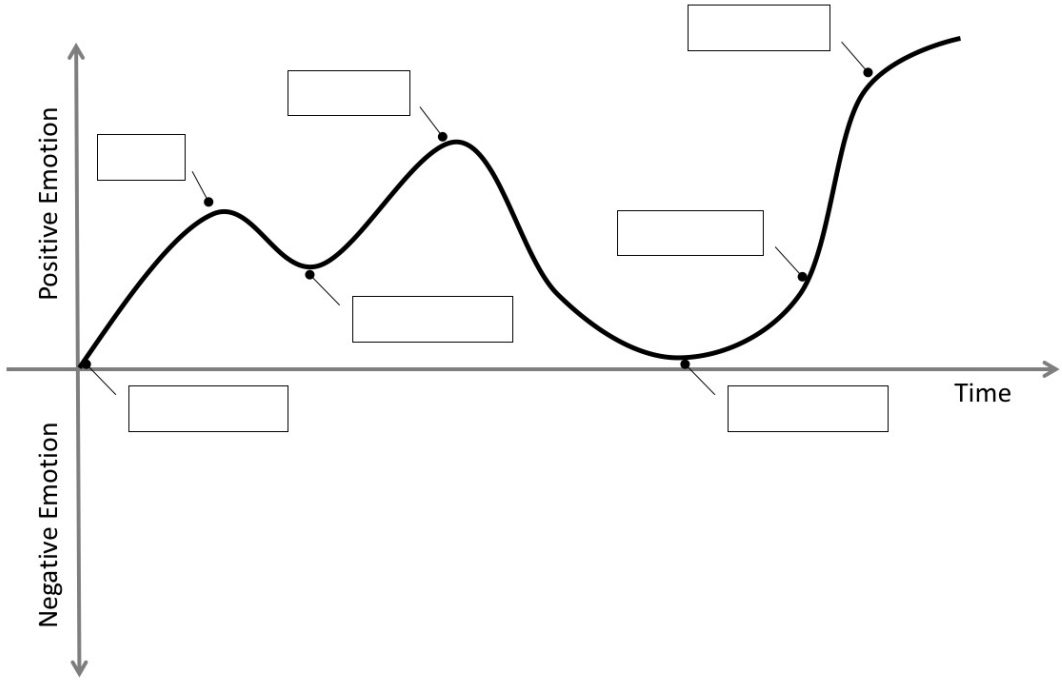

Figure 3.1 Emotional Wave to Grasp Dynamic Inner State

3.3.2.1 Self-Description by Participants

Each of the participants was requested to record one's own cognition of one's nature dynamics. To capture the formation of intersubjectivity, the qualitative coincidence of fluctuations, in other words, emotional wave patterns, is analysed by comparing the customer journey maps of all participating individuals. In contrast, it is not important to meet quantitative coincidence since each individual has a different degree of intensity in his/her expression.

The challenge evaluating inner human nature as numerical information is significant, however too detailed numerical calculations are counter-productive and fail to reflect the true status. An appropriate range of precision according to the nature of research object, intersubjectivity among different individuals is required. The authors carefully duplicated evaluation methods to capture each participant's emotional fluctuation to see the degree of qualitative coincidence of fluctuation as a state of intersubjectivity being formed among them, pursuing higher precision while avoiding meaninglessly detailed numerical calculations.

Pattern Comparison

One evaluation method is a simple categorization of wave patterns, which is captured as a combination of three modes (increasing, unchanging, or decreasing). For instance, when an observation term is divided into two periods, wave patterns can be categorized into nine patterns (Figure 3.2): increasing-increasing, increasing-unchanging, increasing-decreasing, unchanging-increasing, unchanging-unchanging, unchanging-decreasing, decreasing-increasing, decreasing-unchanging and decreasing-decreasing.

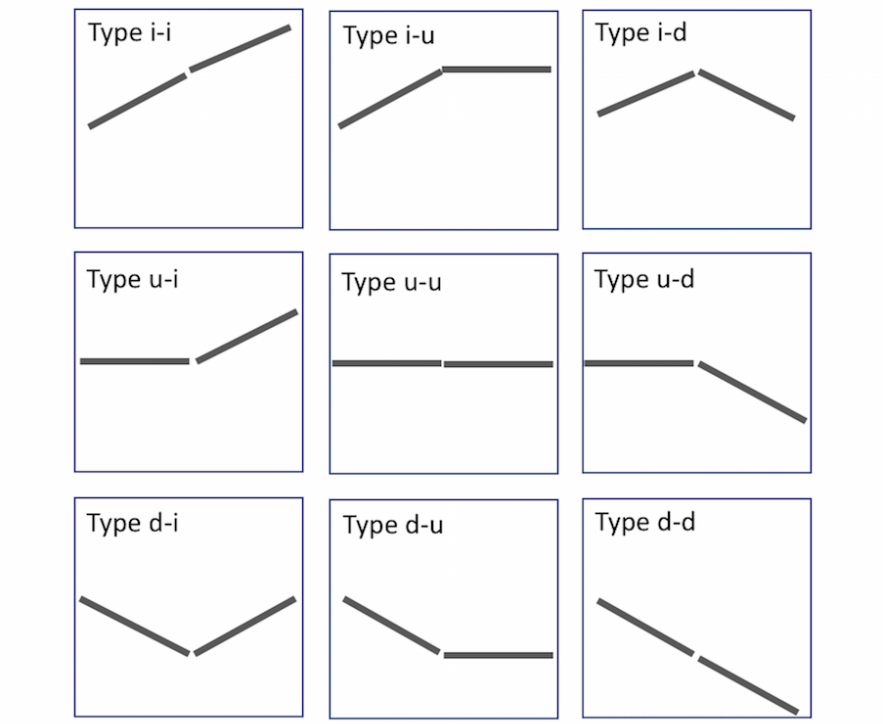

Figure 3.2 Simplified Categorization of Wave Patterns

Quantitative Comparison

The other evaluation method is a quantitative comparison of each participant's emotional waves. Numerically self-described emotional waves are normalized for pattern recognition according to each participant's maximum amplitude throughout the experiments, and also appropriately simplified considering the precision of cognition ability of participants.

For instance, let f_P be a continuous function such that $f_P(t)$ represents the person *P*'s original emotional value at time *t*. The function $\widehat{f_P}$ is defined as the normalized function of f_P, considering the individual difference of emotional amplitude. The function $\widehat{f_P}$ is formally expressed as,

$$\widehat{f_P}(t) \stackrel{\text{def}}{=} -1 + 2\frac{f_P(t) - m_P}{M_P - m_P} \qquad (1)$$

where $M_P = \max_t f_P(t)$ and $m_P = \min_t f_P(t)$. Obviously, it is not difficult to check the following three conditions hold for $\widehat{f_P}$:

$$\forall t\left[-1 \leq \widehat{f_P}(t) \leq 1\right],$$

$$\forall t\left[\left(f_P(t) = M_P\right) \Longrightarrow \left(\widehat{f_P}(t) = 1\right)\right], \textit{ and}$$

$$\forall t\left[\left(f_P(t) = m_P\right) \Longrightarrow \left(\widehat{f_P}(t) = -1\right)\right].$$

On the other hand, $f_P(t)$ can be approximated as a discrete function $\widetilde{f_P}(t)$ defined over a discrete series of time points $t_1, t_2, \ldots, t_N$, where each t_i is defined with an appropriate time interval so that every inflection points of f_P is included in the domain of $\widetilde{f_P}$.

Then the degree of intersubjectivity formation among individuals $P_1, \ldots, P_n$ $Isub(P_1, \ldots, P_n)$, can be defined as follows:

$$Isub(P_1, \ldots, P_n) \stackrel{\text{def}}{=} \frac{1}{nN}\sum_{t=t_1}^{t_N}\left(|f_{P_1(t)} - Ave_{(t)}|^2 \ldots + |f_{P_n(t)} - Ave_{(t)}|^2\right) \qquad (2)$$

where $Ave_{(t)} = \frac{1}{n}\sum_i^n f_{Pi(t)}$.

3.3.2.2 Observation by Experts

Three experts observed each team from external appearance throughout the experiment. All of the experts have more than fifteen-year experience evaluating team projects. They

were asked to observe and record participants' behavior focusing on how inter-subjectivity was formed in each team along with their own professional point of view to evaluate the phenomena in a duplicated approach for higher precision (3.3.1).

3.3.3 Context

In order to track a dynamic change of design context for each individual and team, the authors introduced the concept of context vector. A context is expressed in vector form in this study based on self-descriptions of participants. Each word shown in all descriptions is categorized and each category is given a different coordinate axis.
For instance, when all of words found in all self-descriptions can be categorized into n categories, the $\overrightarrow{Ctx}(P)$, context vector of person P, can be expressed,

$$\overrightarrow{Ctx}(P) \stackrel{\text{def}}{=} (F_P(1), \dots, F_P(n)) \qquad (3)$$

where $F_P(i)$ is a context force effected on the person P in category i.
Then the distance between contexts $\overrightarrow{Ctx}(P)$ and $\overrightarrow{Ctx}(Q)$ can be defined as follows:

$$DIST\left(\overrightarrow{Ctx}(P), \overrightarrow{Ctx}(Q)\right) \stackrel{\text{def}}{=} \sqrt{|p_1 - q_1|^2 \dots + |p_n - q_n|^2} \qquad (4)$$

where $\overrightarrow{Ctx}(P) = \left(p_{1,} \dots, p_n\right)$ and $\overrightarrow{Ctx}(Q) = \left(q_{1,} \dots, q_n\right)$.

3.3.4 Co-Creativity

As described in 2.2.1, co-creativity in this study is defined *as a shared motivation among individuals to realize and develop their concepts*. As an absolute evaluation of co-creativity, each participant is asked to express one's degree of motivation toward realization of each concept as a percentage. As a relative evaluation, each participant is asked to order these concepts, to compare more clearly the effect of design process on co-creativity generation among individuals.

3.4 Outline of Experiment

3.4.1 Introduction

This study was carried out with the aim of elucidating the dynamic mechanism of co-creation from excessively complex phenomenon that is seen, for instance, in cluster formation and business generation. However, it is necessary to simplify the phenomena to be experimented in order to understand their fundamental behaviors. In addition, current studies have not argued from the viewpoint of relationships between co-creation subjectivity among individuals (intersubjectivity) and motivation toward realization of the co-created (co-creativity) and this study tries to fill this research gap through this experiment. Based on the results of accumulated case studies (Matsumae, 2014a, 2014b, Matsumae & Burrow, 2015, 2016) and other informal case studies as well as preliminary experiments, authors have also assumed that intersubjectivity generates the motivation among individuals towards the realization of the co-designed concept.

Although there are many familiar exercises to develop team mood and inter-relationship among participants such as the "Marshmallow Challenge" exercise (Wujec, 2010), these are not structured to examine the motivation towards the process realization. Therefore, this study has contrived the "designing a pizza" experiment, which is utmost simplified but still maintains the following fundamental factors of co-creation dynamics: intersubjectivity, context and co-creativity. For the pizza designing experiment, clay modelling has been adopted instead of sketching. Therefore, no special skills were required to start the modelling process. Relatedly, another advantage of using clay modelling was the allowance for iterative process, that is, easiness to change and remake the design through the process. More importantly, "designing a pizza" is a comparatively easy and simple work for participants to realize the co-designed concept in final results (cooking a *real* pizza) than, for instance, the co-designed business model concept (starting a *real* business). In business model designing, there could be many other factors besides the fundamental factors of co-creation dynamics, which encourage or discourage motivation towards the realization of the co-designed concept, such as economic

conditions, private circumstances, social circumstances, and so on. When designing a pizza, it is much easier to exclude the effect of these other factors on the motivation for achieving the end result of the design concept. Therefore, the focused behaviors of co-creation subjectivity formation (intersubjectivity) and motivation toward the realization of the co-designed concept (co-creativity) are clearly observed through this "Little Red Riding Hood's Pizza Design for Grandma" experiment.

The purpose of this experiment is to obtain knowledge concerning how a design process affects (1) formation of intersubjectivity among individuals involved, and also (2) their motivation toward realization of the co-designed concept. With the purpose of examining the behavior of each identified major factors of co-creation dynamics (e.g. intersubjectivity, context vector, co-creativity), the experiment "designing a pizza for Little Red Riding Hood to bring to her sick grandmother" has been carried out. The behavior of each factor has been measured as explained under the section 3.3 and the co-creation dynamics model is proposed based on the results obtained in 3.7.

3.4.2 Participants

Thirty professionals from various occupations participated in this experiment. Participants were divided into six teams, from A to F, and each team had five members, numbered, for example, as A01, through A05 in team A. Team composition was carefully determined and the authors confirmed in advance that no members of the same team had any previous knowledge of other team members, to examine the formation process of inter-subjectivity in the experiment without the influence of existing relationships. Each team was also composed to maximize diversity in terms of gender, sector, and rank in the organizations they belong to (Table 3.1).

Table 3.1 Attributes Status of Team Members

	Team A					Team B					Team C					Team D					Team E					Team F				
G	m	m	f	f	m	m	m	m	f	m	m	m	m	m	f	m	f	m	m	m	f	m	m	f	m	m	m	f	m	m
S	M	M	M	W	P	M	M	O	W	P	M	M	P	O	M	M	O	M	M	P	M	M	M	W	O	M	M	M	O	W
R	L	L	L	F	F	F	L	L	F	F	L	F	F	L	L	L	L	F	F	F	F	F	L	L	F	F	F	F	L	L

G: Gender, m: Male, f: Female; S:Sector, M: Manufacture, W: Welfare, P: Public, O: Others; R: Rank, L: Leader, F: Follower

3.4.3 Procedure of Experiment

The procedure of the experiment has three processes, introduction (W00), co-operative work (W01) and co-creative work (W02) (Figure 3.3). After each process, participants were required to record their emotional wave in five minutes. Considering cognitive precision, participants were instructed to record their emotional wave on a 5-point likert scale (-2, -1, 0, +1, +2) at the beginning, middle, and end of each period in this experiment and record short explanations as to their emotional wave (Figure 3.4). Participants were also asked to record their motivation toward realization for each concept as described in 3.4.3 at the end of the series of works. Experts were asked to observe and record participants' behavior and each team's degree of formation of intersubjectivity in real time along a continuous time axis throughout the experiment as described in 3.3.2.2. This experiment was also recorded as video for ex-post evaluation.

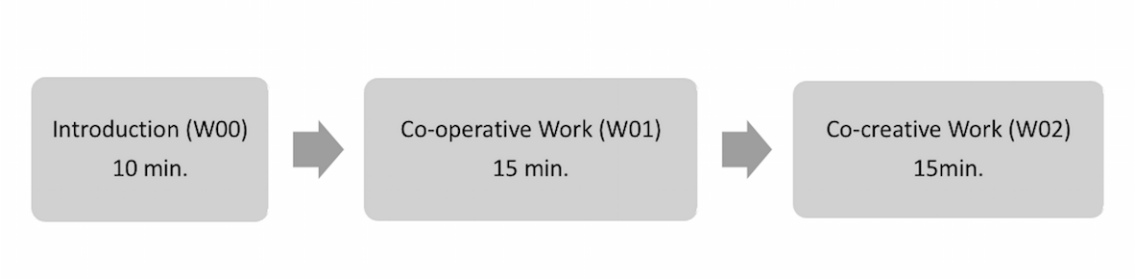

Figure 3.3 Procedure of Experiment

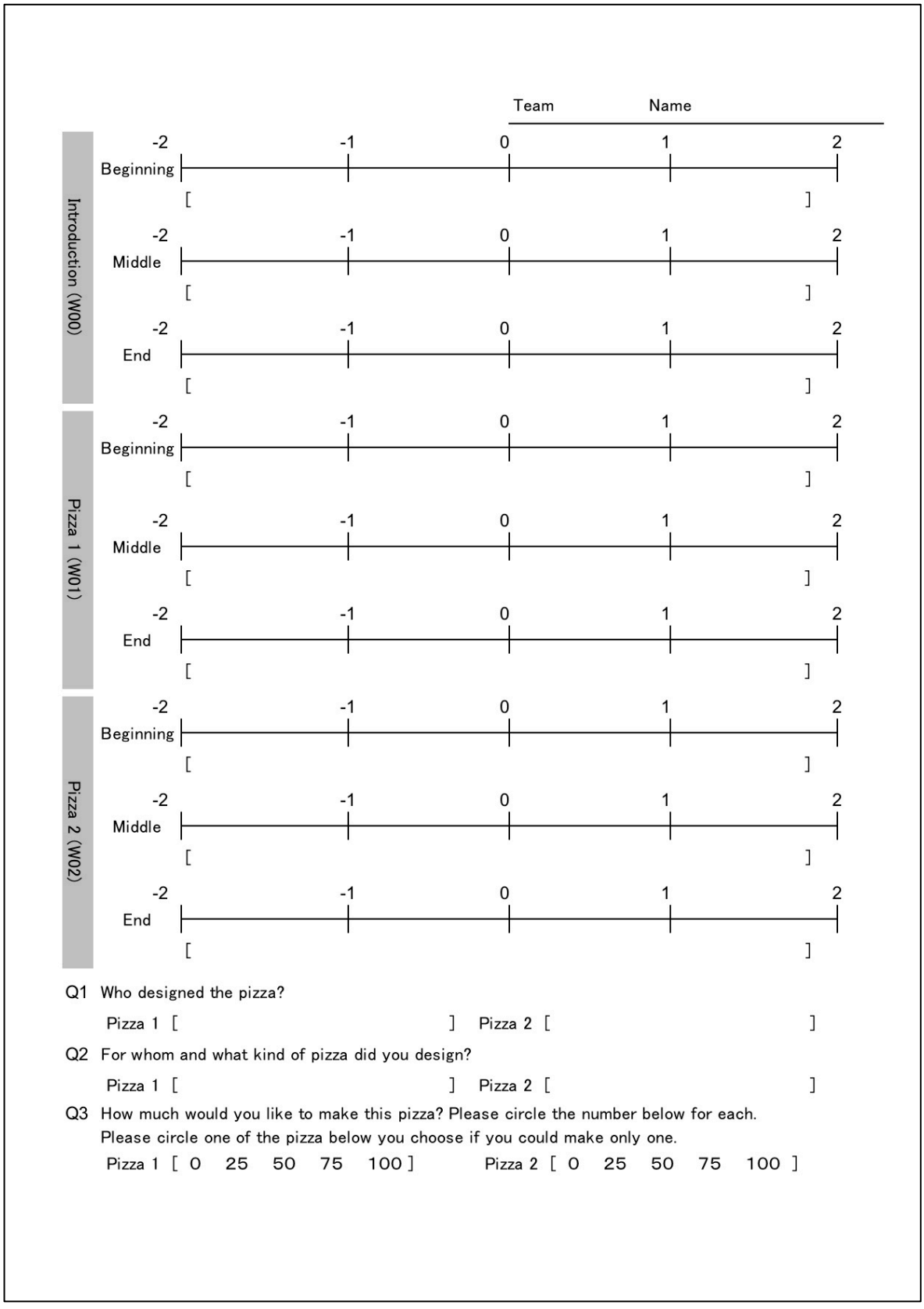

Figure 3.4 Self-Evaluation Sheet

3.4.3.1 Introduction (W00)

Participants were led to their designated table by team and given 10 minutes to introduce themselves to each other. Then they were given information that they would be assigned a set of collaborative design work as a team: designing a pizza for Little Red Riding Hood to bring to her sick grandmother. Even though every participant knew the story of Little Red Riding Hood, they were reminded of the outline of the story to ensure uniform knowledge of the story before the work sharing its picture (Figure. 3.5). Identical sets of materials for the experiment such as 10-colour-clay and pizza design template sheets had been prepared for each table in advance (Figure 3.6). At the end of each work, the evaluation procedure was explained and each participant was asked to record the transition of his/her emotional wave as described in the beginning of 3.4.3. No collaborative work was requested of participants during W00. W00 was designed not only to prepare for a set of collaborative design works but also to capture the basic status of participants.

3.4.3.2 Co-Operative Design Work (W01)

As a co-operative design work, each of participants was required to design a pizza in five minutes using a simplified design template Figure 3.7. Then each team chose one pizza design out of the five by rolling dice to make into clay-pizza. Participants were requested to co-operate in each team to make a clay-pizza strictly following the chosen design in the following ten minutes.

3.4.3.2 Co-Creative Design Work (W02)

As in W01 above, as a co-creative design work rather than cooperative design work, participants were requested to design a pizza together in five minutes in teams using the same simplified design template as the one for W01. However, in W02, the design was not chosen by the roll of dice, but co-designed by all members in the team. Then participants were requested to make a clay-pizza together by team based on their own design in the following ten minutes. They were allowed to change their original design during their clay work.

Figure 3.5 Shared Image of Little Red Riding Hood (Okahoge, n.d.)

Figure 3.6 Prepared Tables for Experiment

Menu

Crust × Source ￥1,000
Crust（Choose one） • **Regular** Fluffy bread type crust • **Crispy** Crispy, crunchy, thin and light crust • **Wheat** Roasted wheat germ kneaded savory crust • **Customize**（ ）
Source（Choose one） • **Italian tomato source** Tomato, onion, and vegie’s tasty source • **Curry source** Mild curry taste source • **Gratin source** Creamy white source based source • **Salsa source** Spicy source with red peppers and other spices • **Teriyaki source** Sweet and salty soy source based source • **Customize**（ ）

Topping ￥300 each, 6 at maximum
Meat Sliced bacon, diced bacon, pepperoni salami, sausage, chorizo (spicy), charcoal-grilled beef, roasted chicken, taco meat **Seafood** Shrimp, squid, scallop, tuna **Vegetable** Sliced tomatoes, grape tomatoes, onions, green papers, red peppers, potatoes, eggplants, spinaches, zucchinis, corn, pineapples, mushrooms **Cheese** Mozzarella, parmesan, cheddar, blue cheese **Others** Basil, black olives, garlic, jalapenos, mayonnaise, chopped seaweed, mochi, half-boiled egg **Customize**（ ）

Name : _____

1

Figure 3.7 Simplified Pizza Design Template

3.5 Results of Experiment

Sets of clay-pizzas prototyped during W01 and W02 in each team are shown in Figure 3.8 (From Left to Right: Upper for A, B; Middle for C, D; Lower for E, F).

Figure 3.8 Sets of Clay-Pizza Prototyped during W01(Left) and W02(Right)

3.5.1 Intersubjectivity

To evaluate the intersubjectivity being formed among individuals, degrees of coincidence of each participant's emotional waves are examined in two ways: pattern comparison (3.5.1.1) and quantitative comparison (3.5.1.2). The evaluation methodology described in 3.3.2 was applied to obtained data from the experiment described in 3.4.

3.5.1.1 Pattern Comparison

The results of each team's simplified pattern comparison are shown in Figure 3.9 (team A to team F) below. There are two sets of lines for each team, an emotional wave for co-operative work (W01) placed on the left and one for co-creative work (W02) on the right. Participant D03 withdrew due to illness, and her data have been excluded from the calculation.

From simplified pattern comparison, the major tendency concerning intersubjectivity can be captured visually; (1) wave patterns have less variety in W02 than W01, (2) these results match well with the experts' evaluation on intersubjectivity; for example, "Team C lacked a sense of unity during W01 but rapidly formed it and then worked dividedly in W02.", "Team E enjoyed both works individually, didn't challenge co-creation in W02 and failed to form intersubjectivity throughout the experiment," or "Team A formed intersubjectivity the earliest and kept it until they finished W02."

Each expert described clearly whether intersubjectivity is formed or not in a specific team and to what extent, and their evaluations were generally consistent. Each had observed, from different points of view, for instance, postures of team members, words used in conversation, a centre of "gravity" in a team, "temperature distribution" in a team, rhythms of communication, and so on. However, not all factors considered for evaluation are verbalized; rather, each of the experts seems to have evaluated intersubjectivity by integrating both these verbalized factors and non-verbalized factors.

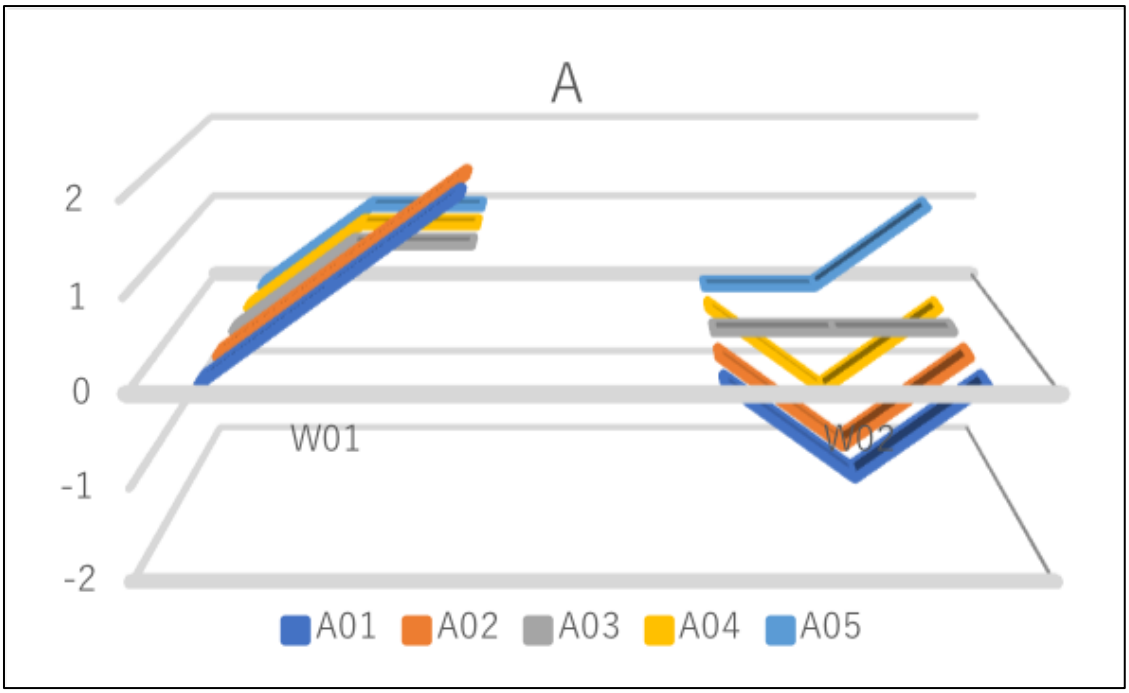

Figure 3.9a Pattern Comparison between W01 (left) and W02 (right)

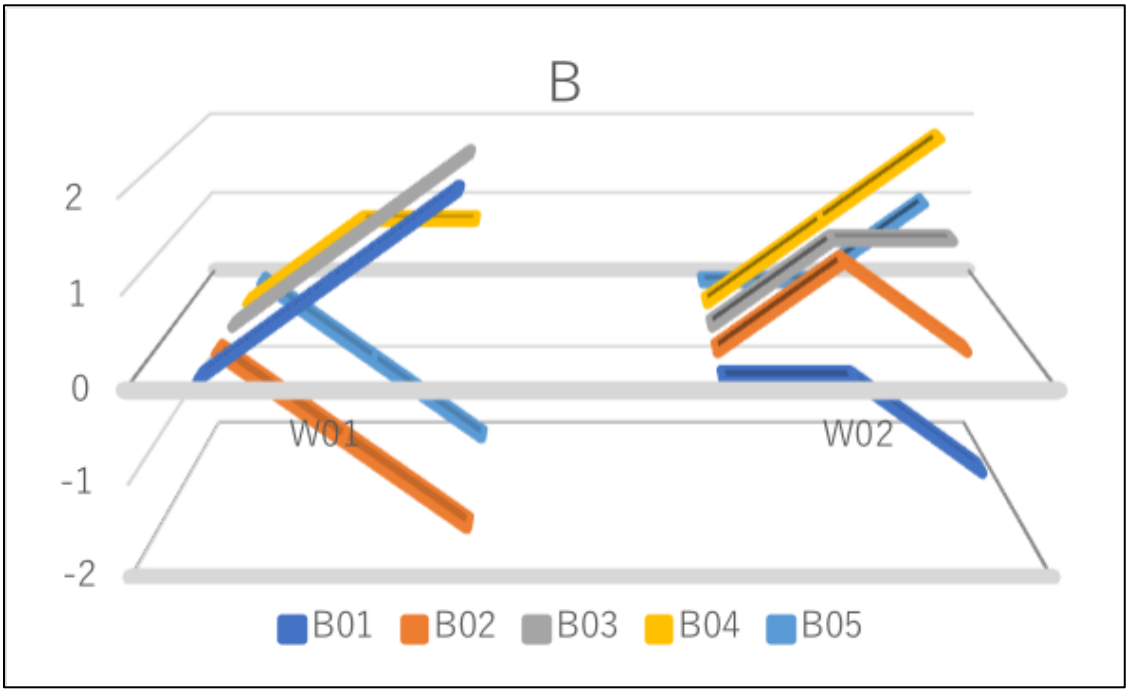

Figure 3.9b Pattern Comparison between W01 (left) and W02 (right)

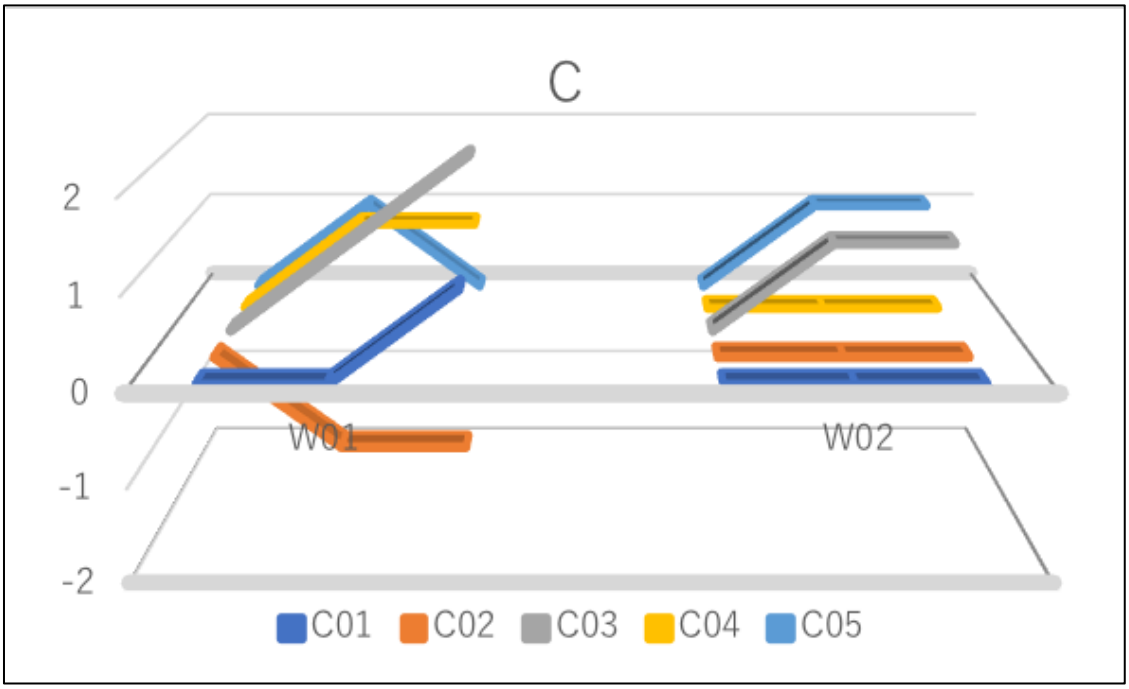

Figure 3.9c Pattern Comparison between W01 (left) and W02 (right)

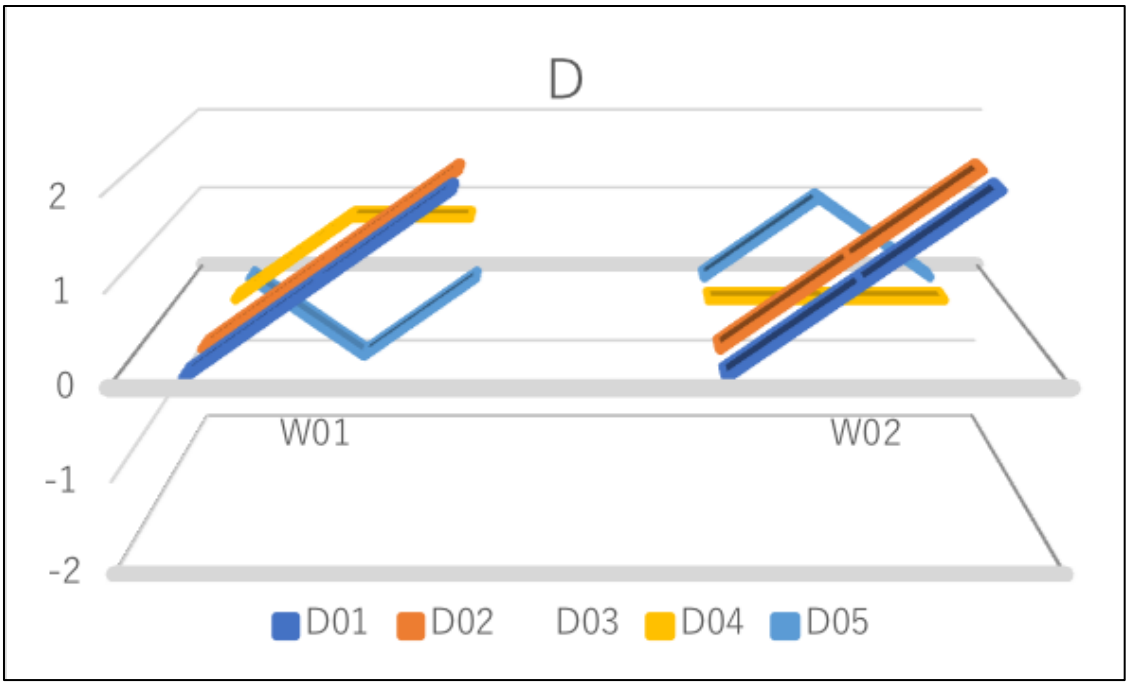

Figure 3.9d Pattern Comparison between W01 (left) and W02 (right)

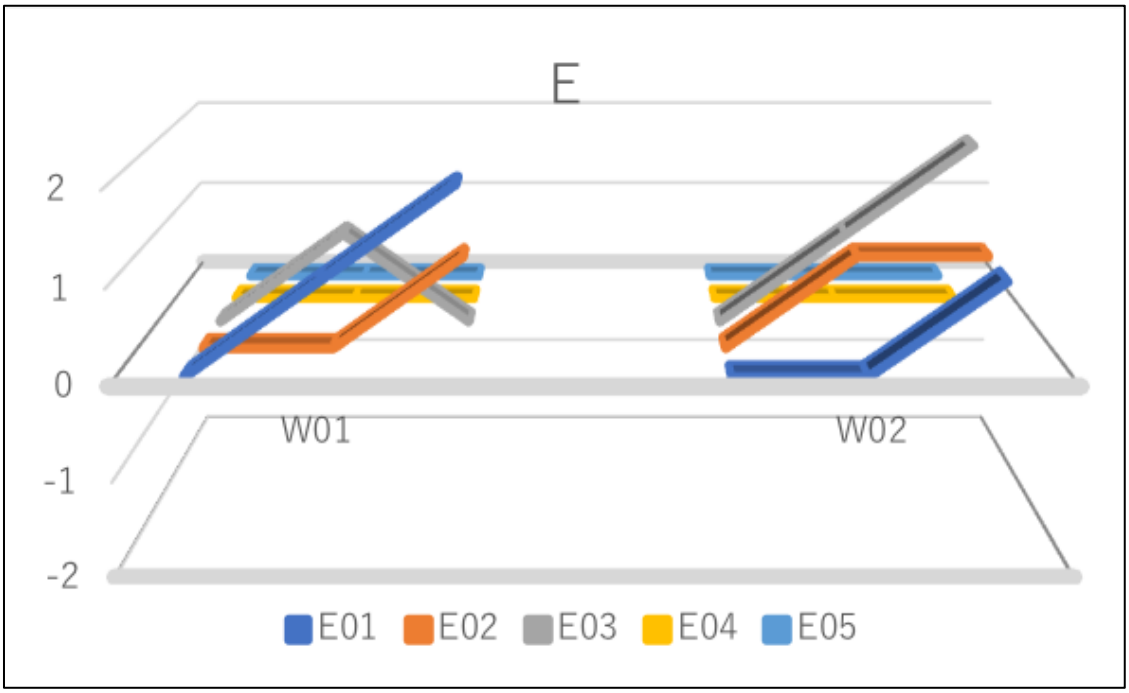

Figure 3.9e **Pattern Comparison between W01 (left) and W02 (right)**

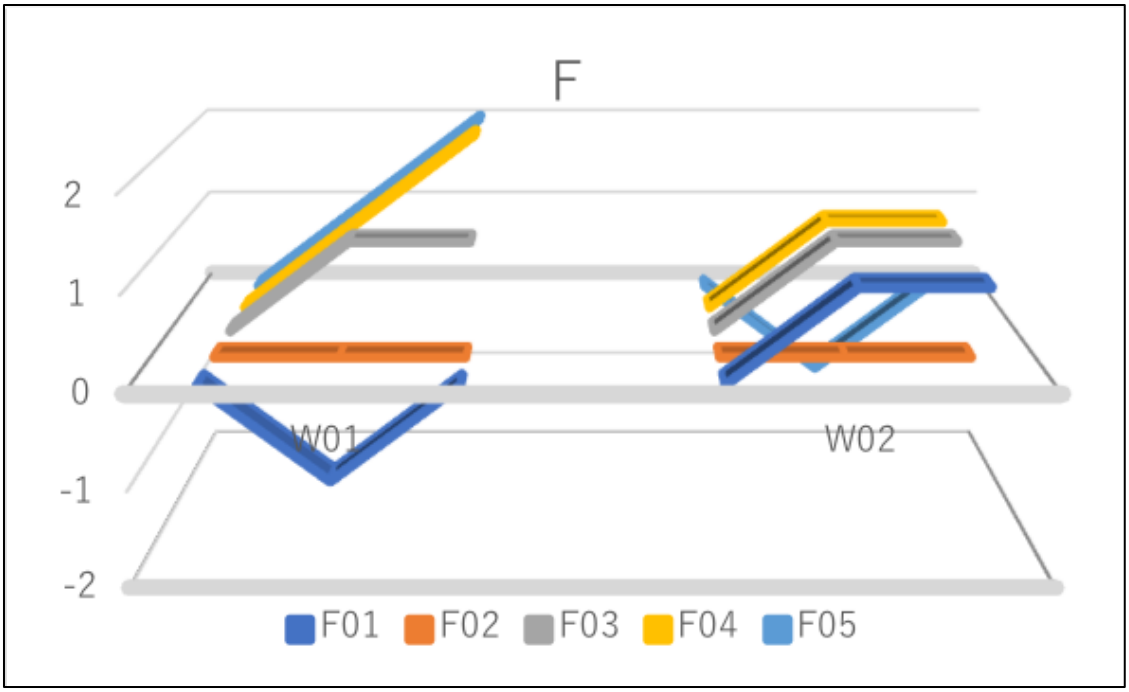

Figure 3.9f Pattern Comparison between W01 (left) and W02 (right)

3.5.1.1 Quantitative Pattern Comparison

To capture the quantitative variance of intersubjectivity, the authors applied the methodology described in 3.3.2.1 to data obtained from this experiment. According to our definition, the more intersubjectivity is developed, the less variance of intersubjectivity occurs. The results are shown in Figure5. The calculation of the t-test showed that this result of differences between W01 and W02 for the variance of intersubjectivity is statistically significant (t=1.95, df=5, p=0.05).

Except team E, where co-creation was not tried during W02 as written in 3.5.1.1, the variance of intersubjectivity decreased from W01 to W02 and converged below 0.8 in W02. Here again results match well with the experts' evaluation on intersubjectivity; for example, experts observed from team B that continuous interactive communication among individuals accelerates the formation of intersubjectivity.

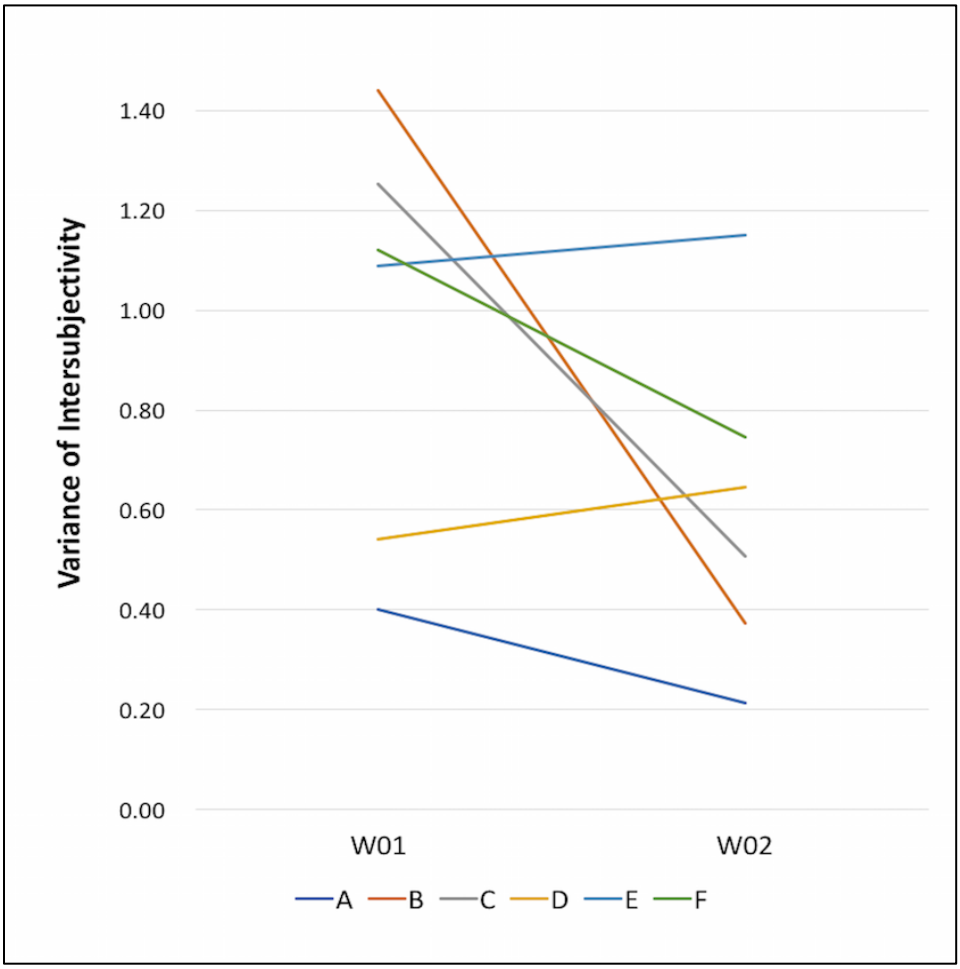

Figure 3.10 Quantitative Comparison on Variance of Intersubjectivity

3.5.2 Context

All words self-description by participants as their design context are categorized into eleven dimensions; such as “nutritious”, “soft”, “colourful”, “grandma’s favourites” as shown in Table 3.1.

Figure 3.11 shows the sum of distances in each team between the reference context and each participant’s context in W01 and W02. The t-test showed that this result of differences between W01 and W02 in relation to the sum of the distance of context vectors is statistically significant (t=2.95, df=5, p=0.032).

It is clear that the sum of the distance of context vectors decreased from W01 to W02, except for team E where co-creation was not attempted during W02. The contexts of individuals converged through the co-creation process, on the other hand that co-creation process is led by their contexts.

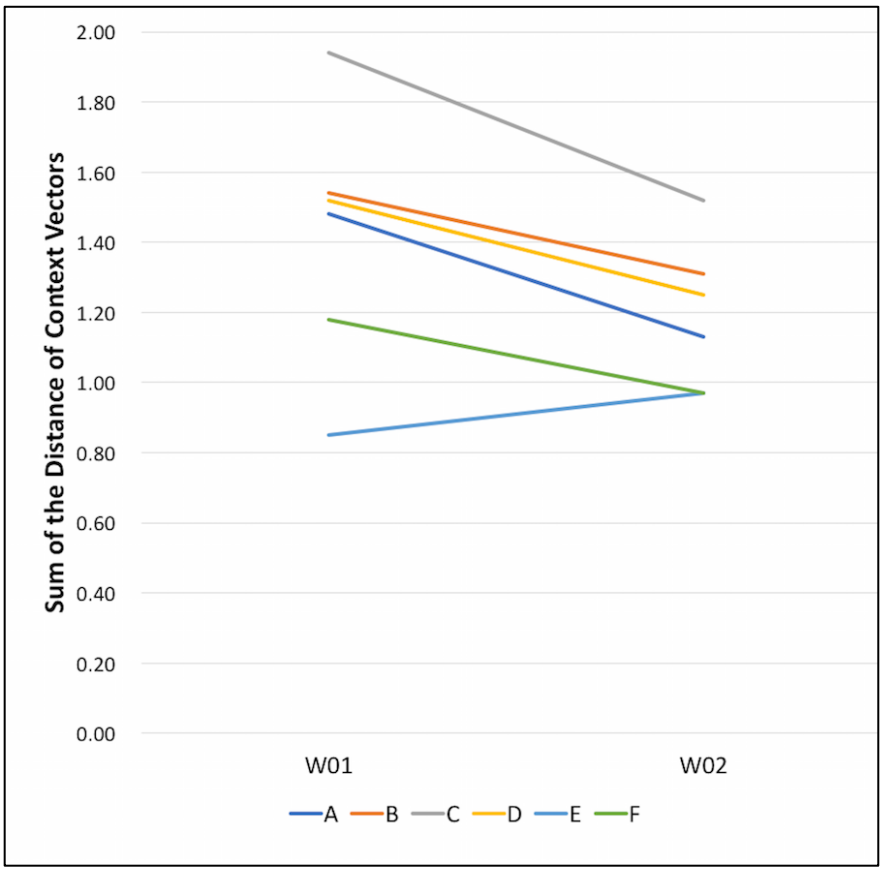

Figure 3.11 Sum of the Distance of Context Vectors

Table 3.1 Examples of Context Vector Categorization

Examples of Context Vector	Examples of expression by participants *Lower: Original Expression of Participants*
considerations for colour	colourful, coloured, coloured rich, nicely coloured, cheer her up with colours, emphasize appearance (put green), make it gorgeous with sauce red and cone yellow *カラフルな、いろどりのある、彩り豊か、彩りよい、色味で元気に、見た目重視（緑を入れる）、ソースの赤やコーンの黄など華やかに*
considerations for ease of biting	tender, soft, not hard, without hard ones, disapprove hard ones, weak bite power, easy to chew off, possible to eat without teeth, dentures *やわらかい、ソフトな、固くない、固いものを除いた、固いもの不可、かむ力が弱い、簡単にかみきれて、歯がなくても食べられる、入れ歯*
considerations for reduction of resistance feeling	low stimulation, not taste strong, mild, stressless to eat, familiar to eat, orthodox, basic, simple, standard, general, exclude likes and dislikes *刺激の少ない、味が濃くない、やさしい、食べやすい、食べ慣れている、オーソドックスな、ベーシックな、シンプルな、スタンダードな、一般的な、好き嫌いのない*
considerations for nutritional balance	considering nutritional balance, healthy ingredients, health conscious vegetable-centric, plenty of vegetables, medicinal meal, vegetable main *栄養バランスを考えた、ヘルシーな具材、健康志向の野菜中心、野菜たっぷり、薬膳、野菜メイン*
considerations for increasing appetite	draw appetite, appetizing, grandmother's favorite ingredients, favorite taste, she would like, delicious *食欲がわく、食欲をそそる、バーさんが好きな具、好きな味、好きそう、美味しい*
considerations for Little Red Riding Hood	well-eaten by Little Red Riding Hood too, easy to make even for Little Red Riding Hood, made from ingredients within Little Red Riding Hood's reach, easy to carry even for children *赤ずきんちゃんもがっつり食べられる、赤ずきんちゃんでも作りやすい、赤ずきんちゃんができる範囲で食材を集めた、子どもでも持ち運びしやすい*

3.5.3 Co-Creativity

As described in 2.2.1, co-creativity in this study is defined as *a shared motivation among individuals to realize and develop their concepts*. As expected, the relative evaluation of co-creativity described in 3.3.4 indicates a clear tendency to formation of intersubjectivity. In teams A, B, C and F, where the variance of intersubjectivity decreased from W01 to W02, all participants answered that they want to realize the pizza concept co-created in W02 more than the one co-operated in W01. On the contrary, 2 of 5 in team D and 3 of 5 in team E, where the variance of intersubjectivity increased from W01 to W02 answered that they want to realize the pizza concept in W01 more than the one in W02.

From the absolute evaluation of co-creativity described in 3.3.4, Co-creativity Index, the ratio of members who want to realize the concept co-created in a team, is calculated for each team and for each work, W01 and W02. The relation between the Co-creativity Index and the variance ratio of intersubjectivity is indicated below in Figure 3.12. It shows that the more intersubjectivity converged among individuals, the stronger co-creativity was shared in a team.

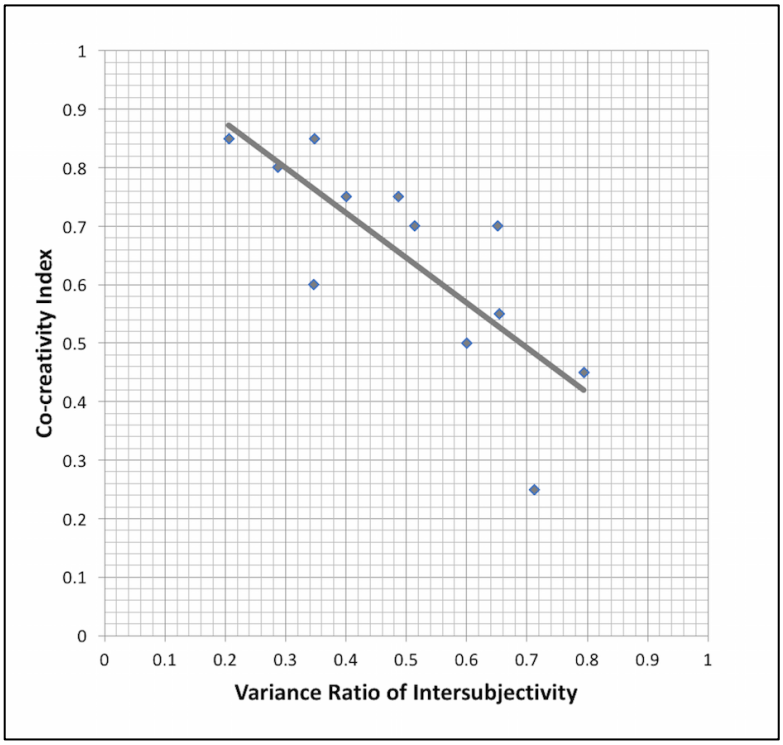

Figure 3.12 Relation between Variance of Intersubjectivity and Co-creativity

3.6 Implications

3.6.1 Theoretical Implications

The knowledge obtained from the experiment is as follows: intersubjectivity among individuals is formed through the co-creation process; the co-creation process is directed by the context of each individual, and an individual's context is also altered through the co-creation process; co-creativity, which is defined as a shared motivation among individuals to realize their concept, is generated through the co-creation process; the formation of both intersubjectivity and co-creativity are positively correlated.

Hereafter, we will discuss theoretical implications based on the knowledge obtained from the experiment above. From the perspective of understanding dynamic mechanisms, it is important to make it clear which comes first, co-creation or co-creativity, and co-creation or intersubjectivity. Being in *a mutually interactive relationship* might be sufficient for the static understanding of co-creation as a concept, but not for a dynamic understanding for its practice.

Co-Creation Converges Individual Contexts

The result of the experiment in this study indicates that the co-creative process converges individual contexts (Figure 3.11). Star, who had advocated and developed the concept of the boundary object (Leigh Star, 2010; Star & Griesemer, 1989), also criticized the ignorance of this dynamic in her literature, as well as denied the major assumption that collaboration comes after consensus (or a clear common goal, in this study), inherent in collaboration studies in the statement:

> Many models, in the late 1980s and continuing today, of cooperation often began conceptually, with the idea that first consensus must be reached, and the cooperation could begin. From my own field work among scientists and others cooperating across disciplinary boarders, and two historical analyses of heterogeneous groups who did cooperate

> and did not agree at the local level, it seemed to me that the consensus model was untrue. Consensus was rarely reached, and fragile when it was, but cooperation continued, often unproblematically. The dynamic involved in this explanation is core to the notion of boundary objects (Leigh Star, 2010). For the purposes of this study, Star's "cooperation" is equivalent to our "co-creation."

Co-Creation Forms Intersubjectivity

In this study, we observed that co-creation forms intersubjectivity (Figure 3.16). Benjamin explains this phenomenon as granted using the term "thirdness:" the process of creating thirdness is in how we build relational systems and how we develop the intersubjective capacities for such co-creation (Benjamin & Ph, 2004). Thirdness is explained as a co-created third ("intersubjectivity" in this study) that has the transitional quality of being both invented and discovered. To the question of "Who created this pattern, you or I?" the paradoxical answer is "Both and neither," due to the simultaneous awareness of "me", "you" and "us" (Stensæth, 2013)

Co-Creation Generates Co-Creativity

The results of the experiment in this study indicate that co-creation forms intersubjectivity and generates co-creativity. It also supports the fact that both intersubjectivity formation and co-creativity generation are positively correlated (Figure 3.12). Here, an outward act is implied as a manifestation of co-creativity, and its practical implications will be discussed in 3.6.2.

Benjamin also pointed *intersubjective thirdness* can help orient us toward responsibility and more rigorous thinking, even as our practice of psychoanalysis becomes more emotionally authentic, more spontaneous and inventive, and more compassionate and liberating to both our patients and ourselves (Benjamin & Ph, 2004). According to her description, Stensæth is likely to be more conscious of this point of view: co-creation is suggested as a possible path to achieving these goals by, for example, evoking feelings or accommodating the need to act and to create social relationships. Co-

creation also motivates users to communicate and collaborate within new social relationships (Stensæth, 2013).

The main limitation of these implications is the simplicity of the design problem in the experiment in this study. We have intentionally selected a simple design problem in this study: designing a pizza for Little Red Riding Hood to bring to her sick grandmother. This is because the focus of this experimental study is to evaluate the fundamental factors of co-creation dynamics, intersubjectivity, context, and co-creativity. The second reason for selecting this design problem was that we wanted to assign a design problem that rendered the individual competency level equal every participant. When it comes to designing a pizza, in general, everyone is familiar with the process due to pizza delivery services, and it is highly unlikely that anyone knows how to design one professionally in a group in a fifteen minute period. Furthermore, there are other recognized important factors, like the impact of mood and the individual, but we have carefully excluded their effect on the experiment in this study.

Strictly speaking, this study tries to capture basic co-creation dynamics using a simple situation with few fundamental factors. In the future, more minor factors in co-creation dynamics should be considered to apply this basic model to describing co-creation dynamics behaviors in more detail.

3.6.2 Practical Implications

The knowledge obtained in this experiment on the dynamic mechanism of co-creation suggests that a relationship can be designed and managed by dynamically controlling its design process through the dynamic nature of co-creation. Reflecting the exponential increase of the importance of relationship design and management, various fields can be applied to this co-creative approach. Hereafter, we will discuss the practical implication of the experiments in terms of relationship design and management.

As seen in the previous section, co-creation forms intersubjectivity and new relationships, and it also generates co-creativity, a shared motivation among individuals

to realize and develop their concepts. How can we utilize the dynamic mechanism of co-creation for a desirable figure (Nagai & Taura, 2010): better business, a better society, or better well-being?

Co-Creation Forms Intersubjectivity

Individuals and/or organizations who have merely networked or gathered in one place do not suddenly perform as an organization. Every organization has its origin, which raises the following questions: How can independent individuals or organizations in various contexts start to perform as one organization? How do these individuals recognize each other as a "we" that shares intersubjectivity rather than a separate "you and I?" A unique relationship emerges out of mutual regulatory recurrent co-creative interactive processes from a micro temporal level to larger macrolevels of the interaction (Tronick, 2003).

From the perspective of the dynamic nature of co-creation in forming intersubjectivity, a typical domain in which the dynamic mechanisms of co-creation could be applied is in marketing and serviceology, where unique and competitive customer relationships are valued. Moreover, the design and management of open innovation (Bogers, Chesbrough, & Moedas, 2018) requires the expansion of organizational boundaries to customers and other stakeholders from different organizations, the interactions of co-creators, and the creation of new value (Roser, DeFillippi, & Samson, 2013).

Co-Creation Generates Co-Creativity

Realizing innovation requires forming a new organization, for instance, a team, a company, or a cluster of individuals and/or organizations to provide the resources required for its implementation.

From the perspective of co-creativity as a shared motivation among individuals to realize and develop their concepts, this requires application to systems design and management where *a desirable figure* (Taura & Nagai, 2009) is pursued iteratedly. As an example in business, the system that creates customers' willingness to pay a premium is influenced by the quality of its relationship interaction (Collier, Barnes, Abney, & Pelletier, 2018).

Moreover, co-creation can be proposed as a means to expand the innovation and

value creation capability of the firm while nurturing customer relationships and lowering marketing, research, and development costs. The benefits of co-creating value include better product quality (Fuller, 2010) and greater customer satisfaction (Nambisan & Baron, 2007) specifically with regard to the market entry of a new product or service (Roser et al., 2013).

Various infrastructures have advanced toward a global scale, and those infrastructures now have greater accessibility for individuals and/or organizations that used to be excluded from the innovation ecosystem. This remarkable increase in accessibility to these social infrastructures leads to the horizontal fluidization of relationships, which had remained rigid and vertical as they grew outdated. Compared to a vertical system with a clear goal decided by the top and followed by those lower in its fixed hierarchy, dynamic changes in relationships among stakeholders are characteristic of a horizontal system.

Accessibility enables individuals and organizations to pursue relationship optimization to realize a desired innovation. This implies that the importance of and opportunities to build system iterating optimizations in dynamic design and management have rapidly increased in comparison to times when the innovation ecosystem was vertically fixed. Design and management methodology utilizing dynamic co-creation mechanisms can be used to deal with this matter systematically.

3.7 Proposition of the Dynamic Model for Co-Creation

One of the most well-known models on creativity is the one proposed by Amabile, which has been cited more than 4,000 times (Amabile & Pratt, 2016). Its three main components (domain relevant skills, creativity relevant skill, and task motivation) constitute a complete set of the general factors necessary for creativity (Amabile, 1983, 1988). When she initially proposed the model, she explained that these assumptions were accompanied by set of related observations about the factors that appeared to be necessary for creative behavior and also stated that that conceptualization of creativity to relied on a number of assumptions based in both formal and informal observation because it included the nature of creativity (Amabile, 1983). This study is similar to hers in the sense that it includes the

nature of co-creativity and has enough reason to refer her approach to consider empirical observations and experiences in addition to a theoretical basis in related literature.

Representing the results of this study and literature referred to in this chapter, major factors of co-creation are placed into a co-creation dynamic system called the Inverted Vortex Model (hereafter, IVM) (Figure 3.13). This model indicates that individuals with various contexts form intersubjectivity through co-creation, as moving objects, black points in Figure 3.13, converge at a deeper point along with the fluid flow of the vortex under appropriate conditions. The co-creation process and individuals' contexts interact with each other as a vortex, and the moving objects interact with each other. The objects converge in the vortex, and moving objects are transformed, occasionally breaking the vortex.

The point emphasized in IVM represents expressing the dynamic mechanism of co-creation: what comes first is not a common goal or intersubjectivity among individuals, although it is necessary for these to originally appear within a certain boundary object to start co-creation. A common goal and intersubjectivity are materialize and developed alongside co-creation.

The IVM visualizes the mechanism of the co-creation process and explains the whole fundamental mechanism in a diagram, rather than through specific factors, as in previous models. This model was developed based on the result of experiments, complemented by the literature introduced below and practical experiences gathered from past case studies (Matsumae, 2014a, 2014b, Matsumae & Burrow, 2015, 2016), and improved through discussions with experienced practitioners who lead decentralized knowledge clusters. These included both locally rooted contexts and the global context, namely the Knowledge Innovation Community of the European Institute of Innovation and Technology. Thus, this model has in fact succeeded in applying a flat form that enables practitioners to describe, discuss, review, and explain the co-creation dynamic process between/within the knowledge clusters, absorbing practical viewpoints and reasonable suggestions of local and international practitioners.

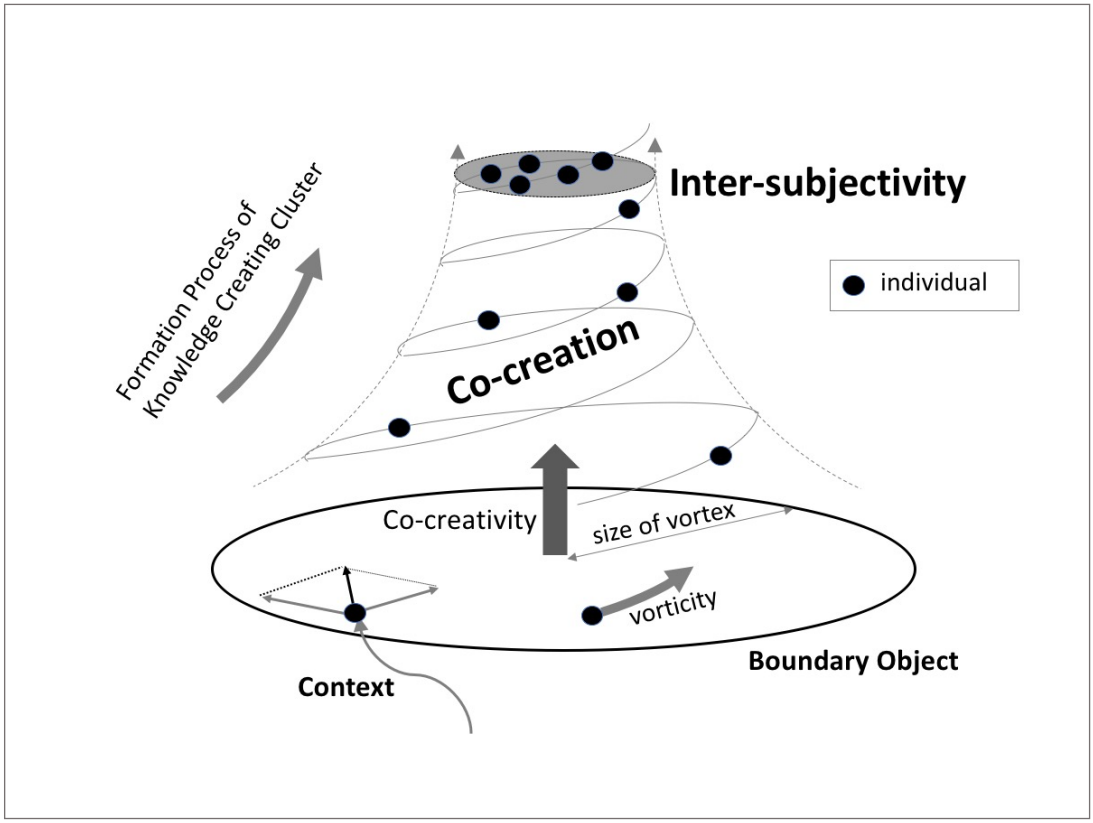

Figure 3.13 Inverted Vortex Model

Boundary Object

The original definition of a boundary object was an object that is adaptable to multiple viewpoints and robust enough to maintain its identity across them (Leigh Star, 2010; Star and Griesemer, 1989). In later studies, the boundary object was scaled up as an arrangement that allows different groups to work together without consensus, especially in the context of a collaboration infrastructure (Leigh Star, 2010).

By setting an appropriate boundary object and co-creation process for a project, different individual contexts can be bundled and sharpened. Focusing its function on involving different contexts in this particular co-creation, the authors introduce two concepts to characterize a boundary object based on the analogy of Rankine's combined vortex: 1) the size of a boundary object to describe its reach and 2) vorticity of the boundary object to describe how it works for each individual.

Context

Creation exists in contexts. Some contexts can be described in the same dimension, but others can only be described in different dimensions. Each individual has his or her own original context. Contexts can be modified through interaction with other contexts, and these interacting contexts can generate a new context. The authors introduce the concept of the context force vector to describe the direction and the magnitude of each creator's context. A sum of the context force vector components in the specific direction and vorticity of a boundary object is one of the parameters used to determine a dynamic process of co-creation.

Co-Creativity

As co-creativity was defined to mean a shared motivation among individuals to develop and realize their concept in 2.2.1, the factors of IVM seem to parallel Amabile's factors of motivation. Amabile indicated that motivation includes two factors: the individual's baseline attitude toward the task and the individual's perceptions of his or her reasons for undertaking the task. Baseline attitude is explained as the degree to which it matches his or her existing preferences and interests, and perceptions are proposed that depend largely on external social and environmental factors (Amabile, 1983). The boundary object in the authors' IVM has a similar role to Amabile's baseline attitude since the boundary object indicates the boundary of an individual's existing preference and interests. Likewise, context in IVM works similarly to perception since it leads to an individual's creativity.

Dynamic Mechanism of Co-creation

Individuals work independently in different contexts before they are given a new project or task in a horizontal relationship with other members. Initially, an appropriate boundary object should be set to maintain a common identity across participants. This way, different individual contexts can be bundled and sharpened (as shown in Figure 3.13). At this level, individuals hold unique context force vectors with their own directions and magnitudes (e.g. each individual has a unique level of motivation towards the ultimate purpose). If all other members hold same context force factor with a similar direction and magnitude, the co-creation process will proceed in that direction, but that is extremely

unlikely in a natural environment. Therefore, the sum of the context force vector components (vorticity) that consist of bundles of context force factors with different directions and magnitudes make a whirlpool with a specific direction through the co-creation process. Intersubjectivity among the members of the project is formed as a whirlpool, a co-creation process sharing socialization, externalization, combination, and internalization. Individuals convert tacit knowledge to new tacit knowledge through shared experiences and social interactions.

From a practical standpoint, when the speed and power of a whirlpool gets higher, the inner part of the whirlpool becomes more dense and compact. Likewise, according to the model, when co-creation gets stronger, intersubjectivity gets more solid. This is how knowledge creating clusters form through the co-creation process.

There are other important factors that were not examined in this study. *Ba* can be modelled using fluid and its properties, like culture and mood (Windisch, 2011), could be described by fluid properties such as viscosity, and the static impact of each individual, for example, personality and capability, could be described by the mass of the mass point. The effect of those factors is carefully excluded from the experiment in this study and remain an issue for future study.

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Chapter 4

Discussions

4.1 Introduction

In the previous chapter, the importance of grasping co-creation as *a dynamic system* containing its major factors was emphasized rather than focusing on one single factor. Methodologies to evaluate fundamental factors of co-creation dynamics, such as intersubjectivity, context, and co-creativity, were proposed, and an experimental study was conducted related to the type of collaborative design process in order to examine them. Representing the knowledge obtained from the experiment, the Inverted Vortex Model was proposed in order to describe a co-creation dynamic system focusing on the formation process of intersubjectivity.

Following the previous chapter which proposed the IVM as a flat form that enables practitioners to describe, discuss, review, and explain the dynamic co-creation, we deploy and indicate the possibility of IVM application to relationship design and management in this chapter through case studies as examples of IVM application.

4.2 Applications

4.2.1 Relationship Design and Management

In a generation phase of an entity, whether it is a legal one or not, it is essential to form and manage appropriate collaborative relationships among individuals to start and sustain

collaboration, since each of them has originally been in a different context as an independent individual. Some relationships should be co-creative while others should be entirely co-operative, and the appropriate relationship type changes dynamically along a time axis.

The formation of intersubjectivity among different ontological entities in horizontal relationships and its effect on knowledge co-creation are the fundamental factors for designing and managing horizontal innovation ecosystems for SMEs and startups. To design and manage these relationships, it is necessary to have a methodology to describe and place the intended relationship among intended individuals at an intended time. It has been mainly a problem of co-creative relationship since co-operative relation can be explicitly described, and the IVM can be applied to the problem as a methodology design and manage co-creative relations.

Furthermore, how should we consider the difference of ontological levels between individuals and organizations? The IVM could be applicable even when we think about the dynamic relationship of organizations, since it is among the interfacing individuals of each organization that the actual co-creation relationship is generated. Intersubjectivity and co-creative relationship are still formed among individuals joining co-creation regardless the organizations to which they belong in contrast to co-operative relationship, since each of them is required to share a phase of socialization according to the definition of co-creation of this study. We regard this as the intersubjectivity through which tacit knowledge is transferred directly between individuals, but not between organizations. In the IVM, the influence of belonging to a certain organization on individual should be counted as a context of the individual to which he or she belongs, focusing on individuals rather than on the organization. Therefore, the IVM, a dynamic model of co-creation, can be also applicable to the design and management of a system that includes different ontological levels, such as individual, organization, and inter-organization, by focusing on its individuals.

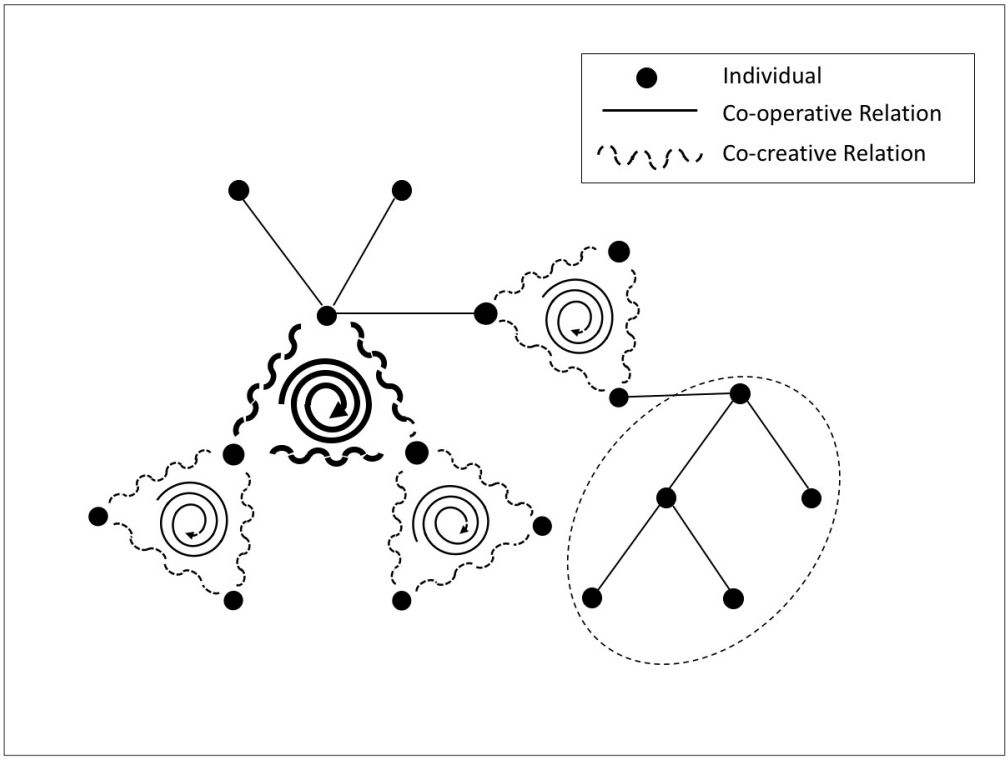

Figure 4.1 Application of the IVM to System Design and Management

4.2.2 Formation of Knowledge Cluster: Structural Experiment

4.2.2.1 Overview

In Japan, small to medium sized enterprises comprise 99.7% of companies and employ 70% of the workforce in regions outside the Tokyo area in Japan. More than 99% of all businesses in Japan are small or medium-sized enterprises (hereafter, SMEs); they also employ a majority of the working population and account for a large proportion of economic output (Economist Intelligence Unit, 2010). Although the revitalization of local society has become a significant national issue, the local innovation ecosystem has been controlled by the long-standing dominant centralized innovation ecosystem and most of local SMEs still remain dependent on vertical relationships with larger companies and excluded from innovative opportunities, channels, and human resources. Therefore, it is essential to establish a methodology to design an innovation ecosystem to generate

sustainable collaborative business among them. Simply gathering various organizations at one place is not enough to form the basis of sustainable collaborative innovation.

As an example, the traditional architectural industry has been devastated by the excessive pursuit of economic efficiency coupled with outdated engineering regulations. Traditional architecture's holistic but economically less efficient production system has been decimated. In addition, Japanese architectural regulations based on technical knowledge in the late modern period (Conder, 1892; Tatsuno, 1895) underestimated the seismic performance of traditional Japanese architecture. However, regional SMEs, which were to innovate and carry on traditional Japanese architecture for the future, rarely had sufficient resources or social credibility to deal with these problems by themselves. Due to this limitation of resources and networks in architectural industry, it was essential to design an innovation ecosystem to generate a sustainable collaborative project among them.

The formation process of horizontal collaboration among organizations was different from generating one within an established organization or one among organizations in vertical relationships since each organization runs independently within its own context. Here, we used this formation process of knowledge creating clusters to explain the relationships among *co-creation*, *intersubjectivity*, *context and co-creativity* in the dynamic model.

4.2.2.2 Formation Process of Knowledge Cluster: Structural Experiment

Formation of the Core

In 2002, an e-mail was posted to the regional mailing list, a group of various occupations including academia, industry, government and media. In the email, an ecologist asked help to hold a one-year series of seminars by a well-known structural engineer specializing in the field of traditional wooden architecture. No other local regions had ever organized a seminar by this researcher, but three mailing list (hereafter ML) group members from architectural industry prepared to host one (Figure 4.2).

Figure 4.2 Formation Process of Agglomerated Diverse Concerned Parties

Diverse Participants

A regional association of carpenters decided to host the seminars. Since the ML community was open to the public and the attitude of the host association was accepting, the seminar and following activities were managed not only for a specific industrial community but welcomed diverse organizations and individuals interested in traditional Japanese wooden architecture. This diverse group included carpenters, designers, managers, and local government officers, all of whom usually work in different culture and contexts. Thus, an agglomeration of diverse organizations gradually developed along with the series of seminars.

Increase of both Interest and Confusion among Participants

The seminars were just a knowledge transfer from the lecturer to the participants. However, participants increased both their interest and their confusion. The confusion was caused by the dichotomy between the outdated regulations participants had been using, and what they were being taught at the seminars based on the latest engineering. To alleviate this confusion, in December 2002, core members planned and prepared the first primitive structural experiments with the cooperation of a major measuring device company (Figure 4.3).

Figure 4.3 Preparation for the First Structural Experiments

Outburst of Autonomy

In May 2003, carpenters built several types of scaled down units and the first structural experiment was realized. Some experimental models were traditional, and others were modern. We captured the difference in collapse behaviours and also rough data of both the transition of displacement and load. We were not able to build some of the typical seismic elements of traditional Japanese wooden architecture in these downscaled models because of the unchangeable density of wood.

By this time, the confusion among participants had disappeared and was replaced by the desire to pursue real knowledge based on their own professionalism. During and after this experiment, an engineer from the public experimental forestry station joined the activity. We could not help moving toward the next step (Figure 4.4).

Figure 4.4 First Downscaled Structural Experiment

Launch of University-Industry Collaboration

Soon after the first experiment, core members visited a professor of the rare research group

targeting traditional Japanese wooden architecture and asked his cooperation for the full-scale structural experiment. He approved the proposal and the university-industry collaboration relationship began.

In July 2003, two months later, we carried out the first full-scale seismic structural experiment under university-industry collaboration. It is said to be the first full-fledged experiment in Japan ever led by carpenters active in the field, according to an authorized practitioner since the 1960's (interview with Kazuma Masuda, Tottori University of Environmental Studies, July 2003). An increased number of regional architects and local government officers, and regional mass media came to observe this experiment and some of them joined the community.

This experiment demonstrated the obvious fact that traditional Japanese architecture has different but effective seismic mechanisms from modern architecture. Traditional structure does not rely only on rigidity but on the balance of rigidity and flexibility. Experiments confirmed the engineering effectiveness of traditional Japanese architecture and engendered the desire to continue the experiments. We hoped to gather reliable engineering data to support the rescinding of unreasonable regulations and improve traditional Japanese architectural structures. Thus, the community formed and shared a common mission among diverse organizations (Figure 4.5).

Figure 4.5 First Full-Scale Experiment under University-Industry Collaboration

4.2.2.3 Application of the Model

Here, we suppose to explain the formation process of the knowledge clusters in above case relevant to the fundamental factors of IVM. In addition, we discuss the main phases of the formation process which we observed through the case.

Contexts of the Case

Social Context of Traditional Japanese Architecture

Japanese wooden architectural structures can be roughly divided into two contrastive types: traditional and modern wooden structures. This word pair does not necessarily mean old and new, but rather reflects a fundamental difference in engineering principles and philosophy (Table 4.1) (Suzuki, 2003). The modern wooden structure was not developed in the context of evolution from the traditional structure, but suddenly came into being at the time of the Meiji restoration in 1868, when Japanese society was rapidly modernizing by adopting Western systems and culture.

Table 4.1 Comparison between Traditional and Modern Wooden Structures in Japan

	Traditional Wooden Structure	Modern Wooden Structure
Attitude Toward Nature	Awe - symbiosis - follow the grain of nature	Conquest - have human wisdom control and conquer nature
Structural System	Acceptance - flexible structure - nature formed structure	Opposition - rigid structure with brace/wall - human intended structure
Resistance System	Distributed damper system - distributed absorption inside the structure - multi-step protection	Load-bearing system - rigid resistance without any collapse within its expected load - all/nothing protection
Production System	A part of ecological cycle - holistic - local-rooted and customized	A part of industrial production system - priority on economic efficiency - mass production
Basic Philosophy	Japanese view of nature - based on the tradition of wisdom and experience	Western rationalism - based on scientific knowledge

The history of regulations on Japanese wooden structures has been harsh since the Meiji restoration (1868). The Meiji regime's main strategy to modernize Japan was to learn and transfer *advanced* western knowledge and style into Japan. Josiah Conder was the invited foreign government advisor who introduced Architectonic into Japan and was also the first professor of the architectural engineering department of Tokyo University. He evaluated traditional Japanese architecture as very inferior in technology for its lack of the

rigid structural system common in Europe (Conder, 1892). After the Shonai earthquake, his successor, Kingo Tatsuno, compiled an outline of wooden architectural seismic structural regulations, which standardized the system of braces and metal joints (Tatsuno, 1895). In 1916, Toshikata Sano, who studied under Tatsuno, submitted a report stating, "I could not find any evidence that traditional Japanese structures have a unique seismic structural system as an alternative to braces. It is obvious that braces would produce rigidity in Japanese wooden structures, and the view that too much rigidity might harm the entire structure is a kind of preconceived notion." This report has become the fundamental principle of Japanese wooden architectural structure (Sakamoto, 1993).

This idea espoused by Sano was enforced as the *Order for Enforcement of the Building Standards Act* and the *Housing Loan Corporation Requirements for Specification*, from 1950. Both regulations evaluate wooden structures only on wall quantity by means of braces and metal-joints. These regulations are still in force and compel carpenters to abandon traditional architectural structure. For the sake of progress in seismic structural engineering, it is now unarguable knowledge among experts that quantifying walls is far from efficacious engineering. Ductile strength is as important as, or even more important than, rigidity. Isao Sakamoto, an authority on modern wooden architectural structures, admitted "it is not appropriate to evaluate traditional Japanese architecture by the rigidity standards of modern wooden architectural structures. However, I have never seen an alternative or persuasive standard to replace it" (Sakamoto, 1993). In response to these vicissitudes, the architectural industry was compelled to change its way of building from the traditional to the modern wooden structure (Table 4.1). Nevertheless, carpenters, who directly feel the stability of a structure, have remains suspicious of the stability of modern wooden structures. Since 1950, a traditional wooden house has become a thing built only when a capable carpenter, able to furnish the entire production system, met a rich enough customer, who did not need a house loan or governmental building certification.

Wooden architectural structures have been basically regarded as worthless subjects of study in academic societies of structural engineering and have been left behind. It was after the Hanshin-Awaji earthquake in 1995, that academic attention was drawn to wooden architectural structure. In 2000, the epoch-making modification of the Building Standard Law was enforced. Because it allows performance designs by calculation of response and limit strength (hereafter CRLS), obstructions to the theoretical possibility of building

traditional Japanese structure disappeared. In 2001, an academic working group for developing design methods based on traditional Japanese architecture using CRLS was formed and started its research and development activities in the Kansai branch of Architectural Institute in Japan (Masuda, 2005; Suzuki, 2003).

The production system was also drastically changed. The emergence of firmly fixed vertical specialization in the industry led to economic efficiency, but at the same time, deprived the actual production team of their intellectual involvement in the production field. For example, a master carpenter called *tohryo* was not only a carpenter but also an architect with his own philosophy, rich in knowledge, and designed and managed an entire system of architecture. Increased separation of cognitive skills and kinesthetic/manual skills in the production system has led to difficulties in building a holistic traditional architecture and led to a moral decline which has caused some fatal accidents.

Contexts of Stakeholders in Industry

The representative contexts of various stakeholders' industry-side were; 1) education for innovation, 2) research for innovation, 3) channel for innovation, and 4) stamp of credibility.

First, from the viewpoint of educational function, the industry side was educated, with engineering knowledge of traditional Japanese architecture through activities related to this collaboration. This educational function gave the younger participants, or brought back to the senior ones, not only engineering knowledge, but also an independent mindset, confidence, and self-esteem. These educated and empowered people gradually began to try to leave the fixed vertical industrial system, which had been treating them as just mindless labouring bodies.

Second, from the viewpoint of research, the industry side got competent researchers and research facilities to solve their fundamental questions. With university-industry collaboration, they finally got the opportunity to support their hypothesis with convincing data. As if this was water absorbed into dry land, they were eager to further research and development to take responsibility for their own profession.

Third, as a mechanism for channelling innovation, a number of channels were opened; ones to academia, media, policy, information, grants, competent job seekers, core customers, and fellow traders or cross-industrial partners to rejuvenate their work together.

Even in the middle of the recession, when the number of construction companies fell 14% in seven years (Ministry of Land, Infrastructure, 2012), SMEs involved in the collaboration expanded their areas and attracted customers interested in their specialized expertise. Before we started this university-industry collaboration, even among fellow carpenters working for generations in the same region there was a tendency to keep their knowledge to themselves. Working together for the series of structural experiments opened their minds, and not a few cases were seen of SMEs involved sharing and improving their useful knowledge and generating new business together beyond the region. A horizontal industrial system gradually emerged here and there in Japan.

Last, from the viewpoint of social credibility, the data and activities under the university-industry collaboration lend a social credibility to SMEs. This credibility created remarkable social impact and also differentiated involved SME's businesses from others. It helped their development in terms of their business, too.

Thus, the university-industry collaboration provided a holistic solution to the serious and deep-rooted problems in traditional Japanese architectural industry. It enabled the SMEs involved to break free from the fixed vertical industrial system in an architectural industry in terminal condition, and restructure it into a flexible horizontal industrial system, in other words, a knowledge creating cluster centred on traditional Japanese architecture.

Contexts of University

Contribution to society is recently touted as the one of the three major missions of universities in Japan. It is actually difficult to maintain fruitful university-industry collaboration without having an association with the contexts of a university. In this case, university-industry collaboration expanded spontaneously to other research groups in the same university and it implies that the project is in the context of university.

First, from a research viewpoint, both the university and industry were able to share the same research values and themes and focus on the same engineering achievements. The industrial side willingly offered the field of research and education as well as practical knowledge and skills, even when this did not have a direct connection to the collaboration (Figure 4.6). Second, from an educational viewpoint, students learned and studied with actual production fields and people. Students were highly motivated and

deeply interested in their research theme, knowing its necessity.

Figure 4.6 Various Kinds of Supports for University Activities from SMEs; SMEs helps research by offering research field (left); Exchanging diverse knowledge can stimulates leaning in both side (center); Actual industry field can offer the accurate and updated image of research theme and its necessity (right).

Common Contexts Shared among the Stakeholders

As described earlier, wooden architectural structure had been basically regarded as worthless as the subject of study until 1995. Therefore, accumulating reliable engineering data on various units of traditional Japanese wooden architecture itself is a significant result. The formation process of this cluster had grown along with this common context, namely a series of structural experiment held by university or industry accumulating data related in each of local areas.

Furthermore, the series of structural experiments confirmed the efficacy of Japanese architectural structures in absorbing earthquake energy with its flexibility (Kitahara, 2009b, 2009a), and demonstrated that too much rigidity which lacks the balance of rigidity and flexibility does harm the entire structure. This is contrary to Sano's opinion in the 1950s' (Sakamoto, 1993), which led to unreasonable regulations on wooden architectural structures.

Each of the experiments supported Suzuki's views on traditional Japanese architecture shown in Table 4.1 (Suzuki, 2003). The contrastive differences between traditional and modern Japanese wooden architectural structures were clearly observed concerning characteristic seismic performance and the collapse mechanism (Figure 4.7).

Figure 4.7 Experiments on Various Units of Japanese Traditional Architectural Structure

The common contexts were formed and represented by the phrase, “the future is led by traditional wisdom,” through a series of structural experiments. We experimented not only to accumulate data on seismic performance, but also to continue research and development on several types of innovative units in harmony with traditional Japanese architecture. Some of the results were implemented into the renovation of traditional Japanese architecture (Figure 4.8, Figure 4.9).

Figure 4.8 Experiments on the Innovative Unit as Extension of Traditional Structure

Figure 4.9 Examples Implemented Engineering Achievements

Boundary Object

In this case, the interest in wooden structure of traditional Japanese architecture was a main boundary object. The size of boundary object was large enough to bundle various organizations and individuals related to traditional Japanese architecture; carpenters, researchers, architectural engineers, governmental agencies and citizens. Structural experiments are the major research methodology for researchers, and structural specimens are familiar to practitioners. The vorticity of the boundary object was strong and stable enough to keep involving participants in various contexts and to sharpen activity toward their goal. The component of context vector of each participant toward the centre of the boundary object strengthened, since structural experiments on a life-threatening seismic problem aroused their professionalism and the strong desire for unproved true knowledge.

Traditional Japanese architecture could also be a boundary object, with a scale larger than a structural experiment but with a vorticity too weak to form a knowledge cluster. The series of seminars was also too small and too weak to function as a boundary object.

Co-Creation

According to the definition of co-creation in this research “to create something together

sharing the phase of socialization among individuals", knowledge co-creation was realized among diverse participants by sharing *structural experiments*. Structural experiments were developed by repeating the following basic process; each of the participants acquired tacit knowledge directly by observing structural experiment (socialization), and planned the next experiment together based on analysis of the data and phenomena observed as a carpenter, an architectural engineer, a researcher, a government officer, or a citizen.

Contrary to the series of seminars, which just transfers explicit knowledge from the lecturer to the audience, those who were involved in structural experiments recognized themselves as members concerned with the project. In other words, intersubjectivity was formed among the participants in various contexts. A common context was generated based on intersubjectivity and autonomous actions within the common context arose spontaneously. This shared knowledge creation spiral generated the vortex in the boundary object.

Intersubjectivity

Intersubjectivity among stakeholders is gradually formed as the basis of co-creation by sharing socialization, which is the process of converting tacit knowledge to new tacit knowledge through shared experiences and social interaction (Nonaka & Takeuchi, 1995).

In this case, after the series of seminars finished in 2003, the university-industry collaboration continued to hold experiments and seminars to exchange knowledge and support this mission. Various regional professionals related to this mission were involved and various funds were drawn from them. Co-researchers from other universities and related fields also raised the quality of the project. The flexible attitude of the university and the passion of the mission-based community of action naturally led to the expansion of the range and the depth of the university-industry collaboration. The more contexts the community contained, the more important became the role of core members as the catalyst for university and industry collaboration.

To summarize, we identified five phases in the formation process of knowledge creating clusters through accumulated observations. The five phases are as follows:

Phase 1: Agglomeration of diverse concerned parties

Agglomeration of diverse concerned parties is a necessity but is just the starting point to form a knowledge-creating cluster. In this example, this phase could identify during the formation of the core with diverse participants.

Phase 2: Introduction of boundary objects

A relationship building mechanism is required among the diverse stakeholders. Since each stakeholder stands in a diverse context, the relationship building mechanism must be inclusive enough to cover diverse contexts. The boundary object functions as this mechanism. The way how this phase accomplished in this case has explained under "Increase of both Interest and Confusion among Participants".

Phase 3: Activation of autonomous knowledge creation

After stakeholders are bundled by a boundary object, it is necessary to activate them for autonomous dynamic knowledge creation. The inner motivation of each party arising from autonomous creative activity is the engine that sustains the cluster. This phase could identify in "Outburst of Autonomy".

Phase 4: Formation of a common context through co-creation

Next, particular components of diverse contexts among stakeholders gradually converge into a common context and intersubjectivity among stakeholders is formed through the process of exploration of knowledge co-creation. Through launching of university - industry collaboration and building of *intersubjectivity* this phase could be distinguished.

Phase 5: Stabilization

Although flexibility is a great advantage in the autonomous creative phase, a minimum framework is then introduced to stabilize the very fragile agglomeration. This phase has occurred when concerned parties have reached a certain convergence of autonomous common context.

In this example, the same set of seminars was launched parallelly, all over Japan and the regional success expanded to nationwide success. Since no other regions had been able to form this kind of university-industry collaboration, these regional seminars linked together as a nationwide network to share knowledge.

This network was incorporated as non-profit organization in September 2005. This organization was less focused on structural engineering than it had been. However, more than 400 nationwide carpenters, architectural engineers, forestry industry workers, professors, writers, and citizens who share the mission joined. A major carpenters' guild was later absorbed into the organization.

Even after the foundation of this nation-wide organization, substantial activities continued in each region and the organization took the role of linking the regional activities and people. The main role of the organization administrative office in Tokyo today is outward activity, such as publication, and lobbying to change unreasonable Japanese wooden architectural structural regulations.

4.2.2.4 Discussions

In this case study, a knowledge creating cluster was formed among diverse parts centered on a series of structural experiments to prove the engineering rationale and effectiveness of the traditional Japanese architectural structure. A nationwide, autonomous knowledge-creating cluster was formed among diverse parties, centering on a series of structural experiments to prove the engineering rationale and effectiveness of traditional Japanese architectural structure, as its boundary object. It was a project that lasted almost two years and had incorporated 420 organizations. The details on why and how this co-creative cluster was formed and developed are described in the previous section.

As described in the previous section, the flexible, non-hierarchical, and open-minded attitude of the leaders enabled the expansion of the range and depth of collaboration. The bureaucratic structure tries to avoid conflict and different opinions, yet the diversity of opinions encourages the idea generation among creative people. The emergence of divisive opinions have been inefficiently perceived by the administrative hierarchy, which needed to be constrained. The bureaucratic structure encourages information privacy rather than information sharing (Yeh, 2012). These were also well observed during the project; when the relationship becomes less hierarchical, more useful knowledge is exchanged.

Open innovation spreads across a wide set of areas and domains, such SMEs, different high- and low-tech industries, and non-profit organizations. Moreover, an increasing attention should be paid to the contingencies of open innovation processes (Bogers, Chesbrough, & Moedas, 2018). What important is to engage multiple stakeholders from various organizations, different levels of hierarchy, and dissimilar professions in simultaneous joint activities to increase the diversification needed in order to broaden the information and experiences, and the amount and quality of the development suggestions (Tossavainen, 2016).

While most of SMEs are not well known, they form the backbone of the service sector and play a crucial part of the manufacturing and export supply chain in Japan. The well-being of this enormous sector is therefore crucial to the well-being of the overall economy (Economist Intelligence Unit, 2010), and the methodology of relationship design and management can support them to leave a lower hierarchy and participate in open innovation.

4.2.3 Formation of Sustainable Relationship: Business Model Design

4.2.3.1 Overview

Some social problems might be solved in a dependent way, such as a grant, a donation, or charity. However, in most cases, such dependent solutions end up as just a symptomatic therapy and can seldom provide fundamental solutions. Without professional services neither those social problems nor the sustainable and effective impact towards these social problems could be solved or achieved. In contrast, changing our business from profit-oriented business to people-oriented business is essential and effective way to solve the social problems caused from the overwhelming traditional business.

How can an appropriate business be generated in its society? How can a business be sustainable and deeply involved with its customers or society members? Especially if the business aims to take a certain social role in its society, it is highly productive to involve society members in these decision-making processes.

In order to answer above questions, we applied Business Model Canvas with some groups of business's potential customers of diverse backgrounds. We utilized Business Model Generation Canvas not only to co-design business models but also to take most advantage of its secondary effects of developing customer-oriented service innovation; visualization of thoughts, joy derived from co-creation, emotional attachment to or sense of deep involvement in the creation.

Business Model Canvas

A business model describes the rationale of how an organization creates, delivers, and captures value, and a business model shows the logic of how a company intends to make value. It does not matter if it is a non-profit or a for-profit enterprise (Osterwalder & Pigneur, 2010). Social enterprises may be mission-driven, focused on delivering social impact versus a financial return on investment, but they still need a sustainable model to scale over time. Within the age of social interaction, business models must have the capability to adjust quicker and elastically.

The Business Model Canvas (Figure 4.10) helps mapping, discussing, designing and inventing new business model as well as questioning existing models among various people. It is a tool used as a conversation piece for establishing how we interact with our

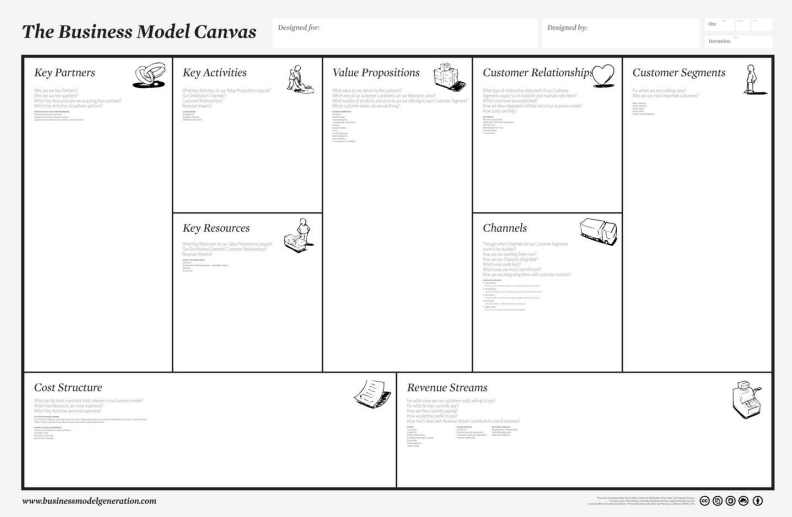

Figure 4.10 Business Model Canvas

customers. It is also a framework that helps us understand how different entities of a business come together to create value for customers. The complexity of business models

makes it difficult to argue about them. A business has many interrelated moving pieces, thereby, it is easy for a person and a team to miss something when creating a business model. This complexity and possibilities easily lead to misunderstanding each other when people try to invent new business models.

The Business Model Canvas helps in generating new ideas by asking a few key questions and can be described through nine basic building blocks centered on the main block called the Value Proposition. It is a flexible template for capturing, analyzing, and creating a shared language between the nine building blocks of a business model.

4.2.3.2 Formation Process of Sustainable Relationship: Business Model Design

In terms of the freshness of the business model ideas, participants should be from various business units, of different ages, with different areas of expertise, of differing levels of seniority, with a mixture of experiences, and from diverse cultural backgrounds. Therefore, participants were gathered from various fields, professions, seniorities and ages. A careful attention has paid to maintain the balance among group members when they were grouping.

The workshops reported here were held in different languages, in Japanese and English, so that our workshops can involve multicultural participants as society members. The participants were informed regarding the business they are going to work on, including its mission and problems, and the concept of the Business Model Canvas a week before the workshop. Short guidance on the target business and the methodology was offered at the beginning of the workshop.

Three workshops were carried out as mentioned below with best efforts to offer actual business environments which enabled participants to realize and understand the target business they were working on. Workshops were held on actual business sites, used streamed video images from actual business sites, or in the presence of a key person around whom the business has been based.

Workshop 01

Target Business

Participants worked on a local tennis school. Its director has qualified for the all-Japan championship five times and the national athletic meet five times, and also has the experience of a national team coach of a top junior tennis tournament. He runs his tennis school to convey the joy of tennis widely in the local community whether someone wants to be a professional player or not.

The director has difficulty gathering students and wants to know what his potential customers really expect him to do in the local community. This problem is one of the key questions for his business success in terms of both profits and social impacts.

Participants

Participants were diverse in age, nationality and profession: ranging in age from 19 to 64, three nationalities (Japanese, Sri Lankan, Chinese), diversity in profession (university students, a medical doctor, a house wives/husbands, a social care manager, a nursery school director, a confectioner, a retired, a local government employee). They were divided into three small groups ensuring the diversity in profession and age (Figure 4.11).

Figure 4.11 Streamed Video Image from Actual Business Site

Workshop 02

Target Business

The same business was targeted as in workshop 1.

Participants

Participants were multi-cultural: in age ranging from 8 to 48, of five nationalities (Japanese, Sri Lankan, Italian, Chinese, and American), in profession (university students, house wife/husbands, a NPO member, a job seeker, a teacher, and a local government employee, and an elementary school student). They were divided into two small groups ensuring diversity in profession and age (Figure 4.12).

Figure 4.12 Workshop Held with Diverse Participants

Workshop 03

Target Business

Participants worked for a newly opened café. The café's mission is to serve to sustain for the health of people, community, and global environment through running its business.

The cafe owners were experienced, and the staff also willingly shared the its mission. A collaboration with local farmers had just started. The café owner was unsure what kind of services his customers really expected in the local community. This problem should be one of the key questions for their business success in terms of both profits and social impacts.

Participants

Participants were diverse: in age ranging from early 20s to late 50s, in profession (university students, a professional singer, a CEO of traditional products shop, a web-contents designer, a confectioner, an entrepreneur, and a local government director). They were divided into five small groups ensuring diversity in profession and age.

Figure 4.13 Workshop Held in Actual Environment

In every workshop above, the participants were also asked to fill the Empathy Map (Figure 4.14), before working on business model canvas. The Empathy Map is a useful tool to understand customer's environment, behaviours, concerns, and aspiration. To co-design a customer-oriented business model, participants start from understanding its customers. After discovering as many customer segments as possible in order to focus on the business model from the aspect of the customer segments as well as the customer

perspective, each group chooses the most promising customer segment to be explored by using the Empathy Map.

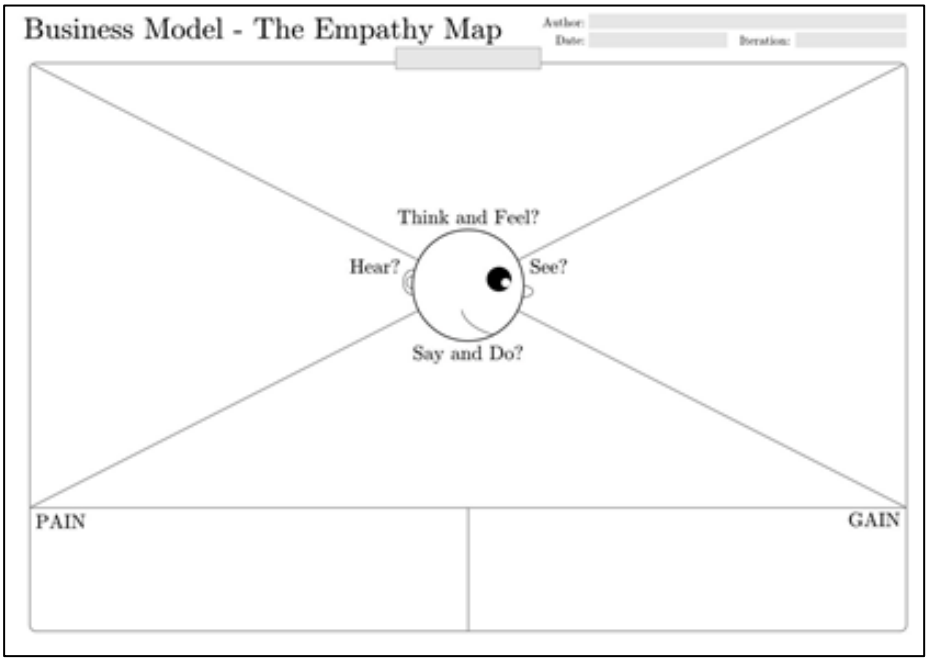

Figure 4.14 Empathy Map

Each group was encouraged to find gain creators and pain relievers for the customer segment they choose on the basis of their Empathy Map as a part of the Value Proposition, the core of the Business Model Canvas. Participants are encouraged to produce "What if?" questions for each element of the Canvas to pivot their basic idea and generate innovative business model. At the end of the workshops, the director of the target business, who participated in the workshop with his position concealed, states his opinions about the business models generated there and how he would absorb them into his real business.

4.2.3.3 Application of the Model

Here we explained the fundamental factors of our innovation design methodology with relevance to the process of formation of sustainable relationship among business, managers and potential customers (participants).

Context

There were diverse set of participants who vary each other in age, nationality and profession: ranging in age from 8 to 64, five nationalities (Japanese, Sri Lankan, Italian, Chinese, and American), diversity in profession (university students, a medical doctor, a house wives/husbands, a social care manager, a nursery school director, a confectioner, a retired person, a job seeker, a NPO member, a local government employee and elementary school student).

Boundary Object

In here, the boundary object that bundle the individuals and the main identity across the participants was their uniqueness as business's potential customers. Even though there were diverse set of participants explained under context section, the borderline of them was their similar needs towards the product or service provide by the business.

Co-Creation

As the definition "to create something together sharing the phase of socialization among individuals", all the participants were able to get involved and excited while co-designing business models with Business Model Canvas, although it is often said Japanese people are not used to free discussion among a diverse group.

Further, it is obvious that grouping is the key factor to enrich group work to co-create innovative services. It is important to keep horizontal power balance among group members as well as to involve members with various back ground. During the basic flow of the workshop process, participants' contexts were altered as matching with the shared context while enjoying the participation in the business.

Co-Creativity

Most of the new services co-created and proposed in those workshops were willingly implemented by directors. 92 % of participants who had never known about the target business before the workshop kept their interest in it at least a week after the workshop.

Intersubjectivity

A potential customer group for the target business was formed, who deeply understand the target business, including its mission, problems and possibilities. Finally, they feel ownership of the desired business design.

4.3.2.3 Formation of Sustainable Relationship

Understanding Customers

It is widely heard among interviewed business managers that they have difficulty understanding customers' needs. It does not necessarily mean that they do not have any information on their customers. They usually have had plenty of explicit knowledge on them already. To say more accurately, what they have had little opportunity is to capture the context of their customer's behavior, tacit knowledge.

Since Business Model Canvas enables visualizing a business model which has been difficult to pull out of one's mind and transfer to another, it becomes much easier for business managers to understand the context of their customers' behavior by joining these workshops.

Understanding Business

On the other hand, it is also common for customers to have less opportunity to understand the context of the services offered to them. First, it is simply because business enterprises are seldom provided with the opportunity to introduce their mission and how it reflects their current services offered to customers. Second, customers usually pay less attention to how the services are delivered than what the services are.

The process of our workshops offers opportunities for business enterprises to explain their mission and how it is reflected in their services. In addition, customers can understand the whole structure of the business by using Business Model Canvas, how their services are delivered to them.

Interaction between Services and Customers

As productive and sane interpersonal relations are based on both deep understanding of the other side and interactive communication between both sides; the relations between services and customers will be productive and sane when they have both understanding for the other side and the interaction between them.

As mentioned in 2.1, Business Model Canvas can not only visualize a business model but also help mapping, discussing, designing and inventing new business models as well as questioning existing models among various people. Therefore, Business Model Canvas could be a communication tool to interact between services and customers and enable to lead a customer-oriented service innovation. Understanding and involvement with the business brings attachment to it.

4.3.2.4 Discussions

When the methodology for relationship design and management (4.2.1) is applied to business model design, there are two logical approaches to deal with the relationship design factor: 1) the types of relationships among individuals are determined by following a business model design and 2) the business models are designed based on the possible relationships between specific entities. In practice, these two approaches are used dynamically, based on their implementation results.

As described in the previous section, the latter approach has been taken to co-create business among various individuals from both profit and non-profit organizations. In addition to the cases explained in 4.3.2, more than 70 teams, which mainly consisted of individuals from SMEs, have experienced similar challenges in designing and implementing business innovation models. Increased interconnectivity with co-creators allows companies to generate and leverage a range of benefits that seem to cut both ways. While customers and other co-creators benefit from greater personalization and value as a result of co-creation processes, companies can build competitive advantages by turning just-in-time knowledge of co-creators into just-in-time learning for their organizations (Roser, DeFillippi, & Samson, 2013).

As seen in the above cases, the role of the customer has been significantly changed from a passive consumer to an active co-creator of knowledge and value in terms of new business development. The outcomes of customer knowledge co-creation had already been recognized and discussed in the literature from customer relationship management and knowledge management perspectives as advanced marketing, which is expected to lead sustainable competitive advantage (Lawer, 2005), in this study related to the formation of intersubjectivity with customers. Nambisan & Nambisan (2008) have identified five roles that customers can play in new product development: conceptualizer, designer, tester, support specialist, and product marketer (Nambisan & Nambisan, 2008). Since each organization has its own context toward co-creation, they need to decide on how they will implement and manage their specific co-creation activities (Roser et al., 2013). A closely related model is the open innovation model, wherein the source of valuable idea is seen as residing outside the firm. This model points that most of the ideas come from lead users and the model is applicable in a large spectrum of products, from toys to surgical instruments (Banerjee & Sharma, 2015).

It is obvious that team members are the key factor in co-creating innovation. To settle innovative ideas into society, it is important to gather participants who are expected to be involved with the targeted business: an implementing body, a creator, an expert, students, and various citizens in an appropriate timing will accelerate the innovation. It is also important to keep horizontal power balance among participants as well as to involve members with various backgrounds to generate and sustain co-creation, not to break but accelerate the vortex in the IVM. Real environments help participants understand the actual image of target businesses and led to reasonable, innovative ideas. From this perspective, it is criticized that lack of knowledge of average customers and for bringing only incremental changes (Lojacono & Zaccai, 2004), and substantial contributors to innovation were extreme users and developers who had the ability to implement their ideas into workable prototypes (Banerjee & Sharma, 2015).

As a result of the co-creative team projects above, participants not only co-created their business model but also formed motivation and relationships, that is, intersubjectivity, to implement it. It is natural that each stakeholder has the motivation to

realize what is co-created by himself or herself in his or her own context. Therefore, it is effective and essential to install co-creation processes in terms of autonomy, sustainability, and the possibility of realization as the engine of an innovation ecosystem. The literature also supports the conclusion based on empirical studies as follows. This leads to two important inferences. First, co-creation will be influenced by the customers' perception about value creation; second, the value created through co-creation can cause benefits beyond the direct value associated with pure consumption. The second inference gives a new orientation to co-creation, wherein the involvement of customers in R&D processes enhances innovation efficiency (Banerjee & Sharma, 2015).

Following the results of those case studies, this basic methodology for relationship design and management using the dynamic mechanism of co-creation is *actually* adopted to local innovation ecosystems focusing on the formation of intersubjectivity. Design thinking project is chosen as a co-creation factor for its human-centered and highly co-creative process.

Design thinking programs and pilot policies are designed and implemented in local governments to develop a local-rooted innovation ecosystem that is autonomous and de-centralized. Entrepreneurship education and relationship building using the secondary effects of design thinking are the two cornerstones of the programs. Students and diverse local SMEs learn design thinking methodologies as value creation methodology in team project by 1) observing and empathizing to potential customers and users in the current context, 2) deepening insights and defining the problems while broadening their perspectives, 3) co-creating potential business models to solve the problem bridging to global innovation ecosystems, and 4) prototyping and testing it involving various stakeholders. As the part of the outcomes of these series of the programs and the pilot policy above to build a local-rooted innovation ecosystem, we observed among them that; 1) sharing design thinking methodology as a boundary object and co-creation process among participants, 2) designing of actual innovation in teams, 3) forming intersubjectivity in teams to implement design innovation, and 4) bridging between teams and various types of innovation collaborators.

4.3 Contributions to Co-Creation Studies

The number of studies on co-creation has remarkably increased following the exponentially growth of social demands of co-creation in various applicable fields. Neither that the term *co-creation* has been reached to a common definition but rather deployed into various fields (Alford, 2016; Minkiewicz, Evans, & Bridson, 2013; Ramaswamy & Ozcan, 2018; Sanders & Stappers, 2008), nor that the distinction among collaboration, co-creation and co-operation has been clarified. Furthermore, studies on co-creation seem to have mainly been focused on the usefulness of the co-created values or on the efficient collaborative processes toward them, and there seem to be few studies on the mechanism of co-creation itself focusing on the fragile and *dynamic* nature of subjectivity of co-creation among individuals.

Regarding the situations above, this study has challenged to elucidate the co-creation mechanisms among individuals as a dynamic system focusing on fundamental factors, the inner aspects of co-creation mechanisms. The contributions of this study to co-creation studies in terms of academic originality can be described as follows.

First, from the definitions and the discussions on co-creation in existing literature, we concluded that the focused aspect in the study ought to be reflected on the definition, focused more on the *co* aspect and less on the co-created. Therefore, we defined *co-creation* in this study from the aspect of knowledge creation (Nonaka & Takeuchi, 1995) with distinction of fundamental differences between cooperation based on individual creativity and co-creation based on co-creativity formed among individuals. The term *co-creativity* is also conceptualized and defined, as well as referring to existing literatures on collaboration or creativity based on individuals.

Second, existing studies on co-creation tend to take static or discrete approaches, focusing on their partial and external aspects referring studies on collaboration (Banerjee & Sharma, 2015; Jokubauskiene, Patasiene, Bakanove, & Patasius, 2014; Silva & Wright, 2016; Skaržauskaitė, 2013; Tari Kasnakoglu, 2016). In contrast, we have focused on the dynamic nature of co-creation, particularly on its significant inner aspects. Not only its

subjectivity but also its process and consequence, are also dynamic being different from the ones of individual creation. Fundamental factors of co-creation mechanism (intersubjectivity, context, and co-creativity) to be evaluated are specified from each viewpoint of three components of action; subjectivity, process, and consequence. Methodologies to evaluate them are proposed in this study and an experimental study was conducted to grasp their dynamic behaviors in relation with the type of collaborative design process; co-creative collaboration and co-operative collaboration. The experiment indicated how a design process affects formation of intersubjectivity among individuals involved and also their co-creativity.

Third, a challenge grasping dynamic mechanism of co-creation as an integrated dynamic system is desired to develop a methodology of relationship design and management, as an attempt to understand the microregulatory socioemotional processes that generate the unique features of the relationship (Tronick, 2003). This study emphasize the significance of grasping co-creation dynamics as a dynamic system containing fundamental factors, rather than focusing on a specific factor. For this purpose, a dynamic system model is proposed as the IVM in an analogy of vortex to represent relations between the formation of co-creation subjectivity and the co-creative process, based on the knowledges obtained from the experiment.

While the importance of co-creation has been recognized with increased global mobility in the past decades led by developments and extensions of public infrastructures over decades, its difficulty in terms of implementation has been also recognized as well. Therefore, development of the methodology for relationship design and management has become the issue under broader needs. However there has been little studies going beyond the co-creation itself but the *function* of co-creation. This study can be useful since an application of IVM, the proposed dynamic model of co-creation mechanism in this study, to dynamic relationship design and management is indicated based on the knowledge obtained in this study; intersubjectivity formation as a result of co-creation.

It could be more than just a static relationship design but considered as a frontier issue of design science for its exploration of the methodology for a dynamic design which considers time axis in addition to static relationship. This study contributes to the society

with exponential increase in design flexibility where design and management coexist in dynamic circumstances.

4.4 Contributions to Knowledge Science

This study aimed to elucidate a dynamic mechanism of co-creation in its generation phase in terms of both *event* and *entity*, focusing on subjectivities of co-creation. In other words, the study tried to grasp how a co-creation process is generated as an event, how the subjectivity of co-creation is formed as an entity, how the fundamental factors of co-creation are related each other, and how do they behave as a dynamic system.

According to the taxonomy of knowledge science and knowledge management, questions such as"what is Knowledge Science" or "what is knowledge management" are difficult to answer since understandings on knowledge science vary and are not identical, even for professional researchers in the domain (Nie, Ma, & Nakamori, 2007). However, one can share a minimum consensus that the knowledge science must catch the relation between learning and human being based on the relation between self and others (Nakamori, 2003).

Therefore, even though we do not focus either on co-created knowledge or on knowledge management, we believe that this study on the dynamic mechanism of co-creation, which focuses on subjectivity of co-creation, consciously referring to knowledge creating theory (Nonaka & Konno, 2012; Nonaka & Takeuchi, 1995; Nonaka, Toyama, & Hirata, 2015), contributes to knowledge science as the other aspect of knowledge creation explained below.

First, since knowledge-enabling conditions and the SECI model had been mainly developed empirically within *established* larger companies (Krogh, Ichijo, & Nonaka, 2000; Nonaka & Takeuchi, 1995), they should be carefully examined with experimental evidences to expand their theoretical scope to the *formation phase* of new business entities in *gestation phase* (Reynolds & Miller, 1992). Little practical evidence has been indicated on the formation of quadruple knowledge clusters among organizations,

although Nonaka and Konno have mentioned the theoretical possibility (Nonaka & Konno, 2012). We have challenged the elucidation of dynamic mechanisms of co-creation with accumulated empirical studies in relation to a formation process of co-creation subjectivity in its gestation phase, and it has been modelized referring to Nonaka's knowledge theory. A proposed methodology for design and management in flexible relationships for autonomous and horizontal collaborations can be applied not only within but also among organizations. This study has empirically explored the limitation of the knowledge creating theory to its generation phase in terms of event and entity.

Second, this study provides a systematic viewpoint on the separately explained relations between intersubjectivity and boundary object (Nonaka & Konno, 2012) with the IVM, which dynamically indicates the relationship between them driven by individual's context. Moreover, the quantified knowledge obtained from the experiment conducted in this study provides a higher resolution to *ba* where individual contexts and intersubjectivity are *converged* through co-creation, while Nonaka and Toyama's conceptual representation of *ba* explained that both the shared and individual contexts expand themselves through such interaction (Nonaka et al., 2015).

Third, as Nonaka defines the organizational knowledge creation as the process of making available and amplifying the knowledge created by individuals as well as crystallizing and connecting it to an organization's knowledge system (Nonaka, Krogh, & Voelpel, 2006), knowledge science has mainly focused on *the co-created knowledge* rather than on *the subjectivities co-creating knowledge*. In this context, we have often experienced and observed the secondary effect of co-creation as a practitioner, which have formed autonomous knowledge creation clusters among cross-contextual stakeholders (Matsumae, 2014; Matsumae & Burrow, 2016), and have tried to use them in the design and management of innovation ecosystems.

The study that elucidates the dynamic nature of co-creation itself does not include a specific direction in value, but rather only modeled its dynamic nature focusing on human factors. It is applied to the methodology for design and management of co-creative

relationship among individuals in different contexts. In other words, it is the process of creating thirdness—that is, in which how we build relational systems (Benjamin & Ph, 2004). However, by changing the emphasized aspect of co-creation phenomena from the co-created knowledge to the subjectivities of co-creation, its human-centric system is given an opportunity to be focused as the other hidden side of a knowledge creating system. The *relation* has itself a health potential (Stens, 2007; Stensæth, 2013). Therefore, a shift on what is focused can lead the shift of both measurements and principle for optimization from *productivity* to *well-being*.

Co-operation has enabled an *efficient* society managed by simplifying a complicated dynamic system as a series of discrete static system composed only of explicit knowledge confining individuals' creativity. However, creativity is a part of human nature, and society is complicated and dynamic. The IVM proposed in this study is a dynamic model that focuses on human's inner nature and individuals involved, intersubjectivity, and the co-creativity formed among them. The IVM manages society as a dynamic system and treats individuals as creative entities by using an analogy of fluid dynamics. The IVM, represented in a single system, would support collaborative processes by reducing technical barriers to co-creation, which thus far has been avoided due to its complexity. This research contributes to the establishment of an efficient and practical methodology to form and manage sustainable collaborative projects among individuals in different contexts in various fields.

The human factor has been usually argued from the viewpoint of collaboration. In this study, it is argued from the deeper viewpoint of *co-creativity*. The shift of the focused perspective from the co-created knowledge (Nonaka et al., 2006) to the subjectivity of co-creation, i.e., human nature, could be the essential contribution considering the growing research interest in relation between well-being and co-creation. Therefore, the perspective focused in this study will also increase the significance of knowledge science.

4.5 Limitations

The main limitation of this study is the simplicity of the design problem in the experiment. This study has intentionally selected a simple design problem because of the focus of the study in evaluating the fundamental factors of co-creation dynamics, intersubjectivity, context and co-creativity, as well as the relations among them. The second reason of selecting such design problem is that we wanted to assign a design problem that makes the individual competency level equal for all team members. When it comes to the design of a pizza, in general, everyone is familiar to it as a pizza delivery service system and no one knows how to do it professionally in group in 15 minutes. Furthermore, there are other factors that the authors have recognized as important had not included in this study, such as the impact of surrounding individual and atmosphere.

Strictly speaking, this study tries to grasp the basic co-creation dynamics by using a very simple situation only with few fundamental factors. As the future step of this study, more minor factors of co-creation dynamics should be considered to apply this basic model to describe more detail co-creation dynamics behaviors.

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Chapter 5

Conclusion

5.1 Summary

In this study, we introduced the background and significance of our study in chapter 1 and summarized the concept of co-creation and its dynamic nature in comparison with creation and collaboration following the literature review in chapter 2. In chapter 3, we defined the major factors of co-creation dynamics and evaluation methodology for *intersubjectivity* as a co-creation subjectivity, *contexts* as a co-creation process, and *co-creativity* as a consequence of co-creation. Then, experiments were conducted in order to capture both the dynamic nature and the relations between the major factors based on the definitions and methods mentioned above. Based on the findings of this experiment, we discussed theoretical and practical implications in order to apply them to a relationship design and management methodology being deployable for an innovation ecosystem. Finally, we modelized a dynamic mechanism of co-creation as an integrated dynamic system representing the results of experiments in an analogy with fluid dynamics. In chapter 4, we discussed the deployment of the dynamic model proposed in chapter 3 into a relationship design and management methodology and applied it to the case studies in the context of relationship design and management in which the establishment of new relationships throughout co-creation process had been recognized.

We have challenged the understanding of dynamic mechanisms of co-creation in relation to the formation process of *co-creation subjectivity* in its gestation phase, as well as proposed the IVM and applied it to a relationship design and management methodology for flexible, autonomous, and horizontal collaborations.

5.2 Future Research

The IVM, the model proposed in this study, need to be further developed for better understanding of co-creation dynamics. Since this challenging approach, including quantifying co-creation dynamics, has just started and currently represents only fundamental factors in a simplified situation, there can be many supplemental works left for the current basic structure.

First, questioning its implications on other factors that were carefully excluded from this study such as the capability of each individual and mood of *ba* (Shalley, Zhou, & Oldham, 2004), as well as other less major factors than the ones we have discussed in this study. Some factors can be added from the literatures and others from practical experience. To grasp the whole phenomena, it is important to consider both approaches to define the problem accordingly.

Second, the development of an evaluation methodology for each factor is significant. Translate and quantify each social factor to be addressed in the physical model was the key problem of this study. As described in chapter 3, it is important to be conscious on the appropriate precision considering the nature of the evaluated object when it is evaluated under a certain measurement. It can be effective to have another measurement, e.g., the one from the physiological approach, to evaluate the same object for a higher precision.

Design is the process of composing a desired figure toward the future (Taura & Nagai, 2009). Co-creation can be regarded as the design process that facilitates a better society where each individual exerts his or her own creativity, since co-creation subsumes a view of a coexistent society, which is significant considering the given definition of design. Consequently, it becomes more significant to establish a methodology for the design and management of innovation ecosystems to build relationships toward a desirable society, which is fundamental in the design field.

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