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Effect of "prototyping stage" for "Need-Solution Pairs" in design thinking[1]

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Abstract: Design thinking will discover clues for market creation and lead to market creation in an uncertain environment. Prototyping is pointed out as an important act in the design thinking process (Luchs 2015). In this research, we focus on prototyping which is one of the five steps of design thinking. In general, the prototype is positioned as a process of materializing ideas and conducting tests effectively (Brown 2009, Kelley 2013). Von Hippel and Von Krogh(2016) has been pointed out that problems may be found and resolved simultaneously in ambiguous circumstances. Although the concept is shown, its concrete there are few studies showing cases as phenomena. In this research, I present concrete examples of problem discovery and solution generation simultaneously in experiments using prototypes. Using the framework of dialogue, explain the effect on prototype creation by "dialogue angle".

Keywords: Need-Solution Pairs, Design thinking, prototyping, " Naruse pedal", paring process, dialogue ,product innovation, market creation

1 Research problem

This study is to examine the mechanism of Pairing process in Need-Solution Pairs (Von Hippel and Von Krogh 2016). Need-Solution Pairs is a framework of a dynamic viewpoint that needs and solution are simultaneously created while mutually exploring. The feature of this research is to grasp the mechanism of Need-Solution Pairs from two viewpoints. First, pay attention to the role of the prototype. Second, pay attention to the effect of multiple users using the same prototype. These investigations were conducted for the product development process of a car pedal called "Naruse pedal". "Narcepedar" is a pedal in which the accelerator and the brake are integrated. Therefore it is called "one pedal".

Many of the previous studies on product innovation focused on problem-solving behavior (Clark & Fujimoto, 1991; Ogawa, 2000; Lester & Piore, 2004). One reason for focusing on problem solving is the assumption that the problem to be solved is defined. However, in recent years, it has been noted that product development is conducted in a situation in which the problems are not clarified, creating a condition in which problem discovery and solving take place simultaneously (Ishii, 1993, 2009, 2014; Lester & Piore, 2004; Von Hippel & Von Krogh, 2016). Moreover, the importance of solving problems of which customers are unaware (that is, the importance of discovering problems creatively) has also been pointed out (Ishii 2009, 2014; Lester & Piore, 2004; Takaoka & Kotler, 2016).

Incidentally, the existence of users called "lead users" who act in advance of future important markets and their contribution to market creation has been noted (Von Hippel, 1988, 2005; Ogawa, 2000, 2013). Lead users have the characteristics of discovering problems that manufacturers and other users were unaware of and realizing innovation by solving these problems (meeting these needs) themselves.

In this study, the occurrence of simultaneous problem discovery and solving in a case study of product development by a lead user is confirmed. Second, the requirements to realize the simultaneous creation of problem discovery and solving in a situation where the problem has not been defined are considered from the viewpoint of dialogue (Ishii, 1993, 2009; Lester & Piore, 2004).

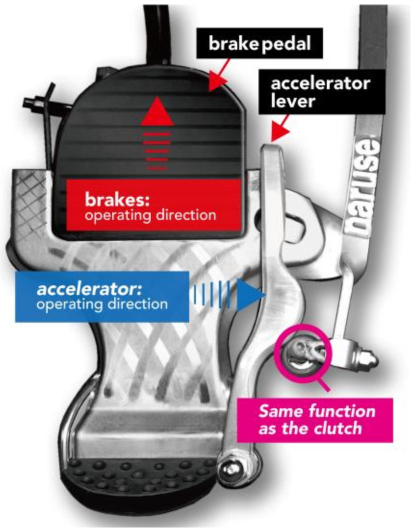
2 "Naruse pedal"

"Naruse pedal" is a user innovation developed by Mr. Masuyuki Naruse. Mr. Naruse is the president of a company developing industrial machinery such as the fishery industry. Mr. Naruse mistook the brake pedal and the accelerator pedal on a private car about 30 years ago. It was an experience I felt the danger of life though it did not become an accident. However, he himself did not intend to make a mistake. This experience is the motivation for "Naruse pedal" development.

Mr. Naruse has experience in the development and production of industrial machinery. Therefore, it possesses the technical skill of mechanical products (Ogawa 2000).

Remove the accelerator pedal and brake pedal attached to a commercially available car. While driving, drive with the right foot on the brake pedal. Therefore, even if you stepped on your right foot unintentionally, the car brakes. Do not accelerate against the intention of the driver.

Figure 1 "Naruse pedal"



Source: Naruse Machinery

The current of “Naruse pedal” is the third generation. The chance of this “Naruse pedal” being born was a remark (information) at the time of use by an automobile manufacturer's engineer. Engineers of car manufacturers have development experience. And I have a different solution landscape than Mr. Naruse. We combined the needs arising from the "using" behaviour by such users with a solution landscape consisting of their own knowledge and experience.

3 Survey method

This paper is based on information obtained in interviews with Mr. Naruse, the developer of the Naruse Pedal, and other relevant parties who have had a relationship with the developer over many years and who fully understand the development of the Naruse Pedal. Information was also gathered from interviews with Mr. Naruse published in newspapers and magazines, and found on the Internet and television, as well as from patents filed by Mr. Naruse and others and from published patent publications.

The published information and interviews confirmed the characteristics of the Naruse Pedal and showed that its characteristic positions were selected based on a comparison with existing pedals. The overwhelming majority of the published information was on the current Naruse Pedal (the third generation pedal). However, the first interview with Mr. Naruse confirmed the trigger for the development of the prototype and made it possible to ascertain the process that led to the specifications of the current pedal. After this, the characteristic positions of the Naruse Pedal were presented to Mr. Naruse, and the order of generation of these positions and the generation process were confirmed.

4 Development of “Naruse Pedal”

Mr. Naruse acquired the patent for the prototype that would become the current pedal in the United States in 1993, and then subsequently acquired it in Japan, Germany, the United Kingdom, France, and Italy in 1995. In Japan, he applied for and acquired 49 patents between 1999 and November 2016, including the model at the trial-and-error stage that led to the prototype of the current pedal. Based on the patent publications, 15 patents relating to pedals and 11 patents up to 2004 that became the current pedal specifications were selected as the subjects of the survey. After this, interviews were conducted with Mr. Matsunaga, along with a second interview with Mr. Naruse, and interviews with Mr. Arata and Mr. Ota. In addition, while linking the patent information, the A method of the KJ method was used to repeatedly enumerate and classify the keywords, link the classifications, and name the classifications.

Naruse Machinery, where Mr. Naruse is the representative director, is a company that develops and produces agricultural and fishery equipment, and it has a particularly large share of the laver-culture machinery market. From his previous work, Mr. Naruse had experience with the technologies used for metal machining and plant material processing. However, up to the development of the Naruse Pedal, he had no connection to the automotive industry (Nikkei Mechanical, September 2000). Therefore, Mr. Naruse had no knowledge of or experience with the design and development of automotive products or vehicles. However, because he had experience with the design and development of industrial machinery, he did possess knowledge about machinery design and

development, metals processing, and materials, along with the experience and skills to actually create the prototype and product. In addition, because his company had these facilities, the environment was in place for him to quickly realize his idea as a prototype. The Naruse Pedal is a case study of user innovation. It was developed by Mr. Naruse as an individual for passenger cars using this sort of knowledge, experience, and environment.
Mr. Naruse provided the following description of the development of the Naruse Pedal, where the problems could not be found.

"I could not find the problems. That was the feeling. We could not find the problems. To do this, we needed to find the problems. I think everything is like this. Once you find the problem, then you attempt to solve it in some way. When the problem is found, in some way or another, it (the solution) will come out. After proceeding to a certain extent, we could not find the problems. On evolving it to the third, fourth, and fifth iterations, the problems became visible to some extent, but in the case of evolving it 0–1 time, there were no problems, in that the problems were difficult to find." (Interview with Mr. Naruse.)

There are at least two types of development. In the first, the problems are clear (to a certain extent), and in the second, "the problems (issues) cannot be found," as in this case study. The Naruse Pedal can be said to be a case study in which we can concretely confirm needs-solutions pairs, in that the problem discovery and solving were conducted simultaneously in a situation in which the problems remained undiscovered, through repeated trial and error.

Actions and Product Redevelopment

Generally, when driving a vehicle, we perform the same stepping action with the same right foot when using both the accelerator pedal and the brake pedal. Therefore, in many cases, when the driver needs to use the brake pedal, it is necessary to move the right foot quickly and accurately from the accelerator pedal to the brake pedal. The Naruse Pedal has the following three characteristics. First, the brake pedal and accelerator pedal are operated using different actions. Second, the foot (generally, the right foot) that operates the brake pedal is in a fixed position when stopping and moving. Therefore, "the action of changing the pedal that is stepped on," which is one of the factors behind stepping on the wrong pedal, becomes unnecessary. Third, when stepping on the brake pedal, the drivers themselves and their actions are absolutely disconnected from the accelerator. In other words, a state is realized where the accelerator cannot be operated. These three characteristics of the Naruse Pedal create a state in which it is very difficult for the driver to think they are stepping on the brake but are actually accidentally stepping on the accelerator (Matsunaga, Hayashi, Sumida, Nishimura, & Koshi, 2011). In this way, the development of the Naruse Pedal considered the relationship between the pedal and the user and the actions needed to operate each of the pedals.

"Using" Actions and Product Redevelopment

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Table 1 Comparison of Naruse Pedal and existing pedal

			Naruse Pedal			**Existing automatic cars**		
	Part of body performing operation action	**Position of right foot when driving**	**Operation action**	**Part to be operated**	**Part of body performing operation action**	**Position of right foot when driving**	**Operation action**	**Part to be operated**
Brake operation	Right foot (generally)	On the brake pedal, heel contact	Step on it	Brake pedal auxiliary pad (mounted on the existing brake pedal)	Right foot (generally)	–	Step on it	Brake pedal
Accelerator operation	Right foot (generally)	On the brake pedal, heel contact	Sideways push	Accelerator arm (connected to the existing throttle wire and throttle sensor)	Right foot (generally)	When driving：on the accelerator pedal when stopping：on the brake pedal	Step on it	Accelerator pedal

Source: prepared by the author

Solving Brake Pedal Problem and Discovering Additional Accelerator Pedal Problems

Because the position of the right foot is on the brake pedal, the problem became one of a state of half-braking, with the brake light constantly on, and it was necessary to solve this problem. As a solution, in 1998, he developed a brake pedal auxiliary pad that was divided into two parts in the middle part of the foot

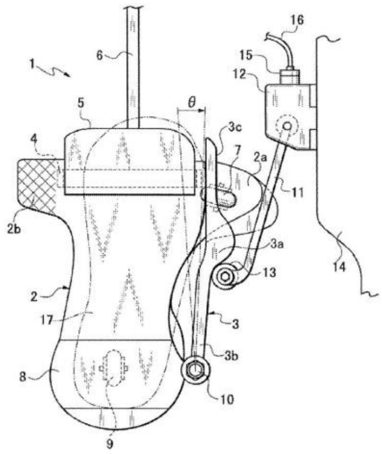
and moved based on the amount the brake was depressed. Stepping-on the brake auxiliary pad with the heel attached to the floor made possible an action of stepping on the same contact area for the sole of the foot and the pedal face, thereby making the stepping action smoother and solving the problem of half-braking and the brake light being constantly on.
A problem occurred with the accelerator bar prototype when Mr. Naruse mounted it in his own passenger car. The accelerator pedal is operated by the action of depressing it. It is possible to depress it with considerable force using the large muscles of the leg. The accelerator pedal in an existing passenger car is operated by the action of depressing it using the entire leg, with the hip joint as the fulcrum (patents publication, Japanese Unexamined Patent Publication 5-16692). Therefore, even women and the elderly are able to generate the necessary load to operate it. However, a sideways, sliding action with the foot made it hard to generate the same load, which made it difficult to operate the accelerator for long periods of time. To solve this problem, Mr. Naruse considered using powerful magnets to supplement the part of the necessary load that was lacking. Subsequently, up to 1999, he developed numerous and different prototypes, including some that incorporated a spring, in which the sideways push action changed the accelerator into a magnet. However, he was not able to reach the same level of operation as a conventional accelerator pedal.

6 Considerations

Third-generation "Naruse Pedal"

As of 2017, the Naruse Pedal has reached its third generation. The first generation realized accelerator operations through the right-foot slide (sideways push) action. The second generation made the action of stepping on the brake pedal smoother and prevented the problem of the state of half-braking and the brake light being constantly on from the right foot being fixed on the brake pedal. The third generation integrated the brake pedal and accelerator pedal, made the slide action smoother, and shut off the accelerator pedal when the brake pedal was being operated.
Mr. Naruse's used a repeated trial-and-error method to answer questions about the actions taken by a driver (user) to operate the accelerator and brake and what kind of pedal specifications would realize these actions. He carried out the development with two constraints for this trial-and-error method. The first was the relations between the drivers (users) and the two pedals, along with the associated constraints on the required actions. The second was the constraint of the interface[2] with the accelerator and brake pedal of existing vehicles.

Figure 2 Third-generation Naruse Pedal (Third-generation model)



Source: U.S. patents: US20110107870

Problem Discovery and Simulating User Experiences

Product development is an activity used to solve the problems of customers (Clark & Fujimoto, 1991; Ogawa, 2000). This problem solving consists of four steps: awareness of the problem, generating choices, evaluation, and decision making (Clark & Fujimoto, 1991, Japanese translation, p. 47). Out of these, awareness of the problem entails being aware of customer needs and simulating future customer experiences (Clark & Fujimoto, 1991, Japanese translation, p. 44). However, when customer needs are unstable, uncertain, diverse, and ambiguous, it is not easy to clearly ascertain the potential future needs of customers and develop a product to meet these needs (Fujimoto, 2003, p. 122; Lester & Piore, 2004). Therefore, in a situation where it is difficult to be clearly aware of the needs, the ability to simulate customer experiences will affect a company's competitiveness (Clark & Fujimoto, 1991, Japanese translation, p. 46). However, it has been noted that in a situation that is highly opaque, there are times when the problem cannot be defined, and in such cases, there are limits to the problem-solving framework (Lester & Piore, 2004, p. 53).

Initial Stage of Development and Prototyping

Uncertainty is generally high in the initial stage of development. Therefore, there are situations in which even those responsible for the development cannot clearly define what is to be developed next. At this stage, for example, even if the developers carefully listen to customers' opinions, it will still be impossible to clearly define the project's goals (Lester & Piore, 2004). The developers go through a trial-and-error process to discover the development problems (Ishii, 1993; Lester & Piore, 2004). High-quality activities at this stage will increase the probability that the product will be a success (Song & Parry, 1996; Khurana & Rothenthal, 1998). Front loading is one method of problem solving (Thomke & Fujimoto, 2000), and it has been shown that rapid prototyping is one effective method of front loading (Thomke, 1998). Research in this field has produced many findings (Takeda, 2000; Gu & Fujimoto, 2000; Takeda, Nobeoka, &

Aoshima, 2004). However, there has been insufficient research on ways to realize rapid prototyping at the initial stage of development.

Effects of Prototyping on Innovation

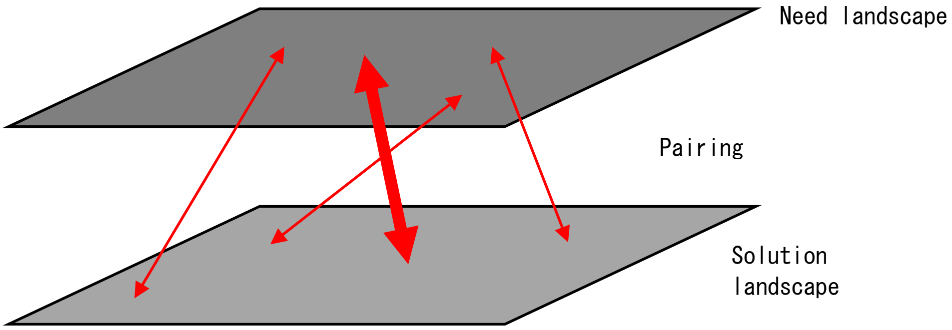
Dyer, Gregersen, & Christensen (2011) conducted a comparative study of approximately 500 innovators and approximately 5,000 management executives and clarified that there is one cognitive skill and four discovery abilities that are requirements to be an excellent innovator. The cognitive skill can be called associative thinking. The four discovery abilities are questioning ability, observational ability, networking ability, and experimental ability. Associative thinking is the ability to implement combinations of new pairings (Schumpeter, 1926). There are three experimental methods for experimental ability, which is one of the discovery abilities. The first is testing new experiences in a new environment. The second is breaking down the innovation into products, processes, and ideas, and the third is verifying the ideas through demonstration experiments and prototyping. Excellent innovators repeat and enlarge at least one of these three experimental methods (Dyer et al., 2011, Japanese translation, p. 155). Dyer et al. (2011) found that in order to obtain clues about the method that would produce success in the future, even when there is no way to succeed in the experiment (Dyer et al., 2011, Japanese translation, p. 170), in terms of the relationship between the experimental ability and the other discovery abilities, the amount of experimentation required to obtain new insights is practically inversely proportional to the amount of questions, observations, and networks that were asked, made, and created in advance, respectively (Dyer et al., 2011, Japanese translation, p. 168). In addition, experimental ability does not necessarily entail planning, and some things will be done by chance (Dyer et al., 2011, Japanese translation, p. 169). It has been noted that there are times when insights occur from the environment and constraints within which the experiment is conducted.

Need-Solution Pairs

Von Hippel and Von Krogh (2016) pointed out that in innovations, there are times when the needs and solutions are paired before the problem is defined. According to Von Hippel and Von Krogh (2016), as shown in Figure 4, the needs and solutions each have an area indicated in two dimensions (the X and Y axes), in which their respective so-called “landscapes”[3] of needs and solutions information[4] are distributed. Moreover, the heights of these areas are indicated by the Z axis.[5] Depending on the benefits from satisfying the height of the needs, the height of the solutions indicates the necessary cost. Problem solving is realized by “pairing” specific points in the two landscapes. Realizing pairing involves exploring the combinations of pairings, with the heights (Z axis) in each landscape as clues. The arrows in Figure 3 show the possible pairings found in the search.

In the model of Von Hippel and Von Krogh (2016), need-solution pairs can be thought of as a model that is determined based on the state of the needs landscape (the solutions information distribution area) at a certain point in time.

Figure 3 Need-solution pairs



Source: prepared by the author based on Von Hippel and Von Krogh (2016)

Ishii (1993) also pointed out the same thing. He presented the viewpoint that the aspect where needs and solutions (seeds) connect is a protocol aspect where undefined and ambiguous needs and solutions are paired while mutually confirming each other. He considered this protocol aspect “not to be a one-way process of saying that the problem is raised and a solution sought, but a two-way process where the problem searches for the solution at the same time as the solution searches for the problem” (Ishii, 1993, p. 17). He also pointed out that these “are processes in which the menu of various solutions and the menu of various needs accidentally associate and crystalize” (Ishii, 1993, p. 18).
In their model, Von Hippel and Von Krogh (2016) noted the existence of problem solving in a state where the problem definition is ambiguous and showed the structure for mutual pairing using the landscape concept. However, they only explained the dynamism in the pairing (dynamic viewpoint) indicating the existence of the landscape Z axis in association with the pairing. They did not comment on this pairing process or the landscape transformation process.

Dialogue with Need-Solution Pairs

When developing a product that meets the needs that customers are not aware that they have, the developers are also in a state in which the problems to be solved have not been defined. Thus, at the initial stage of development, even if the developers listen carefully to the voices of their customers, because there is “radical uncertainty” in relation to the evaluation of the outcome, it is difficult to break down, classify, and clearly define the problems to be solved (Lester and Piore, 2004, pp. 53–55). However, even in this sort of situation, developers must define the problems to be solved, and how problems are defined will have a major impact on the development’s outcome (Lester and Piore, 2004, p. 55). In this sort of situation, the developers use a trial-and-error process to discover problems from the clues that are created in an unprincipled, accidental, and ad-hoc way (Ishii, 1993, p. 34; Lester & Piore, 2004, p. 56).
In this situation, the “dialogue” process is important to find the solutions while defining the problems (Ishii, 1993; Lester & Piore, 2004; Ishii, 2009). At first glance, we might assume a dialogue to be between people. However, there is also

"a dialogue between people (the plan) and resources" (Ishii, 1993, p. 165) and "a dialogue between people and things" as a result of people interacting deeply with the target (Ishii, 2009, p. 228). Ishii (1993) said that the dialogue between your own vision (the plan) and resources is a dialogue between the content of what you want to achieve (the plan) (needs and landscape) and the resources that you happen to have (at that time) in order to realize it (Ishii, 1993, p. 163) (solutions and landscape). Thus, the "resources combination is read and recombined" (Ishii, 1993, p. 165), and, while overlapping with the prior vision (plan) and compromising (Ishii, 1993, p. 165), a search is made for the realizable areas. When the customers and developers are separate, the customers will express something in their daily behavior, and the developers will try to interpret this (Lester & Piore, 2004, p. 69). They express something through their words and deeds that connect to the needs created in their daily behavior, and this can be conveyed to the developers as the "others" through the interpreted dialogue. However, because they are "others," the developers' interpretation may not always be correct. As shown in the example of the development of the Naruse Pedal, the developers themselves interpret something obtained from their daily behavior as users, which is expressed through creation behavior, and we can visualize a development in which the dialogue taking place within a person and the dialogue between the separate customers and developers will be different in terms of speed and quality.

Two Behaviors in Trial and Error

Mr. Naruse developed the current version of the Naruse Pedal through repeated trial and error. One of the characteristics of this behavior is the act of immediately making a physical prototype based on an idea that a developer conceives of one day. This behavior is called "trial production." There was also the behavior of Mr. Naruse installing the prototype he produced in his own passenger car and actually using it. This behavior is called "trial usage." Both are trial-and-error behaviors. Trial production is a trial-and-error behavior of creating a prototype based on an idea and realizing it as a physical product (product realization[6]). Trial usage is the trial-and-error behavior of a user operating the product to be used in an everyday space while confirming the movements of the user's body. The information obtained through these two behaviors provides clues to the next prototype. The dialogue is realized through having a "specific target" and "daily behavior" (Lester & Piore, 2004, p. 69), and it can be considered that the specific target is the prototype (trial production) and the everyday behavior is the trial usage, in this case, of mounting the prototype on the vehicle.

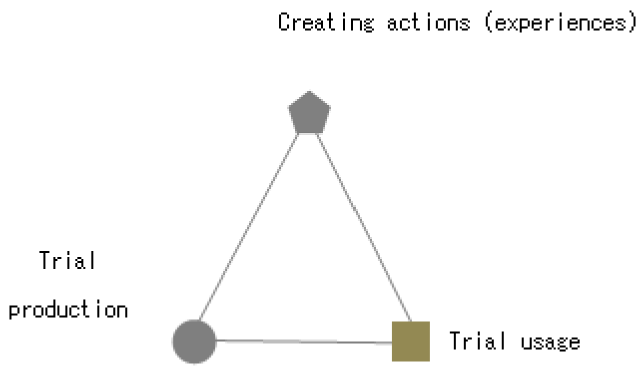
"The Dialogue Triangle"

Mr. Naruse's dialogue was not limited to this because he repeated the trial production and trial usage while creating a picture in his mind about what sort of pedal action for the accelerator and brake would eliminate the problem of stepping on the wrong pedal. Moreover, from the information obtained from the trial production and trial usage, this picture in his mind of the pedal action was changed and re-created. In this way, it can be said that there is a dialogue between the actions that users want to be realized or the creation of experiences, and the behavior of the trial production and trial usage.

Upon confirming Mr. Naruse's development behavior from the viewpoint of this sort of dialogue, we see that there were multiple dialogues. The first was the dialogue between the trial production and trial usage behaviors. The second was between the trial production and trial usage behaviors and the behavior to create the action that he wanted to realize. In this first dialogue, the question of how to reflect the respective behaviors was investigated through the dialogue. The second dialogue investigated the questions of what actions of users when operating the pedals will not cause them to "step on the wrong pedal," and at the same time, if such an action is realized, will it be possible to operate it easily compared to the operations of a conventional pedal. In this way, the simulation of "customer experiences in the future" (Clark & Fujimoto, 1991, Japanese translation, p. 46) was carried out through a dialogue between the trial production and trial usage. Clark & Fujimoto (1991) noted that when searching for the problem, it is necessary to create "customer experiences in the future." In this study, it was shown that the simulation is carried out through dialogue and that in some cases, this structure is realized through the dialogue between the trial production and trial usage.

In order to generate value in the narrow space between use and transmission (Ishii, 1993, p. 223), the realization of value is confirmed through the dialogue that leads to value creation and to raising the level of the value. In the Naruse Pedal case study, in the process of realizing innovation with new value, the following three behaviors were confirmed: ① a behavior to create user actions (experiences), ② "trial production" to create a physical prototype, and ③ "trial production" to realize actions (experiences). Moreover, a mutual dialogue exists between these three behaviors. Here, this mutual dialogue is called "the dialogue triangle" (Figure 3). Mr. Naruse developed the Naruse Pedal as the user and innovator from a dialogue involving one person.

Figure 4 "Dialogue triangle"



Source: prepared by the author

Landscape and "The Dialogue Triangle"

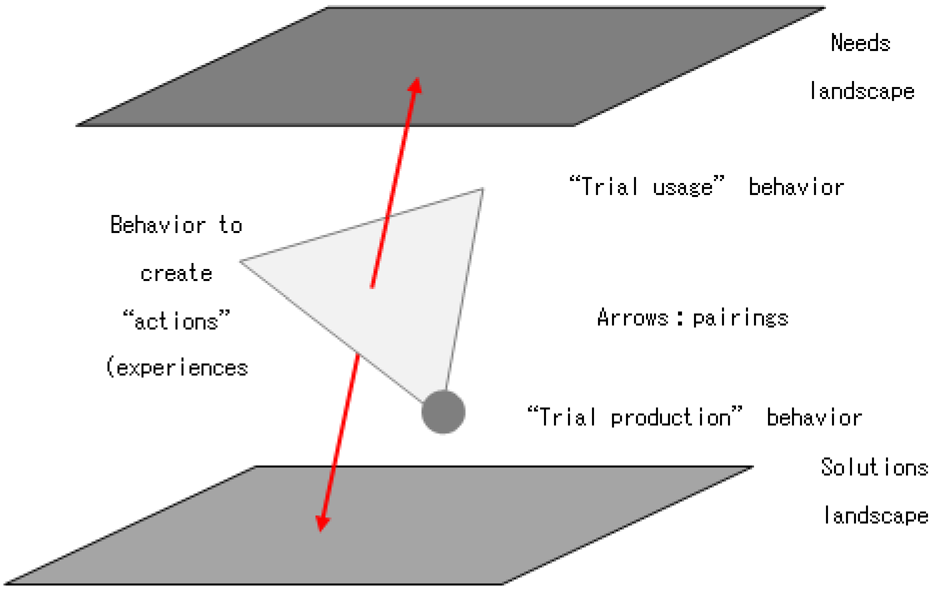
What kind of relationship is there between the landscapes of needs and solutions (Von Hippel and Von Krogh, 2016) and the dialogue triangle? We shall continue the consideration while focusing on the two behaviors of trial production and trial usage.

The solutions landscape is vital for trial production. However, in a situation in which the problem is unknown, which information to select from within the solutions landscape is also unknown.[7] Therefore, clues can be obtained from the information created through the behavior of one's own trial usage and the dialogue with the action to be realized, from searching the solutions landscape for related technologies and processing methods. At the same time, new information acquired through the trial production will accumulate in the solutions landscape.

In addition, the gap between the actions realized through using the prototype and the envisaged actions that accompany this, and the newly created actions, accumulate as needs in the needs landscape.

In other words, a two-way transfer of information is generated between the solutions landscape and the trial production behavior, and between the needs landscape and the trial usage behavior.

Figure 5 The dialogue triangle and landscapes



Source: prepared by the author based on Von Hippel and Von Krogh (2016)

7 Conclusion

We have confirmed that there was a process involving simultaneous problem discovery and solving in the development of the Naruse Pedal, which was a situation where the problems were unclear. This situation was considered using the clues provided by the need-solution pairs (Von Hippel & Von Krogh, 2016) and dialogue framework (Ishii, 1993, 2009; Lester & Piore, 2004). Then, the behaviors of searching for combinations of the two landscapes, as indicated by Von Hippel and Von Krogh (2016), and the pairings were explained using the dialogue framework. In the process of realizing the innovation called the Naruse Pedal, the existence of dialogues with the prototypes as the medium was confirmed. Moreover, it was shown that there were three types of behaviors in the simultaneous problem discovery and solving processes, along with two dialogues toward pairing between the landscapes.

The three types of behaviors were the creation behavior, use behavior, and creation of actions (experiences).

The two dialogues were as follows. First, there was a mutual dialogue between the trial production and trial usage behaviors. Second, there was a dialogue between the trial production behavior, trial usage behavior, and the creation of actions (experiences).

The first and second dialogues took place in an integrated way and were called "the dialogue triangle" in this paper. It is possible that the dialogue triangle exists as the driving force behind the pairings in the need-solution pairs. Moreover, it was clarified that the prototype existed as the medium for this in the dialogues. It is thought that in the future, these findings may lead to related studies on the effects of using prototypes, the organization of co-action members and user-community members based on diverse knowledge and experiences, and the targets of shared dialogue and innovation.

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Notes

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[2]Removing the existing accelerator and brake pedals set in commercially available vehicles and attaching the Naruse Pedal requires constant linkages with the existing control systems and interfaces, which differ according to the individual vehicle types and manufacturers.

[3]Landscape is a metaphor used to explain pairing. (Von Hippel and Von Krogh, 2016).

[4]The information constituting the respective landscapes includes tacit elements (Von Hippel and Von Krogh, 2016).

[5]The height is not shown in Figure 4.

[6]Behavior to realize as a physical product the image a person has in their mind (Takeda, 2000, p. VIII).

[7]Cost can be considered to be the standard, but in the case of a cost standard, the problems are clarified only when the costs of the candidates for selection for the solution information can be compared.