Chapter 4
BoI Value: The Third Value in Value Engineering (VE)

Manabu Sawaguchi

Abstract VE (Value Engineering) is a design method for improving value through a good balance between function and cost. Conventionally, VE has two types of value: "Use value" in practicality, and "Attractive value" focusing on appearance and beauty. On the other hand, in Modern society (that is, "Social growth period"), where individual respects self-actualization, users themselves are willing to create "Inconvenience" by spending physical effort or psychological cognitive resources. But they sometimes think that this inconvenient activity is not so big burden, may determine that there is a "benefit" from the aspect of mental satisfaction. Positively considering such individual subjective evaluation, the author decided to define such satisfaction as a completely new "Third value" called "Benefit of Inconvenience (BoI) Value." Therefore, this paper systematically organizes and introduces the characteristics of the "Third value" to be built here, using the Kano Model, which is well known in the field of product development.

Keywords Value Engineering · Third value · Value in Benefit of Inconvenience · Kano Model

4.1 Features of Value Engineering (VE)

VE is one of the management techniques born in the United States in 1947, and it stands for Value Engineering. Prior to VE, IE (Industrial Engineering) originated from Taylor's "Scientific Management" (1911) and QC (Quality Control) presented in "The theory of Control Chart" (1924) by Shewhart have been developed in the United States (Yoneyama, 1969). The characteristics of IE and QC are to analyze problems in detail by focusing on the current structure and format of existing products and services. They go through a process of looking into countermeasures

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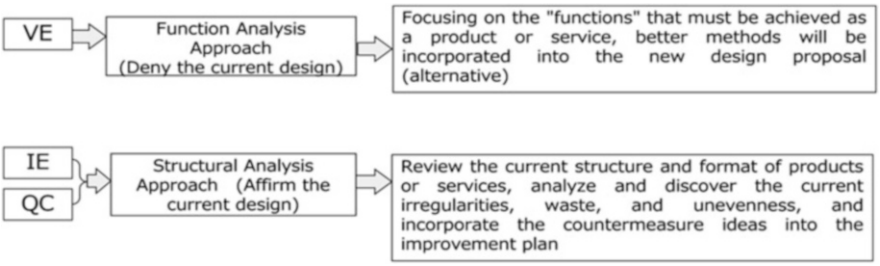

Fig. 4.1 Comparison of functional analysis and structural analysis approaches. Partial additions and corrections in reference (Sawaguchi, 2015)

and leading toward a proposal for a solution. Therefore, it is mainly useful in production management and quality control on the premise of mass production in the manufacturing industry. On the other hand, VE takes the approach of clarifying the "function" that a product or service should originally perform and creating a new design from that function. Therefore, VE is a particularly effective management technique for design-type problems, and the characteristics of these two approaches can be systematically summarized as shown in Fig. 4.1.

In other words, the greatest feature of VE is nothing other than "function-oriented thinking" and "expecting the creation of alternative ideas." In addition, the functions in VE refer to "the functions of products and services intended by design," and the intention is the work and benefit desired by the user.

4.2 The Role of VE up to the Present

IE/QC was introduced in earnest in post-war Japan, and greatly contributed to the realization of "powerful worksite = highly productive mass production processes" in Japanese manufacturing industry during the high economic growth period. On the other hand, many companies have introduced VE during their stable growth period after the oil shock (Tsuchiya, 1982). Specifically, VE has been recognized as an effective management technology for cost reduction, mainly in the export-based manufacturing industry (e.g., home appliances, automobiles, and precision machinery), which was struggling to reduce costs in an environment of strong yen and dollar depreciation, and VE aims to realize cost-effective design proposals based on the function-oriented thinking regardless of the existing structure. It was a timely method (means) for the corporate environment at that time.

4.2.1 Functions Covered by the Current VE

Since the 1980s, VE has not only been a means of cost reduction but also has been attempted to be applied at the upstream stages of product planning and development with the aim of realizing high added value. For this reason, although the target of VE is mainly "use function," there have been more and more cases where "Attractive function" related to design and aesthetics which make users want to own is addressed for products such as durable consumer goods aiming to improve added value. That is, the functions covered in the current VE are these two types.

When applying VE at the upstream stage, as not only products but also service areas and business models are addressed lately, use functions are subdivided into needs functions and want functions, and Attractive functions are subdivided into art design functions and letter functions, so that the functions necessary for users can be understood in detail (see Fig. 4.2) (Sawaguchi, 2020).

4.2.2 Relation Between the Quality in the Kano Model and the Function in VE

In the fields of QM (Quality Management) derived from QC and product development, "5 categories of quality attribute" (see Fig. 4.3) developed by Dr. Noriaki Kano (Professor Emeritus, Tokyo University of Science) in 1980 are widely known (Kamiesu, 2015; Japan Science and Technology Federation, 2021).

Particularly, "The Kano Model" (see Fig. 4.4) describes the changes in which each quality is achieved based on the priority of "must-be quality - > one-dimensional quality - > attractive quality (3 important quality elements)" on two

	Functions which customers desire (Sub-classification)	Example (Smartphone)
Use Function (Practical Function)	<Needs function> Function that makes a direct contribution, especially related to the core of the product, among other practical functions	"Enables voice communication" "Enables transmitting information through social media" "Take photos - Send and receive photos", etc.
	<Wants function> Function that contributes to further customer satisfaction with practical functions other than needs function	"Download your favorite APP" "Enjoy (selected) games", etc.
Attractive Function (Sensitive Function)	<Art design function> Attractive function in design aspect (color, shape, texture, etc.) that makes you want to own the product even more, including functions that appeal to the customer's vision, logo, etc.	"Thin and smart shape" "Bright and colorful case", etc.
	<Letter function> Attractive function in terms of naming and catchphrase that makes you want to own the product even more, and that mainly appeals to the customer's sense of words	iPhone 12 Pro, iPhone 12 Pro Max Galaxy S21 series 5G, etc.

Fig. 4.2 Classification and characteristics of functions targeted by VE. Partially modified (Sawaguchi, 2020)

Three important quality factors	**Must-be Quality** → Dissatisfied when being unsatisfactory; satisfied but taking it for granted	Call audio (It should be clear obviously, if difficult to hear customers will complaint)
	One dimensional Quality → Dissatisfied when being unsatisfactory; satisfied when fulfilled	Battery life (customers are satisfied if the operating time is long, but dissatisfied if it is short), weight, etc.
	Attractive Quality →There is no point in being unsatisfactory (I don't feel dissatisfied), but if it is satisfied, I will be happy	Hi-resolution sound sources (nice to have, but customers are OK without it), curved LCDs, etc.
Indifferent Quality →Whether satisfied or not has no impact on customer satisfaction level		No impact on people who are indifferent to voice input, such as Siri on smartphones
Reverse Quality → When satisfactory, customers become dissatisfied, and when unsatisfactory, customers are happy		Navigation with voice guidance at all times (drivers who want to listen to music carefully are dissatisfied with that function)

Fig. 4.3 Five categories of quality attribute advocated by Kano. Source: Reference Sawaguchi et al. (2020)

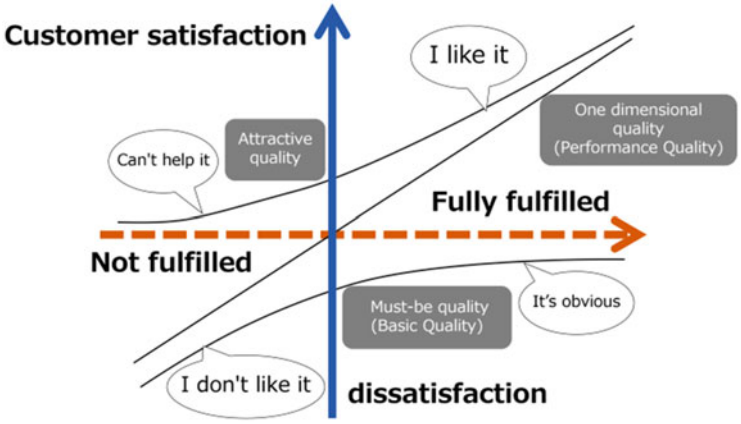

Fig. 4.4 The Kano Model, which shows customer satisfaction. Source: Reference Sawaguchi et al. (2020)

axes in response to high-end users is also internationally well known (Japan Science and Technology Federation, 2021).

According to the nature of the graph shown in this model, when the three quality elements that create value are added, the user's satisfaction keeps increasing steadily. That is, the three quality elements tend to increase monotony just like the two functions targeted in VE, thus they have an affinity for each other. Therefore, the author attempted to create a relative diagram based on the characteristics of the three quality elements and the two functions (see Fig. 4.5).

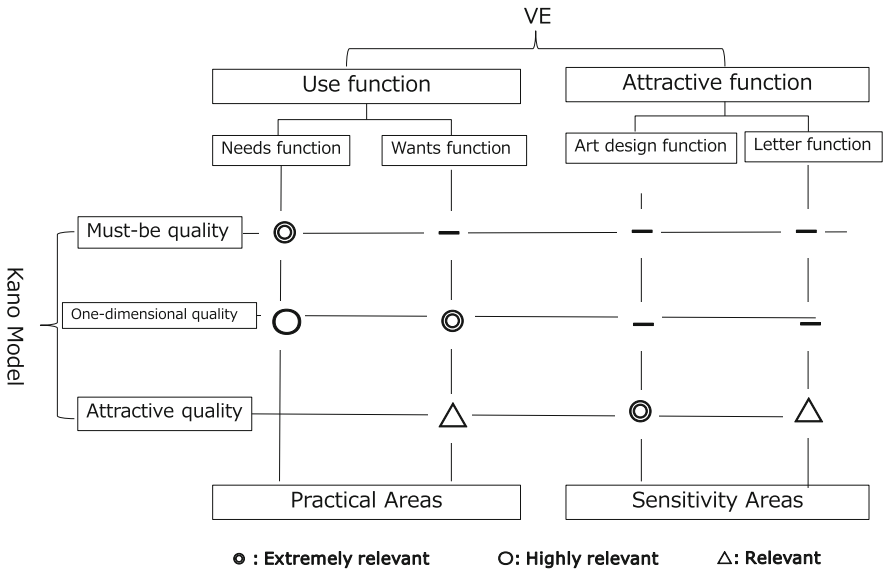

Fig. 4.5 Relationship between the three quality elements and the functions addressed in VE

Must-be quality and one-dimensional quality correspond to the use function in the practical domain. Moreover, it can be said that the must-be quality corresponds to the needs function, while the one-dimensional quality corresponds to the needs function when it is dysfunctional but then it corresponds to the want function after the function is fulfilled. On the other hand, the attractive quality is strongly related to the attractive function in the sensitivity domain, especially the art design function. It can be a want function (e.g., utility option for high-end users) or a letter function (e.g., original logo). Considering the importance of the design aspect seen in durable consumer goods, there is no sense of incongruity in general.

4.2.3 Value-Enhancing Patterns at which the Current VE Is Aiming

In the current VE, except for (1) value improvement by cost reduction (↑) V = F (→) / C (↓), all of them are value improvement by adding new functions and increasing the achievement level of existing functions, that is, three patterns that increase user satisfaction; (2) Realize cost reduction by increasing functions (↑) V = F(↑) / C(↓); (3) Maintain cost and improve functions (↑) V = F(↑) / C(→); (4) Cost is increased but functions are improved beyond that (↑) V = F(↑↑) / C(↑) are the main premise. This phenomenon (high-end pursuit model by adding new functions) is “the basic pattern of value improvement aimed at by VE from the

period of high economic growth - > the period of stable growth - > the bursting of the bubble economy to the present day." It can be summarized as follows if organized in relation to the Kano Model (See Fig. 4.4).

4.3 The Third Function that Will Be Addressed in VE

If only the two functions mentioned in the previous chapter (see Fig. 4.2) are predicted to value improvement (see Fig. 4.6), would it be consistent with the SDGs (Sustainable Development Goals) which are currently attracting worldwide attention? Among the individual objectives, Goal 8, "Economic Growth and Employment" promotes "inclusive and sustainable economic growth as well as full and productive employment and decent employment for all." (Murakami & Watanabe, 2019). Therefore, the author believes that developed countries such as Japan, in particular, need to aim for "a safe and secure society and a society in which individuals can achieve self-fulfillment (named as "social growth period")" rather than focusing solely on economic development in pursuit of convenience.

4.3.1 Quality and VE Expected in the Social Growth Period

Considering the characteristics of social growth period, it can be said that "the society is shifting from tangible material consumption to intangible experiential consumption." In such an era, there is a limit on solely using monotonically increasing manufacturing approach through three quality elements and two functions as previously described. The author found interesting about the concept of "the benefit of inconvenience" proposed by Kawakami et al. (Kawakami, 2011) and focused on its potential of being as the third function in VE. The benefit of inconvenience can simply be described as "an act of intentionally devoting physical

Patterns of Value Improvement (Value-up)	Correspond to cost reduction	Almost corresponds to the "improvement of 3 quality elements (must-be quality, one dimensional quality, and attractive quality)" of Kano Model		
	①	②	③	④
	$\uparrow V = \frac{F \rightarrow}{C \downarrow}$	$\uparrow V = \frac{F \uparrow}{C \downarrow}$	$\uparrow V \frac{F \uparrow}{C \rightarrow}$	$\uparrow V \frac{F \uparrow\uparrow}{C \uparrow}$

Fig. 4.6 Three quality elements and value improvement patterns of VE. Source: Reference Sawaguchi et al. (2020)

burdens and psychological cognitive resources (inconvenience) but obtaining the user satisfaction more than that (convenience).” In other words, an attempt to intentionally make inconvenience and create benefits for users. “BoI (Benefit of Inconvenience) Function = Third function” in VE logically makes sense. (The methodology will be described later.)

On the other hand, the limit of conventional VE is a kind of contradiction in which the intention of intentionally realizing “benefit of convenience aimed at improving user satisfaction (benefit) by not spending physical labor or psychological cognitive resources (convenience)” versus “harmful convenience that leads to a decrease in user satisfaction (harm)” occurs.

In fact, because Kano had foreseen such contradictions from the 1980s, he must have also presented “indifferent quality and inverse quality (see Fig. 4.3).” If these five quality elements are integrated and organized in a two-axis graph of the Kano Model formula, they can be roughly illustrated as shown in Fig. 4.7.

Customer satisfaction by integrating each quality element is close to an S-curve, and at the turning point, a limit of indicating customer satisfaction by the growth of physical fulfillment on the horizontal axis can be seen. Of course, even from the viewpoint of conventional VE, we have tried not only physical satisfaction centered on use function but also the increase in attractive function in the sensitivity area through consumer consumption products. However, this second function does not intentionally interfere (creates inconvenience) with the use function, so it is completely different in nature from the BoI function which claims to be the third function.

Based on what has been discussed so far, the characteristics of the turning point (see the right graph in Fig. 4.7) can be summarized as follows:

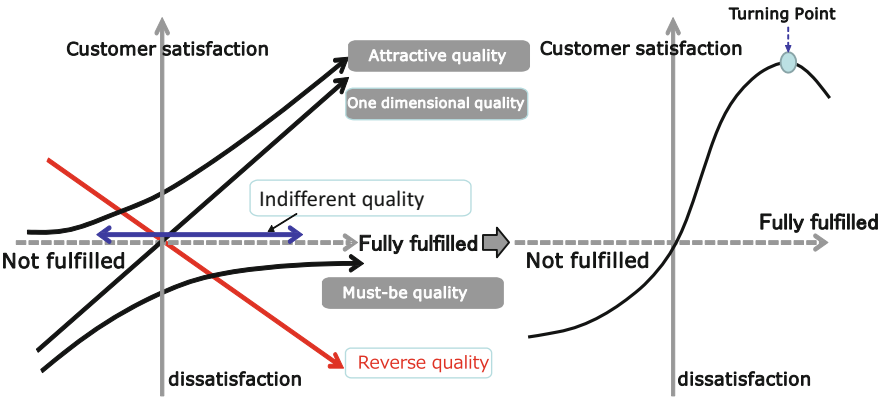

Fig. 4.7 Integrated customer satisfaction curve of Kano model and all quality elements. Source: Reference Japan Science and Technology Federation (2021) added and modified (left), originally created by the author (right)

<Expected characteristics at the turning point>

- Transition from a period of economic growth to a period of social growth.
- An era in which physical fulfillment no longer responds to customer satisfaction.
- Manifestation period of products (products and services) of indifferent quality or reverse quality.
- Period of shift from consumption of goods to consumption of experiences.

Under the circumstances in which such characteristics appear, it means that true customer satisfaction cannot be expressed only by one axis of "physical fulfillment." Therefore, if the value of material consumption is reflected and the "customer satisfaction axis" is replaced by the "spiritual richness axis," which indicates individual values, it can be roughly illustrated as shown in Fig. 4.8.

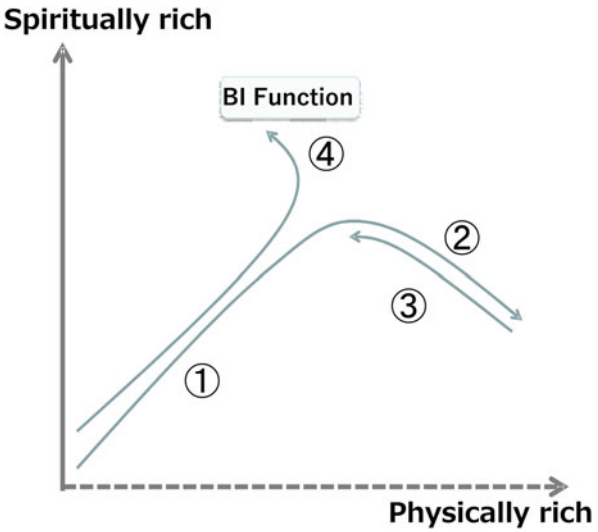

Fig. 4.8 Relationship between Kano Model and BI Function. Source: Reference (Sawaguchi et al., 2020).
① is a state in which physical abundance and spiritual affluence are satisfied, ② is a state in which convenience has caused an excess and the user can no longer be satisfied even though he/she becomes physically rich, and ③ is a means of restoring spiritual richness by going back in time (a kind of nostalgia). On the other hand, ④ shows a new direction that VE in the future should aim for, where spiritual richness is obtained by introducing BoI function (intentionally reduces physical richness). That is, ④ can be interpreted as the introduction of BoI function corresponding to the inverse quality suggested by Kano

4.3.2 *Future VE Covering BoI Function*

The main things mentioned so far are related and the three functions to be addressed in the future VE are organized in Fig. 4.9.

In fact, if the horizontal axis (X-axis) of the Kano Model (left and right graphs in Figs. 4.4 and 4.7) is the "inconvenience ↔ convenience" axis that indicates physical richness, and the vertical axis (Y-axis) is the "harm ↔ benefit" axis that indicates "true customer satisfaction" that also takes into account the mental richness of the user, it becomes possible to systematically organize the combinations of (inconvenience ↔ convenience) and (harm ↔ benefit) for each quadrant (see Fig. 4.10). That is, counter-clockwise, the first quadrant (benefit of convenience) is, corresponding to the second quadrant (benefit of inconvenience), the third quadrant (harmful inconvenience), and the fourth quadrant (harmful convenience).

As is clear from this figure, conventional VE has been to reach the benefit of convenience in the first quadrant from the harmful inconvenience in the third quadrant. As for future VE, "(1) activities to turn harmful convenience into the benefit of inconvenience" and "(2) activities to realize BoI functions from a zero base" can be assumed. Although the functional analysis approach in VE does not necessarily be used (see Fig. 4.1), "activities to turn the benefit of convenience into the benefit of inconvenience" and "activities to turn the harmful inconvenience into the benefit of inconvenience" are also naturally considerable.

Now, the characteristics of these four activities are summarized as follows:

Functions addressed in VE	Characteristics of each function		Natures of each function	Examples of definition of function (shaver)
Use function (the 1st function)	Tangible material consumption (In the case of products)	Practical function	Function which should be equipped with to use a product or service	Cut each hair of beard Prevent spread of shaved hair Absorb shaving impact etc.
Attractive function (the 2nd function)		Sensitive function	Function which makes the user own a product, such as design, appearance, service, slogan, etc.	Refreshing color Modern shape Tight-fitting texture etc.
BI Function (the 3rd function)	Functions of intangible experiential consumption (Mainly for individuals)		Function which creates awareness in spiritual fulfillment caused by inconvenient state of a product or service	(a part of it must be worked manually) Enables to improve shaving skills Gain a sense of safety and reliability etc.

Fig. 4.9 Characteristics of the three functions

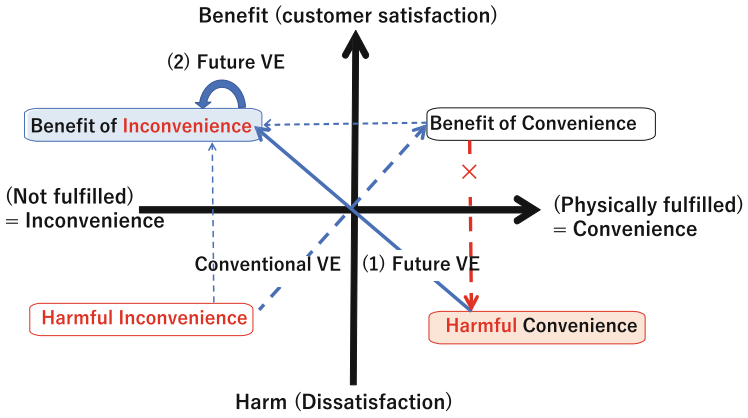

Fig. 4.10 Future VE which achieves BI functions

[Activities to Turn Harmful Convenience into the Benefit of Inconvenience (1) Future VE]
It is assumed that the user's sense of achievement has been greatly weakened for products that have fallen into a state of harmful convenience (EX. fully automatic EVs of the near future). At this stage, for example, by manualizing or deleting some of the useful functions which support fully automatic EV and realizing certain inconvenient functions, level of the "true customer satisfaction = benefit" of the target user could be enhanced. The author leaves to other books and papers (Kawakami, 2011; Matsuzawa, 2019)· for specific examples.

[Activities to Introduce BoI Functions at the Development Stage (2) Future VE]
It corresponds to VE at the planning and development stages, and because it is inconvenient from the beginning, it becomes a VE activity aimed at achieving the BoI function with the intention to obtain a certain benefit. Here, the use of the "Basic System Diagram of Inconvenient Function" (Matsuzawa, 2019) proposed by Matsuzawa et al. can be referred.

Figure 4.11 shows a functional diagram of "Foggy car navigation system" studied by "BoI & VE Study Group[Note)]." As shown here, the functional diagram is illustrated based on "the logic of purpose and means" organizing the functions from the right side (lower-order functions) toward the left side (higher-order functions).

<*Functional diagram of ordinary navigation system (functional analysis)*>

The upper side of Fig. 4.11 shows a functional diagram of a normal navigation system (composed of use functions). Details such as the procedure of making the diagram are omitted, but it has been clarified that the navigation system is a device for increasing movement efficiency.

<*Functional diagram of foggy navigation system (functional analysis)*>

The functional diagram of the foggy navigation system is illustrated on the underside of Fig. 4.11. Since the harmful convenience of "deteriorating the cognitive motivation of humans" has been confirmed, in order to solve this problem, a basic

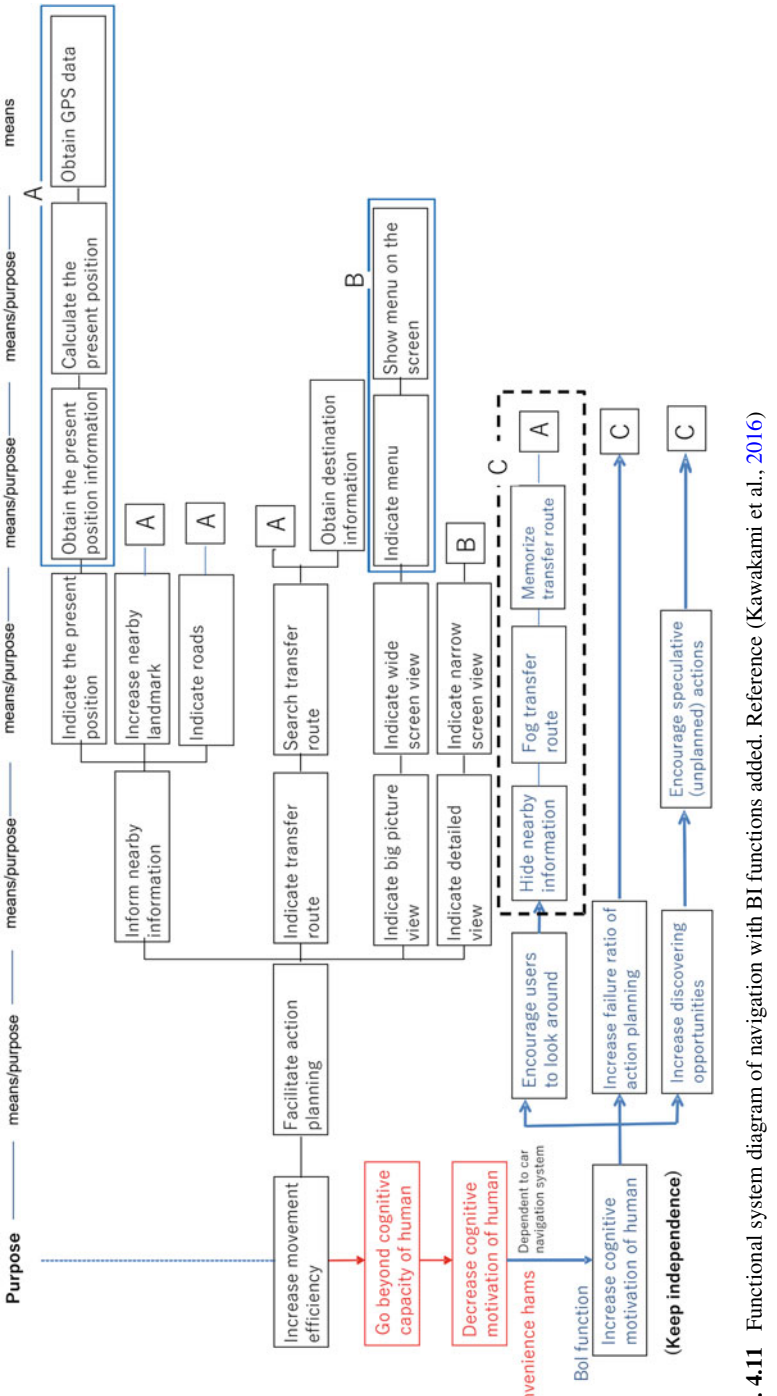

Fig. 4.11 Functional system diagram of navigation with BI functions added. Reference (Kawakami et al., 2016)

BoI function (highest-order level) of "enhancing independence" has been identified. It can be seen that this BoI function is then applied to the foggy navigation system by redefining it in terms of BoI function expression, it can "enhance the cognitive motivation of users (humans)." The lower-level BoI function group to achieve this BoI function is realized by "make ~ foggy," etc. (🄲 in Fig. 4.11).

[**Activities to Turn the Benefit of Convenience into the Benefit of Inconvenience**] The approach is to take up a convenient, multifunctional, high-performance product as a subject and use it as a trigger for thinking to "try to make it inconvenient." Here, we can think of a way to use the "Benefit of Inconvenience/Benefit of Convenience Card" (12 inconveniences which are likely to be obtained from convenience)" (Kawakami et al., 2016; Naito et al., 2013) as a viewpoint for idea generation.

[**Activities to Turn the Harmful Inconvenience into the Benefit of Inconvenience**] It is an approach to find benefits by using products with harmful inconveniences (mainly old products of the past) as a starting point for the idea and making the most of the inconvenience as it is. Here, there is a method of using the "Inconvenience/Benefit Card" (8 benefits which are likely to be obtained from inconvenience)" (Naito et al., 2013) as hints for the idea generation. As the case of VE, it is also feasible to define the "8 items of the Inconvenience/Benefit Card" as "BoI Function (Basic Type) (Sawaguchi et al., 2020) and utilize "12 items of the Inconvenience/Benefit Card" as hints for idea generation to achieve these inconvenient functions.

4.4 Conclusion

Throughout the previous chapter and as a result of examining the concept of inconvenience from various angles, by incorporating the functional analysis viewpoint in VE and the five quality elements advocated by Kano, it has been found once again that the BoI Function can be the third function of VE. Also, since the value concept addressed in VE is based on the user's perspective (user-centered principle), if you add an inconvenience function and understand that "user's benefit increase = value improvement," there are also BoI values, and it can be included in the basic pattern of value. In the future, we plan to empirically verify the new VE theory summarized in this paper with actual products (preferably consumption of experiences).

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Note: “BoI & VE Study Group” (Value Design Lab) The author (Sawaguchi), who also serves as the director of the Value Design Laboratory of Society of Japanese Value Engineering, became the project general manager, and with the participation of Professor Koji Kawakami (currently Professor of Kyoto University of Advanced Sciences), a leading expert in the research of the Benefit of Inconvenience, the study group conducted research activities from October 2015 to 2020. Other study group members are: Dr. Nishiyama (Nagoya Univ.), Dr. Emanuel (Nagoya Univ.), Mr. Matsuzawa (IHI), Ms. Miyata (IHI), Secretariat: Ms. Ono (SJVE)