Doctor Dissertation

Study on Innovative Design Method and Development of a Discovering Method of Essential Latent Needs

(創造設計手法に関する研究と本質的な潜在ニーズの発見手法の構築)

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Summary

Innovation is the practical implementation of ideas that result in the introduction of new goods or services or the improvement in them (Schumpter, 1983). Innovation is closely related to invention as innovation is more on involving the practical implementation of a new or improved invention to make a meaningful impact in a market or society (Schumpter, 1939). On the other hand, innovative design is a process of identifying, pinpointing, and understanding the needs of the user or audience (Shaulis, 2021). Previously, Dixon (1966) defined innovative design as any design that is: new or different, or elegant or uses new ideas, or is an improvement over its peers. Once the market need has been identified, a solution can then be designed. In our proposed innovative design method, we introduced and investigated a method that is able to be applied in designing an intergrated system that could be a valuable solution to the society. This method starts with directly observe activities of things and real people in real trouble in the real field. Then, we think about the value of "I wish there were such things as…", visualize the story, draw a clear sketch to accomplish the story concretely. Next, we solidify the functions and specifications while investigating needs and competition. Then, we create a prototype that able to show and test your ideas, demonstrate to the people who need it, let them experience it, and gain feedback. Lastly, we evaluate the value of product design and development and plan methods for implementing it as an organization, and plan ways to improve and expand globally. All of the steps in this method are important for innovative design, however, in this research this time we focused on co-designing value, big idea, and considering as integrated steps for identifying latent needs of the consumers. It is because identifying needs is an important part in the product development process.

Latent needs are those that many consumers recognize as important in a final product but unable to articulate in advance (Ulrich, 2015). The latent needs addressed in this study was focusing on identifying consumer requirements in product development in the innovative design method. The challenge in identifying latent needs is finding the method to elicit from consumers the needs which are not addressed by any inventors yet in the present market but would delight the consumers if delivered tomorrow. The purpose of this study is to propose and verify the method in the elicitation of latent needs from consumer needs by introducing a working prototype to the consumers, interviewing, and analyzing responses from the consumers.

This research was conducted during the year the start of the COVID-19 pandemic. As the pandemic spread, most countries were forced to go into lockdown or declare an emergency state. The school was closed and business organizations needed to switch to working from home to prevent the spread. The parents were unable to work from home efficiently as they were worried their children will involve in dangerous incidents if the children were left by themselves. Based on this situation, this study was conducted in finding the latent needs of the parents, childcare workers, and children in order to assist them in going through their problems during this COVID-19 pandemic.

The working prototype was used as material to prepare presentation slides for the consumers' interviews. The first presentation slides were focused on the background problems and ideas for the solutions while the second presentation slides provided consumers with a prototype and story of the product that was believed would be one of the solutions to the problems. Interviews were conducted after both slide presentations.

Consumers' responses were obtained and interpreted into consumers' needs in terms of product functions.

In the first study, consumers' interpreted needs from Problem-based interviews and Prototype and Story-based interviews were compared. Based on the results, latent needs interpreted from interviewees' responses and the categories of the needs obtained from the Prototype-based interviews are more than from the Problem-based interview. The latent needs that we were able to obtain from this research were for example, “The device is able to detect small changes in a child while watching he/she sleeping” which could lead into the prevention of unwanted incident such as sudden infant death syndrome (SIDS). This supports our assumption that showing working prototype-based materials with story descriptions can be effective in uncovering potential latent needs.

In the second study, it is assumed that experience, empathy, and knowledge of working prototype is essential elements in product development, therefore, new additional guidelines which are “to write a statement with empathy”, “to write a statement as a designer”, and “to write a statement as someone with experience” were proposed during consumers' needs interpretation to see whether these new guidelines will influence the process of identifying latent needs of consumers. From the result, it is concluded that the number of interpreted needs increased when we applied the new proposed guideline. Although the number is small, the needs might not be interpreted if the new guidelines were not considered. We were also able to obtain a few important latent needs when we applied these new guidelines. A latent need collected from applying the guideline "to write a statement as someone with experience" is “The device is not for teaching love and humanity but for monitoring by watching facial expression, posture, and vital signals such as temperature and heart rate”. We could conclude that including these guidelines upon interpreting raw data from the consumers’ interviews might lead into discovering important and critical latent needs of the consumers.

In the third study, a quantitative evaluation method for identifying latent needs was introduced. The consumers' interpreted needs were rated according to a basis of rating from the three perspectives of importance, latent-ness, and technological feasibility. The Degree of Latent Needs (DLN) was calculated by multiplying these three metrics. Based on the result for the average and variance of DLN mean value for each evaluator which is sufficiently small, it indicates that the basis of rating for three metrics of the DLN is effective. The results also indicate that the 20 highest DLN points of the interpreted needs contain attractive features in terms of design. However, we had gotten some pushback on the average of each interpreted need and its variance which indicates opposing opinions among evaluators. As it is possible that attractive needs are hidden and may lead to the discovery of latent needs through individual pinpoint interviews, the interviews with the minority evaluators were conducted. The interview results indicate that the latent needs with low DLN rates but valuable might be able to be discovered by conducting follow-up interviews such as “The device is able to recognize items (food or not) that a child wants to put in the mouth”. From the results in all three studies, we could conclude that a number of important latent needs are able to be elicited from consumers’ needs by applying the proposed method.

In our fourth study, a decision-making method based on the patent analysis between the conceptual design stage and the prototyping stage in the innovative design method was introduced. Conducting a patent strategy was assumed to support how to select the right concept precisely. In this study, by conducting a patent search in this stage by the designer who understood best the product functions and working principles, a supporting method was introduced to assist the designer in their decision-making process. Based on the result, the method was able to observe whether there are dominating companies or not for our concept

design. If there is a dominating company, the possibility of not being able to produce our concept becomes bigger. This method may be applied as an indicator to support decision-making in the concept design stage in the innovative design method, whether to proceed with the concept design or not and to reduce the possibility of product failure in the future.

From the results of all the studies, we could conclude that these above methods may be applied as assistive tools to support designers' understanding of consumers' requirements and selecting the right concept design.

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Chapter 1 - Introduction

1.1 Innovative Design.

Innovation is the practical implementation of ideas that result in introducing new goods or services or improving in them (Schumpter, 1983). Innovation is not the same as invention (Bhasin, 2012). Still, it is closely related to it as innovation is more on involving the practical implementation of a new or improved invention to make a meaningful impact in a market or society (Schumpter, 1939). According to Utterback (1971), early innovation model only consisted of three phases: idea generation, problem solving and implementation. The innovation process has been evolving ever since (Kotsemir and Meissner, 2013 & 2016), from technology-push and market-push innovation to open-innovation and digital innovation (Hinnings, 2018).

The globalization of the market and the technological improvement of emerging countries had threatened the technology-oriented strategies of the manufacturing industry in industrialized countries over the past few years. The information technology industry represented and manipulated by several gigantic companies is a typical example of success through innovation. In Japan in the 1990s, many Japanese companies dominated the world in terms of market capitalization, but today only one company is in the top 40 in the market capitalization list of companies in 2020. According to the Ministry of Economy, Trade and Industry's "Industrial Technology Vision 2020", the situation surrounding innovation is not favourable for Japan compared to the United States and China, which are striving for innovation-centred technology. Therefore, ideas for innovation to create products and services that realize market superiority and novelty are needed. In response to these problems, many measures have been taken, such as securing human resources, renewing R&D strategies, and strategically concentrating resources, including R&D investment. Another action that was taken to solve the problems was to refresh and investigate the balance between technology-oriented and market-demand strategies and to develop new ideas in innovation development.

Design science is a methodology that result from the ongoing research on methods to support innovation from the perspective of science. It was also defined as “a discipline that aims to elucidate the rules of design act and systematize the knowledge used in design act” in the “Encyclopedia of Design Science” by the Japan Society of the Science of Design (2020). It is also a compilation of valuable methods to support innovation development in Japan. For example, the forecasting and backcasting processes are the important processes that support innovation. Forecasting predicts the future based on current trend analysis. It is usually applied in a linear innovation model, which generally starts with basic research, applied research, development, and the final product. (Methe, 1995). Backcasting approaches from the opposite direction and begins from deciding needs and concepts. It is usually applied in the system integration model wherein this model, to reach the target of needs and ideas; an inventor can consider implementing new or existing technologies owned by them or other companies, which could lead to open innovation (Best, 2003). Forecasting and backcasting processes are also essential in generating a technology roadmap. A technology roadmap is a planning technic to support strategic and long-term planning by matching short-term and long-term goals with specific technology solutions (Garcia et al.,

1997) and one of the technics that manage to support innovation (Phaal et al., 2001). Before finalizing concepts and outlining long-term planning, inventors need to finalize what needs or problems to be solved.

In this evaluation process, a lot of methods are available, for example, questionnaires and focus group interviews. A questionnaire is a valuable data collection tool and can yield high-quality quantitative data while achieving good and honest responses as it provides anonymity (Marshall, 2004). It is conducted thru interviews, telephone surveys, mail surveys, placement methods, the internet, etc., to discover problems, investigate current conditions, and confirm cause-and-effect relationships (Ray, 2003). The general procedure for a survey is to clarify the objectives (Oppenheim, 1992), develop the questionnaire, determine the target population, conduct the preliminary survey, conduct the primary survey, and analyze and report the results.

Interviewing lead or extreme users can help identify needs more effectively. Lead users are customers who experience requirements months or years before the majority of the market and stand to gain significantly from product advances, according to von Hippel (1986 & 1988). These clients are precious resources. They struggled with the shortcomings of current products, and they may have already built solutions to address their demands. Thus they are frequently able to define their growing wants. The team may be able to pinpoint needs that, while explicit for lead users, are nonetheless latent for most of the market by concentrating some of the data collection efforts on lead users (Judge, 2015).

On the other hand, according to Krueger et al. (2001), in the last 40 years, not only for marketing, focus group interviews have been used by government agencies, non-governmental agencies, and academics to help in making decisions for new products and services and evaluating programs or existing products and services. However, researchers need to choose suitable participants, create a comfortable environment to talk and must respect and believe that they will learn valuable information from participants. There were also critical steps addressed again by Krueger (2006), such as developing good questions, conducting the interviews in participants' native language, summarizing and asking for verification at the end of an interview, and to continue observing and learning from how participants respond. According to McLafferty (2004), experiences of conducting focus group interviews demonstrated that smaller groups were more manageable and that groups made up of strangers required more moderator intervention. When implementing the design theme, several points require attention. According to (Sasa, 2020) in the "Encyclopedia of Design Science, in some cases, in fa ocus group interview, a new design may be evaluated alongside an existing design proposal, in which case an analysis that considers time frames and other factors is necessary. A design perceived as uncomfortable may become a design that will be supported in the future. The interview also may end with just liking or disliking the design, but the designer is able to probe deeper into the reasons for liking or disliking the design plan. In addition, it is necessary to understand not only the overall evaluation of the design but also whether the design has been created or understood according to the designer's intention. For example, if the designer intends to create a kid-friendly design, it is essential to evaluate whether the interviewee received the message. Although research by Griffin and Hauser (1993) revealed that the number of customer needs from the one-to-one interviews and focus group interviews indicated no differences, some practitioners believe that for certain products

and customers group, the interactions among the participants of focus groups can elicit more varied needs than one-on-one interviews. However, this belief does not support by research findings yet.

Rabiee (2004) argued that the analysis of qualitative data from focus group interviews requires the development of new skills, imagination, patience, time and practice. Data analysis is a crucial step in the research process. Analysis of focus group interviews is often tricky, and little guidance is provided in the literature. Effective analysis requires the researcher to generate rich data, familiarise oneself with the data, write memos on statements, index statements, create themes and interpret the data (Doody, 2013). There are many option for analyzing qualitative data from focus group interviews. For example, the affinity diagram by Kawakita (1960) and is sometimes referred to as the KJ Method. This method is often utilized as a business tool to organize ideas and data from the brainstorming process. The affinity diagram is able to organize ideas from interview responses within 3 steps: record each idea on cards or notes, look for ideas that seem to be related, and sort cards into groups until all cards have been used. Once the cards have been sorted into groups, label each group and eliminate duplicate ideas. Arrows can be added between items, and groups to show significant relationships and the team may sort large clusters into subgroups for the next analysis. Another example is the Grounded Theory Method, a systematic methodology that has been largely applied to qualitative research conducted by social scientists. The method involves the construction of hypotheses and theories through the collection and analysis of data (Glaser & Strauss, 1967 &1978). A study based on grounded theory is likely, to begin with a question or even just with the collection of qualitative data. As researchers review the data collected, ideas or concepts become apparent to them researchers. These ideas/concepts are said to "emerge" from the data. The researchers tag those ideas/concepts with codes that briefly summarize the ideas/concepts. As more data are collected and re-reviewed, codes can be grouped into higher-level concepts and then into categories. These categories become the basis of a hypothesis or a new theory. In Japan, the nursing field pioneered the use of this technology in the 1980s, and in recent years, it has been used in many practice-oriented fields, including nursing, health, medicine, social welfare, social work, nursing care, rehabilitation, school education, clinical psychology, and marketing. It effectively explains and predicts human behavior by targeting social interactions (actions). After more than 50 years, this method has now branched out into several types and are in competition with each other over the purpose of theory generation and the method of analysis, data coding (Kinoshita, 2014). Another method available to analyse interviewee responses from focus group interview is by utilizing the need statement writing guideline from Ulrich (2015), which were to focus on ‘What’ not ‘How’, to be specific, to create a positive not negative statement, to give attribute to the product and to avoid ‘Must’ or ‘Should’ in the statement. The needs then are organized into a hierarchy of primary, secondary, and, if necessary tertiary needs, and then the relative importance of the requirements are established. By conducting both or either one of the questionnaires and the focus group interviews, there are possibilities for the inventors to discover the problems and requirements of the consumers, which might lead to discovering crucial and important needs from the consumers by correctly interpreting the questionnaire survey answers and the interview responses.

1.2 Innovative Design Method.

Innovative design is a process of identifying, pinpointing, and understanding the needs of the user or audience. Once the need has been identified, a solution can then be designed (Shaulis, 2021). Previously, Dixon (1966) defined innovative design as any design that is: new or different, or elegant or uses new ideas, or is an improvement over its peers. Once the market need has been identified, a solution can then be designed. There has been a lot of research on an innovative design by prominent researchers. For example, the book by Pahl et al. (2007) teaches the methods of engineering design as a condition of successful product development. It breaks down the design process into phases, such as a functional diagram, and then into distinct steps. It also consists with the scientific bases of its design ideas with new solution fields in composite components, building methods, mechatronics and adaptronics. On the other hand, Suh (1990), in his book, created the axiomatic design, a systems design methodology that uses matrix methods to systematically analyze the transformation of customer needs into functional requirements, design parameters, and process variables. The design could be represented in four domains which are customer, functional, physical and process domains. Another problem-solving and designing method is design thinking by Leifer (2011) which consists of five phases of empathize, define, ideate, prototype, and test is an iterative process in which you seek to understand your users, challenge assumptions, redefine problems and create innovative solutions which you can prototype and test. The overall goal is to identify alternative strategies and solutions that are not instantly apparent with your initial level of understanding.

Fig 1-1 The processes in innovative design method

In Ulrich et al. (2015) product development process, the process consists of the planning, concept development, system-level designing, detail designing, testing and refinement and

production stage. According to them, the process is useful to be applied in any type of product but they explicitly focused on engineered, discreet, physical and isolated product. In our proposed innovative design method, we introduced and investigated a method that we hope is able to be applied in designing an integrated system that could be a valuable solution to the society. As shown in Fig 1-1, it starts with setting our mind and directly observe activities of things and real people in real trouble in the real field. Then, we think about the value of "I wish there were such things as…", visualize the story, draw a clear sketch to accomplish the story concretely. Next, we are able to solidify the functions and specifications while investigating needs and competition, as a product to be released to the market. Then, we create a prototype that able to show and test your ideas, demonstrate to the people who need it, let them experience it, and gain feedback. Lastly, we evaluate the value of product design and development and plan methods for implementing it as an organization, and plan ways to improve and expand globally.

This proposed method had been used in a collaboration program between Yamaguchi University and Malaysia-Japan International Institute of Technology (MJIIT), University Teknologi Malaysia for 10 years since 2012. It is called Cross Border Project Based Learning "Global Engineer Training Program" and more than 200 students from both universities had joined it since then.

All of the steps in this method are important for innovative design, however, in this research this time we focused on co-designing value, big idea, and considering as integrated steps in chapters 3, 4, and 5 for identifying latent needs of the consumers. It is because identifying needs is an important part in the product development process. Intellectual design and physical design steps were considered in the next section in chapter 1 and in chapter 3 for prototyping. Chapter 6 discussed a careful survey of competitors' step and the timely business decision making step.

1.2.1 Co-designing Social Value.

In the co-designing social value step, first is to find what is the value that is important to us as human, society or country. For example, if we chose society then what is the problem that if we solved will be beneficial to the society? In this step, by repeating the process of creating, providing, giving feedback n data analysis in co-designing loop, we are able to co-desgning social value with consumers. It is called Product Service System. Fig 1-2 shows a Product Service System (PSS) diagram of a Childcare and Housework support robot in the Covid-19 pandemic (i-Nanny) that we designed in our research. This Childcare and Housework support robot PSS diagram is consisted of products such as robot body, CCTV with motion and heat sensor, sanitizer, and mobile terminal. The services are such as teach and play and connecting with police and authorities and getting rescued by them.

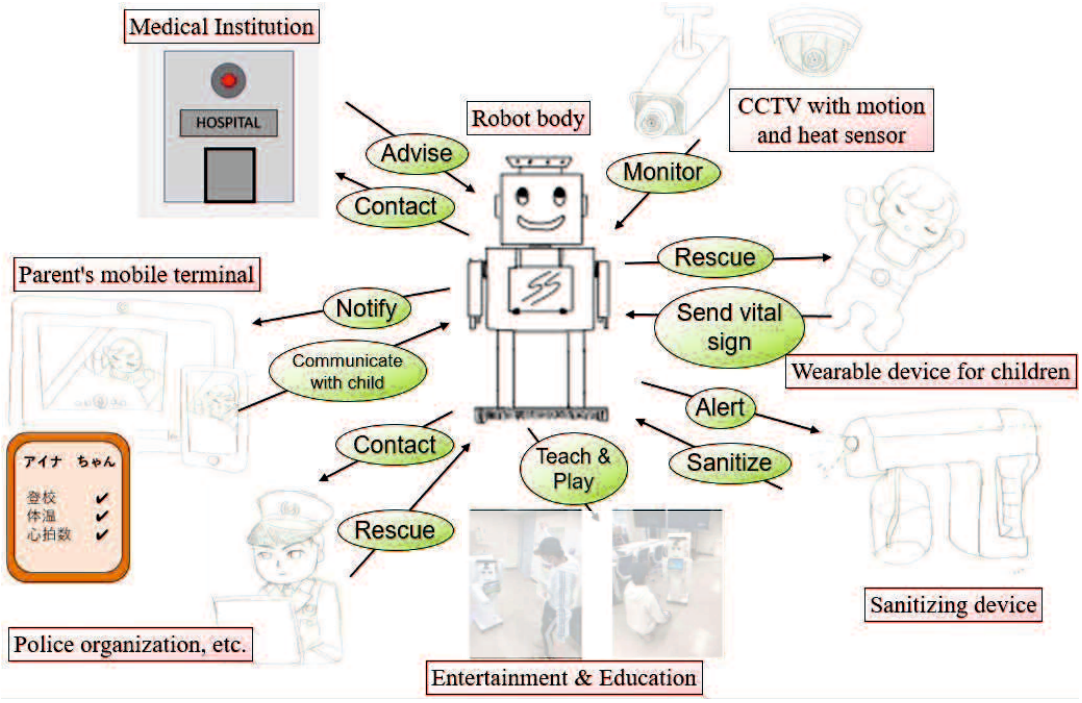

Fig. 1-2 Product Service System (PSS) diagram of a Childcare and Housework support robot in the Covid-19 pandemic (i-Nanny)

1.2.2 Discovering Ideas from Consumers

There are a lot of ways to discovering new ideas in designing. In order to solve the problem that we found in the society, we need to understand consumers needs and discovered solution ideas from them in the real field. The consumers' needs can be measured by categories of lead user, main user followers etc. Needs can be identified more efficiently by interviewing lead user or extreme users. according to von Hippel (1988), lead users are customers who experience needs months or years ahead of the majority of the market and stand to benefit substantially from product innovations. These customers are particullarly useful sources. It is because they are often able to articulate their emerging needs because they had to struggle with the inadequacies of existing products and they may have already invented solutuons to meet their needs. Then the consumers' needs can be extracted from the responses. Understanding latent needs from consumers also is an important aspect. Latent needs are unclear perceptions and distinct to the sight and many customers recognize as important in a final product but do not or cannot articulate in advance (Ulrich, 2015). There are more important than explicit needs in determining customer satisfaction. By focusing a portion of the data collection efforts on lead users, the team may be able to identify needs that although explicit for lead users, are still latent for the majority of the market.

1.2.3 Considering as an Integrated System

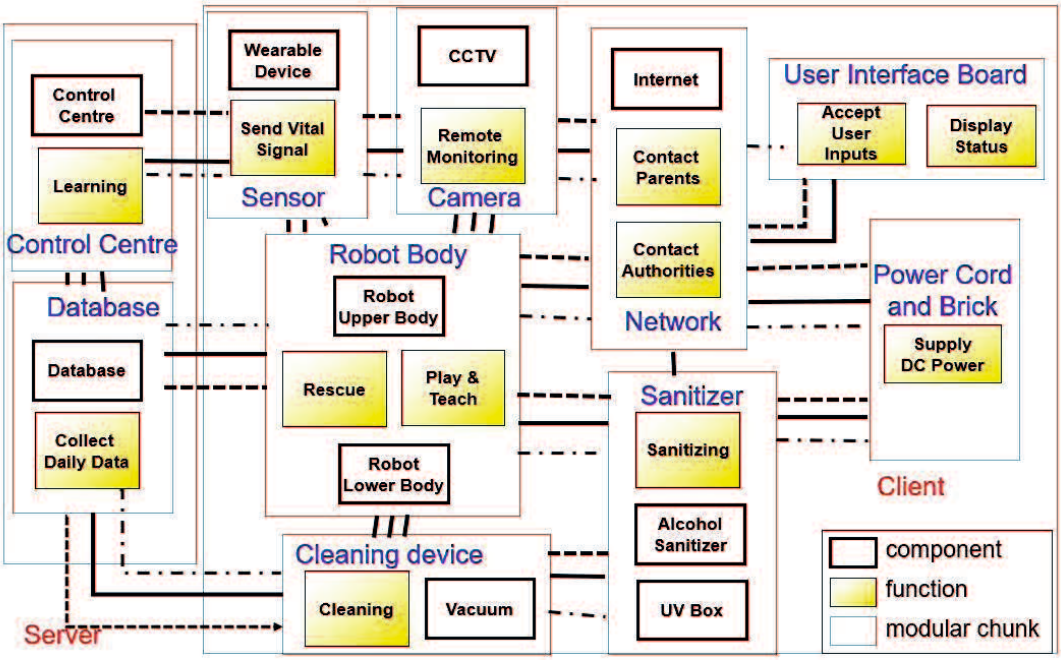

Fig 1-3 Integrated System of childcare and housework support robot in the Covid-19 pandemic (i-Nanny)

Fig 1-3 shows our overall functional diagram of our childcare and housework support robot in Covid-19 pandemic (i-Nanny) as we considered it as an integrated system. It is not only a robot body and other devices on the client side but also consisted of a control centre and database on the server side. The system work for example, if one i-nanny in one house facing an incident for the first time such as a child swallowed a button cell, the central server that connected with it will advised the action to save the child based on the machine learning that were done based on other cases in other houses.

1.2.4 Wonderful Story

How your product or service will work on the user is in the wonderful story step. A wonderful story is very compelling and will explain the concept behind it. A story in a storyboard is a series of images that communicates a temporal sequence of actions involving the product concept. It is often used for scenario visualization, idea embodiment, and interphase design validation. Storyboarding is an externalization of design thinking and an essential step in the realization of any design activity. Story illustration is a process that can be done by anyone, no matter how good or bad you are at drawing. It is important to externalize and share thoughts using the minimum level of visual literacy that everyone has (Price, 2015). Other than storyboarding, prominent researchers in this innovative design field are also have been using similar methods to describe design concept such as use case

diagram (Jacobson, 1992), customer journey map (Moon, 2016), problem frame, system context diagram (Jackson, 2001), and data flow diagram (Li, 2009).

Fig 1-4 indicate a story on a product concept of preventing a child from entering a dangerous area. In this story, we explain that the child is trying to get into dangerous areas such as stairs or balconies. The device detects and notifies parents or authorities by sending videos and audio. Parents then warn and alert the child by using their own mobile devices. The robot also is able to stop the child from entering the area and bad incidents can be prevented.

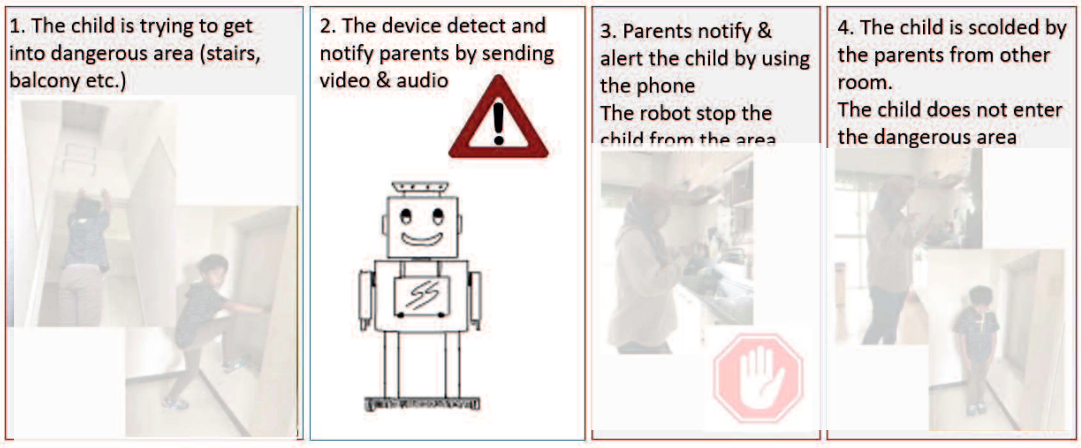

Fig 1-4 The story for a product concept of preventing a child from entering dangerous area

1.2.5 Careful Survey of Competitors

A careful survey of competitors is an essential process before concept selecting. Patent strategy is usually established before product development for understanding market trends, grasping technological evolution, protecting own product intellectual property, and identifying competing firms by competitor analysis. As it is difficult to select of concept design, conducting patent strategy was assumed to support on how to select the right concept precisely.

1.2.6 Well-thought Intellectual Design

In this step, we illustrate stories from the problem and create a functional and sub-functional diagram. The concept was then designed and selected. This provide us with maximum flexibility and systematic approach to find one suitable product concept.

1.2.7 Learning from Physical Design

There are a lot of prototyping types such as physical and analytical prototyping. There are also comprehensive and focused prototype which served different purposed. Prototyping often used to conduct feasibility studies, and integration and system tests. Prototyping also is able to assist in avoiding costly iterations. On the other hand, by introducing prototyping to consumers we might acquire consumers' reaction and could able to find new potential lead consumers. Fig 1-5 show a few of our prototype during the application of our proposed innovative design method.

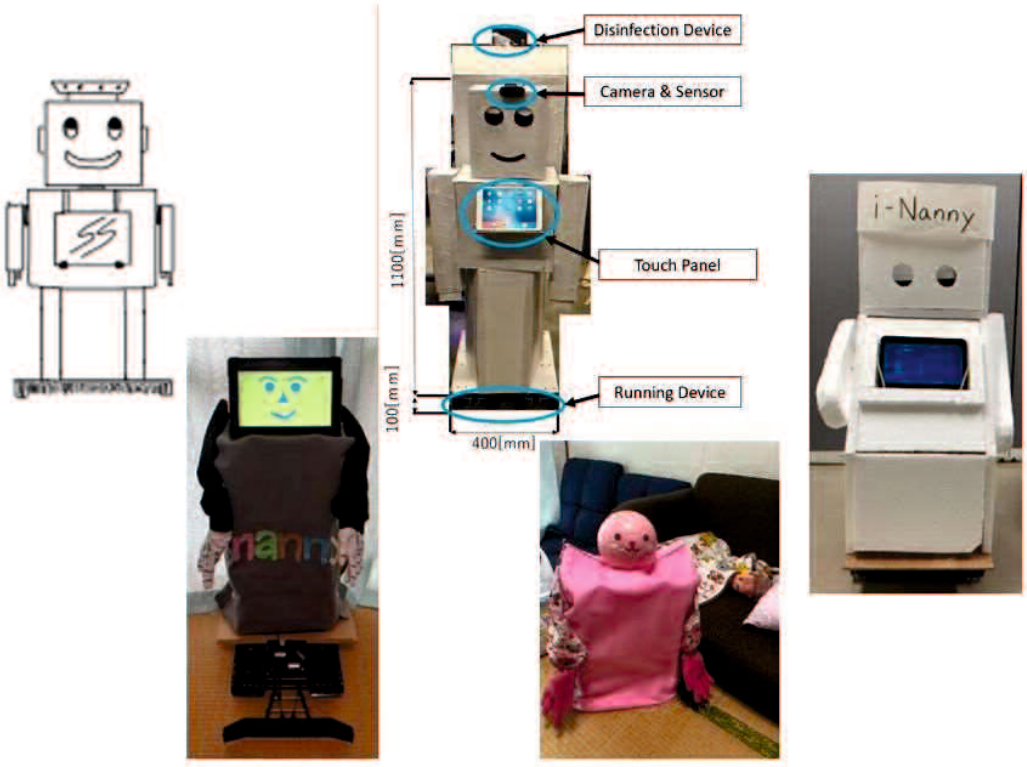

Fig 1-5 Example of Prototype in our Study

1.2.8 Timely Business Decision

There are a lot of challenges in making the right timely business decision. Continuously changing environment is one of the biggest challenge. It is because technologies improve rapidly, customer preference evolving, competitors keep introducing new products and the macroeconomic environment is continuously shifting. Other challenges are for example small changes in concept design might lead to big effect such as cost, and developing, producing, and marketing a new product requires a large investment as to earn a reasonable return on this investment, the resulting product must be both appealing to customers and relatively inexpensive to produce. Another one of the most difficult aspects of product development is recognizing, understanding, and managing such trade-offs in a way that maximize the

success of the product. Any one of these difficulties would be easily manageable by itself given plenty of time, but product development decisions must usually be made quickly and without complete information.

1.3 Design Application of the Method

In this section, we will explain on how we applied the innovative design method for our concept design. As the main theme for this research is childcare, for this sample application, we took “Prevention of left and unattended child” as a concept. In Fig 1-6, the cases of left and unattended child in kindergarten bus that actually happened in Japan in 2022 and 2021 are shown. The cases were occurred in July mid-summer when the bus driver failed to conduct a final check and left the bus locked with the child was asleep inside and end up with the child’s death. Therefore, we felt that it is important to addressed this incident as one of problems that need to be solved.

バス置き去りの女児、懸命に暑さしのごうと…車内に脱いだ衣服・空になった水筒

2022/09/08 11:30

この記事をスクラップする

静岡県牧之原市の認定こども園「川崎幼稚園」に通う河本千奈ちゃん（3）が通園バスの車内に取り残され、熱中症で死亡した事件で、バスの乗降口付近に千奈ちゃんが自ら脱いだとみられる服があったことが関係者への取材で分かった。持っていた水筒も空になっており、県警は、千奈ちゃんが高温の車内で懸命に暑さをしのごうとしていたとみている。

通園バスの駐車場には飲み物や花束が手向けられている（8日午前、静岡県牧之原市で）

千奈ちゃんはバスで登園した5日午前9時頃から約5時間、車内に取り残された。乗車時は全6列のうち前から5列目の座席に座っていたが、乗降口近くの3列目付近で、あおむけに倒れているところを発見された。

5日の牧之原市は真夏日で、屋根のない駐車場に止められたバスの車内は短時間で温度が上昇したとみられる。県警は、千奈ちゃんが水筒の中身を飲みながら暑さをしのごうと着衣を脱ぐなどしたものの脱水となり、動けなくなったとみている。司法解剖の結果、死因は熱中症のうち症状が重篤な熱射病だった。

(Source: Yomiuri Shimbun)

「弟に会いたい」送迎バスに置き去られ、死亡した5歳児遺族の慟哭　再発防止、どうすれば

2021/12/26(日) 10:32 配信 46

47 NEWS

双葉保育園の送迎バス＝2021年7月

福岡県中間市の「双葉保育園」で7月、送迎バスに約9時間置き去りにされた倉掛冬生ちゃん（5）が熱中症で死亡した。原因は1人で運行していた当時の園長（9月に辞任）が車内を十分確認しなかったためとみられ、県警は12月17日、業務上過失致死容疑で当時の園長らを書類送検した。「せめて職員がもう1人乗っていれば」と悔やむ遺族。再発防止が求められるが、送迎バスの安全対策に統一基準はなく、保育現場は人手不足が常態化している。どうすればいいのか。（共同通信＝金森純一郎ほか）

▽どんなに苦しかったか、悔かったか

「おしゃべりで活発な子だった。思い出すと涙がとまらなくなる」。事件から3カ月たった11月、共同通信の取材に応じた祖父（68）は声を震わせた。手元には、まだ幼い冬生ちゃんの写真。好物のカレーをほおばる姿が写っている。母によく「作って」とおねだりしていたという。

(Source: Yahoo! JAPAN)

Fig 1-6 Cases of Left and Unattended Child in Kindergarten Bus in 2021 and 2022

After addressing the problem, we illustrate the problem and possible solution with a story to give us more understanding of the idea. In the story as shown in Fig 1-7, the bus driver gets off and lock the bus without confirming that a child was left inside. The device that the child wear will send the vital sign to the robot body and by the robot judgment, it will notify the kindergarten teacher and will lead to the rescue and prevent the incident. Based on the story, the functional and sub-functional diagram were created and shown in Fig 1-8 and Fig 1-9.

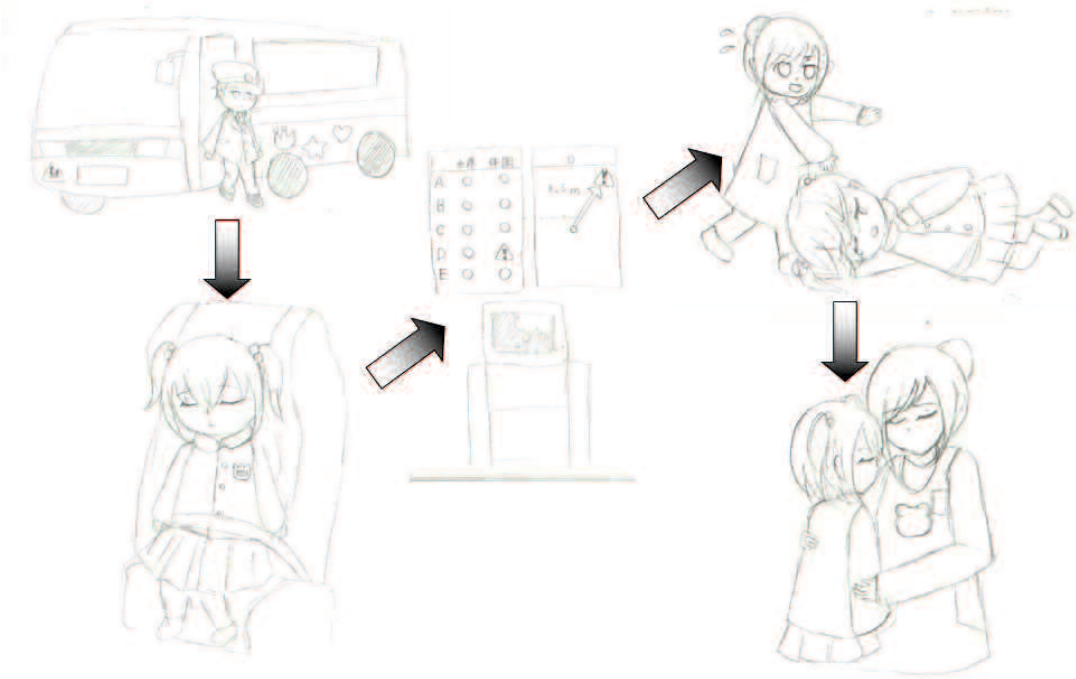

Fig 1-7 Story of Left and Unattended Child in Kindergarten Bus

Fig 1-8 Functional Diagram of Left and Unattended Child in Kindergarten Bus

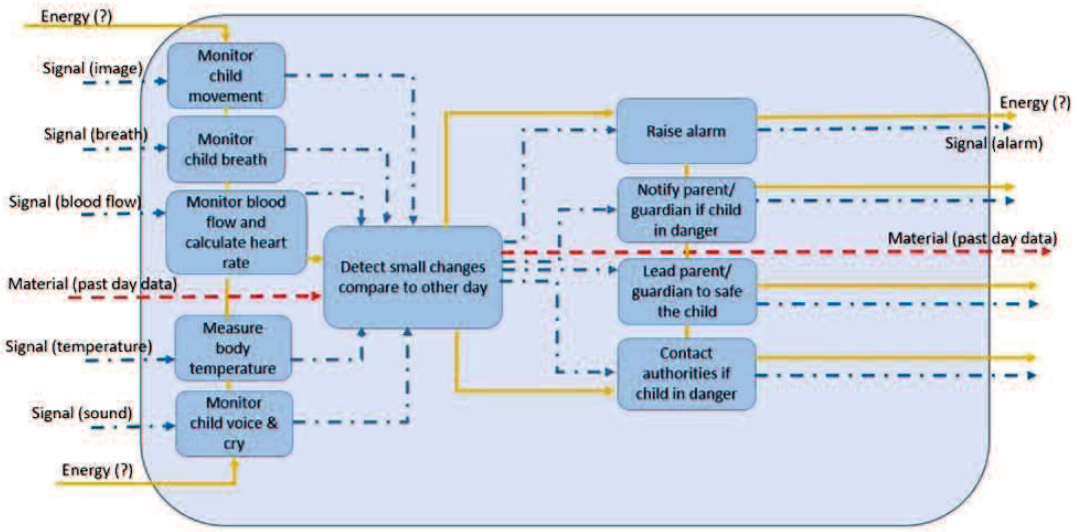

Fig 1-9 Sub-functional Diagram of Left and Unattended Child in Kindergarten Bus

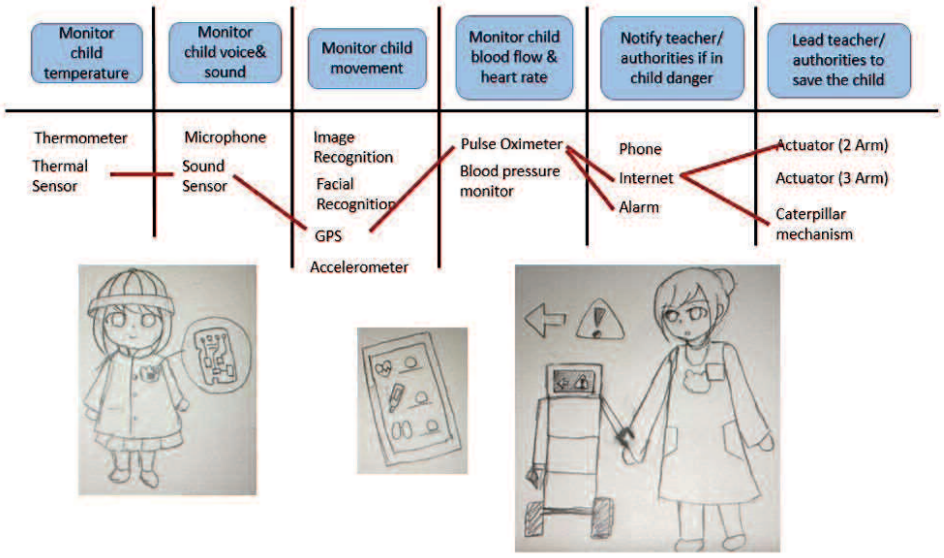

Fig 1-10 Concept Design Diagram of Left and Unattended Child in Kindergarten Bus

In the sub-functional diagram, the function of left and unattended child in kindergarten bus was precise and the sub-functions that were assumed suitable are for example monitor child blood flow and calculate the heart rate, monitor body temperature, notify kindergarten teacher if child in danger and lead teacher or authorities to safe the child. The possible mechanism for all the functions were then outlined in this concept design diagram. The suitable mechanism was selected and the concept design was finalized with the skecth as shown in Fig 1-10. For example, Thermal sensor will detect the child body temperature, the GPS system will determine the location of the child, the pulse oximeter will calculate the child's heart rate and the whole system will judge the abnormal situation. The robot body will then alert the authorities and lead to save the child. Based on the concept design diagram and sketch, the prototype was created and shown in Fig 1-11 and the video story was created and the clips were shown in Fig 1-12.

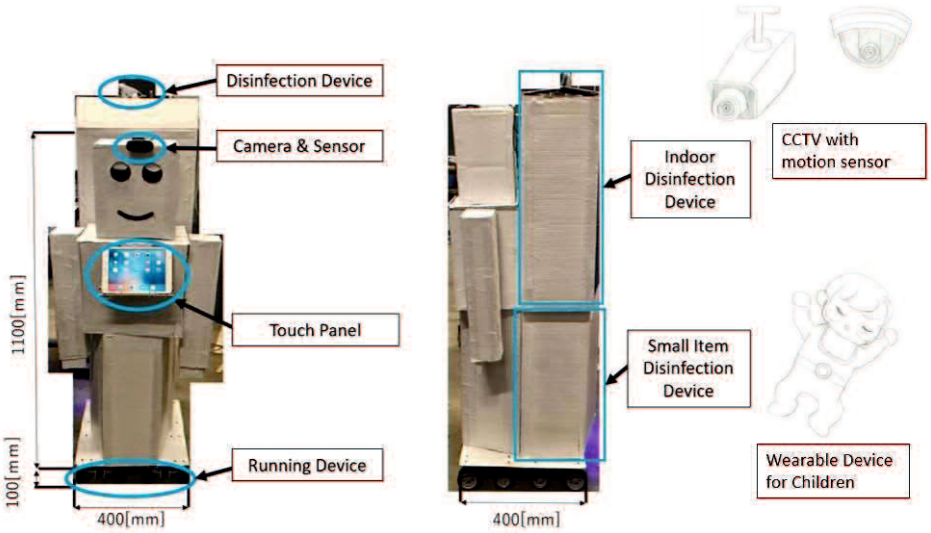

Fig 1-11 Working Prototype of Left and Unattended Child in Kindergarten Bus

Fig 1-12 Video Story of Working Prototype for Left and Unattended Child in Kindergarten Bus

The working prototype and video story will be used in the method later to determine consumers' needs regarding this sample of incident and solution idea.

1.4 Research Purpose

All of the steps in this method are important for innovative design, however, in this research this time we focused on co-designing value, big idea, and considering as integrated steps in chapters 3, 4, and 5 for identifying latent needs of the consumers. It is because identifying needs is an important part in the product development process. Intellectual design and physical design steps were considered in the last section in this chapter and in chapter 3 for prototyping. Chapter 6 discussed a careful survey of competitors' step and the timely business decision-making step.

Chapter 2 discussed previous and recent research on innovative design and latent needs. In chapter 3, we assumed that by introducing a working prototype of the product to the consumers, more latent needs are able to be elicited from the consumers. Prototyping was usually conducted for various purposes such as acquiring consumers or possible lead users' reactions, finding potential customers, avoiding costly iterations, integration and system testing and feasibility study. A working prototype usually represents all or nearly all of the functionality of the final product. The working prototype was used as material to prepare presentation slides. The Problem-based slides presentation was focused on the background problems and ideas for the solutions while the Prototype and Story-based slides presentation provided consumers with a working prototype and story of the product that was believed would be one of the solutions to the problems. We assumed that by introducing the working prototype to the consumer, more latent needs are able to be elicited from the consumers.

The interpretation responses were interpreted into consumers need in product function format and compared with existing product functions to elicit consumers' possible latent needs.

In chapter 4, the consumers' responses from the Problem-based and Prototype and Story-based slide presentations and interviews in our last research in Chapter 3 were utilized. The interview results were listed, interpreted, and analyzed according to the 5 guidelines for writing need statements by (Ulrich et al, 2015) to identify the needs of the consumers. There are "to focus on 'what is the product' and not 'how the product work'", "to be specific as in original responses", "to write 'positive' and not 'negative' statements", "to list the attribute of the product", and "to avoid 'must' and 'should' in the statement". Ulrich's five guidelines for writing need statements are to be known as effectively working on the interpreting processes of identifying all types of customer needs, not specific for identifying latent needs. Hence, in this chapter, we addressed additional guidelines to discover latent needs correctly, precisely, and deeply. The customers' responses from both interviews were interpreted again while considering the 3 new guidelines which are "to write a statement while empathizing with the customers", "to write a statement as a designer who understands the concept of the working prototype", and "to write a statement as someone with experience which in this case as a parent in this Covid-19 pandemic". The results were then compared to see whether these new guidelines will influence the number of interpreted needs.

In chapter 5, the interpreted needs only from the Prototype and Story-based slide presentations and interviews in our last research in Chapter 3 were utilized. To quantitatively evaluate the importance of functions based on latent needs, we first defined the degree/scoring/rating of whether the customer has specifically stated it or is abstractly aware of it) and called it latent-ness. Then to evaluate the importance of product functions based on latent needs we introduced another two perspectives which is importance: whether the function is unnecessary or indispensable; and technological feasibility: whether it is possible or impossible with existing technology, and each index was scored in five levels. Each of all interpreted needs was given scores of each perspective. Then, by adapting calculation method from Failure Mode Effect Analysis (FMEA) (Stamatis, 2003), the three perspectives of importance, latent-ness, and technological feasibility is multiplied to indicate that all three perspectives are essentials. This proposed method was called Degree of Latent Needs (DLN). The DLN results were then analyzed to ensure that all interpreted needs that we considered as important were received high DLN and therefore we can indicate that this method is applicable as supporting method in identifying critical latent needs.

In chapter 6, a decision-making method based on patent analysis at stages between conceptual design, prototyping, and production ramp-up was introduced. When moving from concept design to prototype and mass production stages in product development, large capital investments are required, and careful decision-making is necessary. To assist in this decision-making, stage-gate methods and real options have been proposed, but they have yet to provide sufficient material for decision-making. Usually, patent searches are conducted to find operating principles that realize functions. However, it is thought that the subject of patent rights and information on related patents may provide materials to determine not only whether a concept being designed can be realized, but also whether it should have proceeded within our own organization. Therefore, we have proposed and verified a method

to support concept evaluation in the upstream design stage and decision-making when moving to the mass production stage, using patent information.

The outline and flow of all the study is shown in Fig. 1-13. From the results of all the studies, we could conclude that these above methods may be applied as assistive tools to support designers' understanding of consumers' requirements and selecting the right concept design.

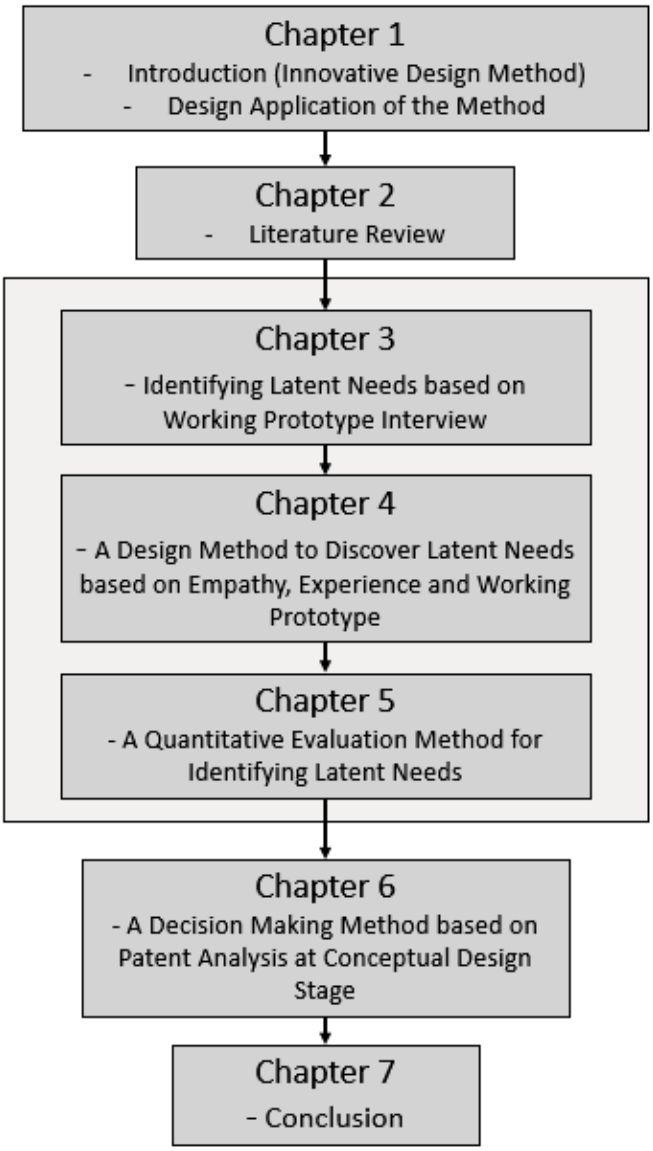

Fig 1-13 The outline and flow of the study

Chapter 2 – Literature Review

2.1 Previous and Recent Research on Innovative Design

Design science is a methodology that result from the ongoing research on methods to support innovation from the perspective of science. It was also defined as “a discipline that aims to elucidate the rules of design act and systematize the knowledge used in design act” in the “Encyclopedia of Design Science” by the Japan Society of the Science of Design (2020). It is also a compilation of valuable methods to support innovation development in Japan. For example, the forecasting and backcasting processes are the important processes that support innovation. Forecasting predicts the future based on current trend analysis. It is usually applied in a linear innovation model, which generally starts with basic research, applied research, development, and the final product. (Methe, 1995). Backcasting approaches from the opposite direction and begins from deciding needs and concepts. It is usually applied in the system integration model wherein this model, to reach the target of needs and ideas; an inventor can consider implementing new or existing technologies owned by them or other companies, which could lead to open innovation (Best, 2003). Forecasting and backcasting processes are also essential in generating a technology roadmap. A technology roadmap is a planning technic to support strategic and long-term planning by matching short-term and long-term goals with specific technology solutions (Garcia et al., 1997) and one of the technics that manage to support innovation (Phaal et al., 2001). Before finalizing concepts and outlining long-term planning, inventors need to finalize what needs or problems to be solved.

In this evaluation process, a lot of methods are available, for example, questionnaires and focus group interviews. A questionnaire is a valuable data collection tool and can yield high-quality quantitative data while achieving good and honest responses as it provides anonymity (Marshall, 2004). It is conducted thru interviews, telephone surveys, mail surveys, placement methods, the internet, etc., to discover problems, investigate current conditions, and confirm cause-and-effect relationships (Ray, 2003). The general procedure for a survey is to clarify the objectives (Oppenheim, 1992), develop the questionnaire, determine the target population, conduct the preliminary survey, conduct the primary survey, and analyze and report the results.

Interviewing lead or extreme users can help identify needs more effectively. Lead users are customers who experience requirements months or years before the majority of the market and stand to gain significantly from product advances, according to von Hippel (1986 & 1988). These clients are precious resources. They struggled with the shortcomings of current products, and they may have already built solutions to address their demands. Thus they are frequently able to define their growing wants. The team may be able to pinpoint needs that, while explicit for lead users, are nonetheless latent for most of the market by concentrating some of the data collection efforts on lead users (Judge, 2015).

On the other hand, according to Krueger et al. (2001), in the last 40 years, not only for marketing, focus group interviews have been used by government agencies, non-governmental agencies, and academics to help in making decisions for new products and services and evaluating programs or existing products and services. However, researchers

need to choose suitable participants, create a comfortable environment to talk and must respect and believe that they will learn valuable information from participants. There were also critical steps addressed again by Krueger (2006), such as developing good questions, conducting the interviews in participants' native language, summarizing and asking for verification at the end of an interview, and to continue observing and learning from how participants respond. According to McLafferty (2004), experiences of conducting focus group interviews demonstrated that smaller groups were more manageable and that groups made up of strangers required more moderator intervention. When implementing the design theme, several points require attention. According to (Sasa, 2020) in the "Encyclopedia of Design Science, in some cases, in fa ocus group interview, a new design may be evaluated alongside an existing design proposal, in which case an analysis that considers time frames and other factors is necessary. A design perceived as uncomfortable may become a design that will be supported in the future. The interview also may end with just liking or disliking the design, but the designer is able to probe deeper into the reasons for liking or disliking the design plan. In addition, it is necessary to understand not only the overall evaluation of the design but also whether the design has been created or understood according to the designer's intention. For example, if the designer intends to create a kid-friendly design, it is essential to evaluate whether the interviewee received the message. Although research by Griffin and Hauser (1993) revealed that the number of customer needs from the one-to-one interviews and focus group interviews indicated no differences, some practitioners believe that for certain products and customers group, the interactions among the participants of focus groups can elicit more varied needs than one-on-one interviews. However, this belief does not support by research findings yet.

Rabiee (2004) argued that the analysis of qualitative data from focus group interviews requires the development of new skills, imagination, patience, time and practice. Data analysis is a crucial step in the research process. Analysis of focus group interviews is often tricky, and little guidance is provided in the literature. Effective analysis requires the researcher to generate rich data, familiarise oneself with the data, write memos on statements, index statements, create themes and interpret the data (Doody, 2013). There are many option for analyzing qualitative data from focus group interviews. For example, the affinity diagram by Kawakita (1960) and is sometimes referred to as the KJ Method. This method is often utilized as a business tool to organize ideas and data from the brainstorming process. The affinity diagram is able to organize ideas from interview responses within 3 steps: record each idea on cards or notes, look for ideas that seem to be related, and sort cards into groups until all cards have been used. Once the cards have been sorted into groups, label each group and eliminate duplicate ideas. Arrows can be added between items, and groups to show significant relationships and the team may sort large clusters into subgroups for the next analysis. Another example is the Grounded Theory Method, a systematic methodology that has been largely applied to qualitative research conducted by social scientists. The method involves the construction of hypotheses and theories through the collection and analysis of data (Glaser & Strauss, 1967 &1978). A study based on grounded theory is likely, to begin with a question or even just with the collection of qualitative data. As researchers review the data collected, ideas or concepts become apparent to them researchers. These ideas/concepts are said to "emerge" from the data. The researchers tag

those ideas/concepts with codes that briefly summarize the ideas/concepts. As more data are collected and re-reviewed, codes can be grouped into higher-level concepts and then into categories. These categories become the basis of a hypothesis or a new theory. In Japan, the nursing field pioneered the use of this technology in the 1980s, and in recent years, it has been used in many practice-oriented fields, including nursing, health, medicine, social welfare, social work, nursing care, rehabilitation, school education, clinical psychology, and marketing. It effectively explains and predicts human behavior by targeting social interactions (actions). After more than 50 years, this method has now branched out into several types and are in competition with each other over the purpose of theory generation and the method of analysis, data coding (Kinoshita, 2014). Another method available to analyse interviewee responses from focus group interview is by utilizing the need statement writing guideline from Ulrich (2015), which were to focus on 'What' not 'How', to be specific, to create a positive not negative statement, to give attribute to the product and to avoid 'Must' or 'Should' in the statement. The needs then are organized into a hierarchy of primary, secondary, and, if necessary tertiary needs, and then the relative importance of the requirements are established. By conducting both or either one of the questionnaires and the focus group interviews, there are possibilities for the inventors to discover the problems and requirements of the consumers, which might lead to discovering crucial and important needs from the consumers by correctly interpreting the questionnaire survey answers and the interview responses.

Innovative design is a process of identifying, pinpointing, and understanding the needs of the user or audience. Once the need has been identified, a solution can then be designed (Shaulis, 2021). Previously, Dixon (1966) defined innovative design as any design that is: new or different, or elegant or uses new ideas, or is an improvement over its peers. Once the market need has been identified, a solution can then be designed. There has been a lot of research on an innovative design by prominent researchers. For example, the book by Pahl et al. (2007) teaches the methods of engineering design as a condition of successful product development. It breaks down the design process into phases, such as a functional diagram, and then into distinct steps. It also consists with the scientific bases of its design ideas with new solution fields in composite components, building methods, mechatronics and adaptronics. On the other hand, Suh (1990), in his book, created the axiomatic design, a systems design methodology that uses matrix methods to systematically analyze the transformation of customer needs into functional requirements, design parameters, and process variables. The design could be represented in four domains which are customer, functional, physical and process domains. Another problem-solving and designing method is design thinking by Leifer (2011) which consists of five phases of empathize, define, ideate, prototype, and test is an iterative process in which you seek to understand your users, challenge assumptions, redefine problems and create innovative solutions which you can prototype and test. The overall goal is to identify alternative strategies and solutions that are not instantly apparent with your initial level of understanding. According to Sawada (2012), design at early stages has a great influence on the final design solution, and designers need a good design support tools for the upstream design. The upstream design process is a process of defining and establishing a problem which later is solved during the downstream design process. They had established a research society for 1D-CAE (1 Dimensional

Computer Aided Engineering), which is a general term for idea, methodology, and tools applicable for the upstream design support, and discussed the concept and definition of 1D-CAE. Based on the research conducted above, we are able to say that innovative design is an important and ongoing research.

2.2 Previous and Recent Research on Latent Needs

Consumers or customers' needs can be identified more efficiently by interviewing lead users or extreme users. According to von Hippel (1988), lead users are customers who experience needs months or years ahead of the majority of the market and stand to benefit substantially from product innovations. These customers are particularly useful sources. It is because they are often able to articulate their emerging needs because they had to struggle with the inadequacies of existing products and they may have already invented solutions to meet their needs. By focusing a portion of the data collection efforts on lead users, the team may be able to identify needs that although explicit for lead users, are still latent for the majority of the market. Ulrich et al. (2015) stated that latent needs are those that many consumers recognize as important in a final product but do not or cannot articulate in advance. Most customers do not actively explore the causes of their problems and cannot articulate their latent needs (Bao et al., 2020; Von Mises, 1949). The latent needs addressed in this study were focusing on consumer requirements in product development. The challenge in identifying latent needs is finding the method to elicit from consumers the needs which are not addressed by any player in the present market but would delight them if delivered tomorrow. The success of a product or a service is largely dependent on how far the product or the service satisfies consumer needs and demands. Therefore, latent needs are particularly critical to product innovation and success.

Rothwell (1986) described new technology based on articulated needs or explicit needs are easier to be accepted and take less time to develop. On the other hand, Cook and Morrison (1961) while pointing out the four degrees of feeling the needs indicated that culture and human nature influence whether the user need become an urgent or a latent need. A latent need might take more time to develop but once the new technology reached a point of new return or what they called a diffusion threshold, it become an urgent need and will continue develop.

Various research had been conducted these days to obtain latent needs from customers. Takahashi (2005) and Sugio (2022) provide an overview of the purpose and utility of technology marketing and introduce the key points of how to proceed and implement technology marketing to find out the latent needs of customers. In their market creation, they explore what the requirements are that the direction of market creation intentions for future market creation satisfy and fit the latent needs of true customers. By conducting an exploratory marketing, the analysis of latent and explicit target markets, product functional structure, product performance, cost balance were considered. Hirukawa (2022) use different word to describe latent needs which he called deep needs. According to the research, deep

needs are created when product and service providers create new benefits. The first step is to extract the function from the technology characteristics, such as materials and networks. Then what benefits can be provided by the functions were considered. The customer characteristics of the people for whom the benefits will be useful were determined. In order to analogize the benefits from the technical and functional aspects, it is essential to keep up with the latest trend information. Kubota (2022) conducted a two-step behavior observation procedure to obtain latent needs and gained 1.4 times higher quality of needs than using only the free behavior observation. Hosomi (2022) conducted workshops applying future design in the search for directions of technological development and innovation in the food sector and in companies and also for obtaining the latent needs of future generations.

In the research by King (2019), to identify the latent needs of older adults in daily life, they found out that older adults were able to express more of themselves using creative methods, freehand sketching, and physical models. Sharing the same interests is also an important factor for the participants to be more open to each other. Raviselvam et al. (2019) stated that it was important to consider extreme user perspectives to derive latent needs. They conducted a step-by-step guidance to select the perspective of extreme users of medical devices by using Activity Diagram and came out with a latency matrix. Raviselvam et al. (2018) applied a systematic framework of Empathy Experience Design (EED) to evoke creativity and empathy of the designer to help experience the perspective of extraordinary users which is in some form of cognitive or physical impairment. By applying this framework, they hope to be able to capture the latent needs of extraordinary users. Then, Raviselvam et al. (2016) created a guideline for finding lead user-like behaviour as they believe that lead user needs will lead into finding latent needs. Therefore, we are able to conclude that selecting the right participants such as lead or extreme users for the research is important in the process of obtaining latent needs.

According to Narver et. al. (2004), customers' latent needs could be defined as tacit knowledge embedded in their behaviors, values, beliefs, emotion, experiences, actions, and goals, whereas their expressed needs or explicit needs only reflect partial aspects of what they really want (Polanyi, 1966). Narver et. al. in their research concluded that the proactive market orientation which address the latent needs of customers has stronger relationship to a new-product success than a responsive market orientation. Various researches were utilizing socialization approaches to identify latent customer needs, such as collaboration with lead users (Von Hippel, 1986), active customer participation (Prahalad and Ramaswamy, 2004), empathic design through contextual observation (Rosenthal and Capper, 2006), and servitization (Valtakoski, 2017). However, Wang et. al. (2022) concluded that a moderate level of servitization is the best choice for manufacturing firms to promote radical product innovation performance as a firm with a high level of servitization becomes overembedded in customer relationships and prevents it from seizing opportunities upon identifying latent needs. Ingenbleek et al (2010) in their research of the relation of value-informed pricing to new product development, acknowledge the importance of knowledge on how product innovation can satisfy customer needs including latent needs. In order for the company to proactively explore market possibilities that are hidden from the competition, anticipatory customer intelligence generation is concentrated on understanding consumers' latent and future requirements (Tellis et al., 2009). Latent needs are actual needs that clients

do not yet recognize. Customers do not necessarily express dissatisfaction if these demands are not met by a supplier because they are unaware of them, hence there is no demand or reaction from them. The client will be "wowed" and ecstatic, though, if a business recognizes this need and meets it. Customers are delighted, excited, and inspired to stay loyal when businesses offer them goods and services that convincingly meet these latent demands (Slater et al., 2014). Working with lead users (customers whose requirements are advanced compared to the rest of the market), ethnographic/observational research, and other methods may all help to shed light on customers' latent and potential wants (Slater and Narver, 1998).

Castellion, a seasoned elicitor of latent needs and growth opportunity indicated that after the emergence of professional associations devoted to new products, the increased recognition of innovation as an academic discipline, the publication of several journals devoted entirely to product development or innovation, and the establishment and acceptance of a new product professional certification, the failure rates of new product development were proven to be lower than 80% and for some products are lower than 50% (Castellion et. al., 2012). Therefore, new designers should be excited to involve themselves in co-designing new products that might be part of the solution to society's problems. On the other hand, Bohlmann et al (2013) in their research, agreed that it is difficult yet important to anticipate and identify customers' needs. However, upon conducting interviews with the managers of several firms they discovered that without information about the product's benefits, customers find it difficult to express their needs in their future.

In the report by Kaya (2015), they redefined "social problems", especially in terms of their explicitness and latent-ness, analyzed the progress of results in research areas with different goals in terms of the types of social problems to be solved, and reexamined the possibility of "social implementation". The comparison of the "Child Safety" and "Interaction" of the social problems, led them to hypothesize that the difference in the type of social problems, "explicit" or "latent," may have also affected the progress of research results. Since "latent" problems must include "claiming activities", in which the problem defined by the innovator is shared with many members, the process is more complex than for "explicit" problems, and the phase of social implementation that can be sought may differ. Natori (2011) in his research also conducted interviews to gain information from customers and to obtain potential customers. Marketing technology is a major challenge. As technology is difficult to see from the outside, he believed that the first step in technology marketing is to first "visualize" the technology and gain customer recognition. Therefore, in his paper, research questions were set: "Are branding of technology of small and medium-sized enterprises (SMEs) and its information disclosure effective in the search for potential customers?" to search for potential customers. As a result, the basic idea of the research question was found to be valid, but there are some items that need to be considered. In addition to the research, Natori (2012) also discovered that the use of websites is effective in searching for new customers and latent needs for the company's technology, but requires the ability to master the "hypothesis-testing approach. However, whether this method is applicable for SME, further verification through a questionnaire survey of a certain scale and case study analysis need to be done. Genba et. al. (2013) felt it is desirable to develop latent demand for products and services for which latent needs have not yet been clarified, but there is a lack of accumulated research on strategic management to achieve this. Their study analyzed the case of the Biodesign

Program at Stanford University and discusses the importance of developing human resources for Latent Demand Exploitation Innovation and the ideal educational program. The program was initiated by Paul Yock from Pfizer and Josh Macower who was keenly aware of the need for engineers to identify clinical needs for innovation in the medical device field and felt it was important to have a similar program to Pfizer's internal demand exploration program at the university level. The program actually provides personnel training that is well versed in information and technology in the field, provides backup through to commercialization with a team of experienced advisors in these ideal conditions, and offers practical education. However, it will not be easy to realize a similar educational program in Japan to foster human resources who can develop potential demand, given Japanese medical practices. Nakajima et al (2006) in their study on the method of acquiring users' latent requirements, discussed the trends and significance of acquiring latent requirements of users, which have recently begun to be addressed in various research fields, and showed that it is an urgent issue in the field of system development as well. Then, focusing on the dialogue between users and suppliers, they developed a hypothesis on supplier behavior (human characteristics) through an investigative interview method.

In the theory of attractive quality by Calgren (2012), an analytical framework is proposed to investigate how the design competencies contribute to identifying latent needs and later discovered that design competencies related to mindset will lead into discovering latent needs. To obtain latent needs in product emotional quality such as aesthetic part, Yanagisawa (2008) developed an interactive shape generation system therefore a non-designer customer might be able to choose a suitable pattern and design from samples. Nishiwaki (2002) discovered that more latent needs are able to be obtained when they asked patient quality of life (QOL) questionnaire compare to direct open-ended questions about patient needs. Durgee (2001) introduces two approaches involving verb-object combinations representing new product functions and casting ideas as “CADWOs” new products that people feel they cannot live without to uncover the latent needs of customers. In the methods of using online product reviews by Zhou (2015), the method was based on use-case analogical reasoning without directly interviewing users. But to finalize latent needs, effective evaluation strategies are still needed and might influence directly by reuse behaviour and prior experience of expert engineers. Therefore, we are able to conclude here that customers need assistance for them to be able to express their latent needs.

A good assisting method is needed to be identified in overcoming the challenge of elicitation and understanding the latent needs to create a valuable product to help the consumers in this modern society. There was various kind of research conducted previously to create a guideline for creating valuable inventions for society. For example, Tsutsui et al. (2020) developed an empathy formation model as other design methodologies had low practicality of empathy. This model consisted of 4 steps of discovery, immersion, connection, and detachment and was expected to contribute to improving the empathy formation upon the innovative design. Yokoi et al., (2021) improvised the design thinking process and introduced a prescriptive model of the cognitive design process that consisted of 5 steps which were requirement finding, design solution finding, verification, documentation, and implementation that will assist design thinking processes. By referring to both the empathy formation model and the cognitive design process by both researchers, we are able to say

that empathy is among the most important elements in the process of discovering the latent needs of consumers.

Customers' voices, responses, and needs are subjective therefore it is difficult to analyze quantitatively and eliciting latent needs from them. There are ongoing researchers regarding this matter. Jiao et al (2009) introduced an analytical Kano (A-Kano) model, which was a calculation and categorizing method of customer needs by using the Kano classifier. This method was adapted from the traditional Kano model (Kano, 1984), which has been widely practiced in industries as an effective tool for understanding customer preferences but is not equipped with quantitative assessment. Ohtomi (2015) classified three kinds of design according to Kano model. One of them is called a delight design that is equivalent to attractive quality in the traditional Kano model. The delight design analysis was performed by measuring the degree of attainment (comfort) and was applied upon designing product sound by using 1DCAE tool. On the other hand, Sakata et al (2007) introduced a customer satisfaction calculation method that consisted of 3 perspectives of satisfaction, expectation, and significance, and the product functions were classified into eight spaces using a three-dimensional positioning map. Product functions with low expectations were considered as latent needs despite having a low satisfaction level too however, the functions with high significance were considered as true latent needs. Another quantitative evaluation approach in product development was introduced by Okamoto et al (2022) who calculated the degree of exploration and exploitation in product design by extracting and analyzing product function from design documents.

Failure Mode and Effect Analysis (FMEA) also is one of the renowned quantitative analysis in product design and development. Dhillon (1992) traced the history of FMEA back to the early 1950s, when it was used for the design of flight control systems. FMEA emerged as a formal technique in the aerospace and defense industries. It is a structured approach for identifying all possible failures in a design, a manufacturing or assembly process, or a product or service (Stamatis, 2003). Failures are any errors or defects, especially ones that affect the customer, and can be potential or actual, while effects analysis refers to studying the consequences of those failures. By scoring the severity of the effect, the occurrence and the detection rate of the failure and calculating the risk priority number (RPN), FMEA is able to assist on discovering failure at its earliest possible point in product or process design. On the other hand, Fault Tree Analysis (FTA) is also an alternative method to investigate failure behavior (Peeters, 2018). A fault tree is a logic diagram that represents the relationships between an event (typically a system failure) and the causes of the event (typically component failures). It uses logic gates and events to model how the component states relate to the state of the system as a whole. Other FMEA alternatives include DFMEA (Design Failure Mode and Effect Analysis), which looks at failures in product design, and PFMEA (Process Failure Mode and Effect Analysis), which investigates process-related failure. We believed that the methods above are able to be applied as assisting tools for product development therefore we assumed that the research on quantitative analysis for identifying latent needs is important.

2.3 Detailed Research Purpose

Kubota (2022) conducted a two-step behavior observation procedure to obtain latent needs and gained 1.4 times higher quality of needs than using only the free behavior observation. Hosomi (2022) conducted workshops applying future design in the search for directions of technological development and innovation in the food sector and in companies and also for obtaining the latent needs of future generations. Raviselvam et al. (2019) conducted a step-by-step guidance to select the perspective of extreme users of medical devices by using Activity Diagram and came out with a latency matrix. Other researches were utilizing socialization approaches to identify latent customer needs, such as collaboration with lead users (Von Hippel, 1986), active customer participation (Prahalad and Ramaswamy, 2004), empathic design through contextual observation (Rosenthal and Capper, 2006), and servitization (Valtakoski, 2017). Raviselvam et al. (2018) applied a systematic framework of Empathy Experience Design (EED) to evoke creativity and empathy of the designer to help experience the perspective of extraordinary users which is in some form of cognitive or physical impairment. Research on discovering latent needs often organized by industries by conducting interviews and showing prototype to potential consumers. However, there is still no academic research on investigating latent needs by introducing a working prototype by the designers and conducting interviews on themselves. In chapter 3, we assumed that by introducing a working prototype of the product to the consumers, more latent needs are able to be elicited from the consumers.

Holtta-Olto (2016) indicate that people with lead user like ability to express latent needs, needs that are shared with but not originally found in regular users. Empathic lead user interviews by Lin (2007) observed a significantly positive effect on latent needs discovery in the trial study, and might emerge as a promising tool for supporting innovation and breakthrough concept generation. Therefore, in chapter 4, a new statement interpretation guideline was proposed. One of the guideline was assumed as by having someone with the similar experience with consumers, raw data will be interpreted more precisely. However, different cases require different experience. Tsutsui et al. (2020) developed an empathy formation model that consisted of 4 steps of discovery, immersion, connection, and detachment. Yokoi et al (2021) introduced a prescriptive model of the cognitive design process that consisted of 5 steps of requirement finding, design solution finding, verification, documentation, and implementation. Empathy was one of essential elements in requirement finding step. Therefore, assuming that empathy is an essential element in the innovative design, another guideline is suggested that by having empathy to the parents and children in this case, we will be able to interpret the raw data more deeply. Lastly, research by Lin also indicated that designers can be transformed into lead users by experiencing the product in radically new ways. Designers that act as lead users are able to demonstrate stronger domain-specific innovativeness than more "ordinary" users (Schreier, 2007) as lead users perceive new technologies as less "complex" and might therefore be better prepared to adopt them. Therefore, the third guideline of the designer who design the prototype and understand deeply the concept of the working prototype was outline to be able to interpret more correctly.

Customers' voices, responses, and needs are subjective therefore it is difficult to analyze quantitatively and eliciting latent needs from them. Ohtomi (2015) classified three kinds of design according to Kano model. One of them is called a delight design that is equivalent to attractive quality in the traditional Kano model. The delight design analysis was performed by measuring the degree of attainment (comfort) and was applied upon designing product sound by using 1DCAE tool. On the other hand, Sakata et al (2007) introduced a customer satisfaction calculation method that consisted of 3 perspectives of satisfaction, expectation, and significance. We believed that the methods above are able to be applied as assisting tools for product development therefore we assumed that the research on quantitative analysis for identifying latent needs is important. Therefore, in chapter 5 we introduced a new quantitative analysis method to elicit latent needs which was adapted from Failure Mode and Effect Analysis (FMEA) calculation method.

Raviselvam et al. (2018) applied a systematic framework of Empathy Experience Design (EED) to evoke creativity and empathy of the designer to help experience the perspective of extraordinary users which is in some form of cognitive or physical impairment. Lead users face needs before the bulk of the users encounters them (von Hippel, 1986). Thus, they may be valuable sources for latent customer needs and product ideas already during product development. In chapter 6, by conducting a patent search in this stage by the designer who also can act as extreme or lead user, and understood best about the product functions and working principles, we introduce a supporting method to assist designer for their decision making process and we assume that it will be able to assist in reducing the possibility of design failure in the future.

Chapter 3 - Identifying Latent Needs based on an Experiment of Working Prototype-based Interview

3.1 Introduction

3.1.1 Latent Needs

Consumers or customers' needs can be identified more efficiently by interviewing lead users or extreme users. According to von Hippel (1988), lead users are customers who experience needs months or years ahead of the majority of the market and stand to benefit substantially from product innovations. These customers are particularly useful sources. It is because they are often able to articulate their emerging needs because they had to struggle with the inadequacies of existing products and they may have already invented solutions to meet their needs. By focusing a portion of the data collection efforts on lead users, the team may be able to identify needs that although explicit for lead users, are still latent for the majority of the market. Ulrich et al. (2015) stated that latent needs are those that many consumers recognize as important in a final product but do not or cannot articulate in advance. The latent needs addressed in this study were focusing on consumer requirements in product development. The challenge in identifying latent needs is finding the method to elicit from consumers the needs which are not addressed by any player in the present market but would delight them if delivered tomorrow. The success of a product or a service is largely dependent on how far the product or the service satisfies consumer needs and demands. Therefore, latent needs are particularly critical to product innovation and success.

Various research had been conducted these days to obtain latent needs from customers. Takahashi (2005) and Sugio (2022) provide an overview of the purpose and utility of technology marketing and introduce the key points of how to proceed and implement technology marketing to find out the latent needs of customers. In their market creation, they explore what the requirements are that the direction of market creation intentions for future market creation satisfy and fit the latent needs of true customers. By conducting an exploratory marketing, the analysis of latent and explicit target markets, product functional structure, product performance, cost balance were considered. Hirukawa (2022) use different word to describe latent needs which he called deep needs. According to the research, deep needs are created when product and service providers create new benefits. The first step is to extract the function from the technology characteristics, such as materials and networks. Then what benefits can be provided by the functions were considered. The customer characteristics of the people for whom the benefits will be useful were determined. In order to analogize the benefits from the technical and functional aspects, it is essential to keep up with the latest trend information. Kubota (2022) conducted a two-step behavior observation procedure to obtain latent needs and gained 1.4 times higher quality of needs than using only the free behavior observation. Hosomi (2022) conducted workshops applying future design in the search for directions of technological development and innovation in the food sector and in companies and also for obtaining the latent needs of future generations. In the research by King (2019), to identify the latent needs of older adults in daily life, they found out that older adults were able to express more of themselves using creative methods, freehand sketching, and physical models. Sharing the same interests is also an important

factor for the participants to be more open to each other. Raviselvam et al. (2019) stated that it was important to consider extreme user perspectives to derive latent needs. They conducted a step-by-step guidance to select the perspective of extreme users of medical devices by using Activity Diagram and came out with a latency matrix. Raviselvam et al. (2018) applied a systematic framework of Empathy Experience Design (EED) to evoke creativity and empathy of the designer to help experience the perspective of extraordinary users which is in some form of cognitive or physical impairment. By applying this framework, they hope to be able to capture the latent needs of extraordinary users. Then, Raviselvam et al. (2016) created a guideline for finding lead user-like behaviour as they believe that lead user needs will lead into finding latent needs. Therefore, we are able to conclude that selecting the right participants such as lead or extreme users for the research is important in the process of obtaining latent needs.

In the theory of attractive quality by Calgren (2012), an analytical framework is proposed to investigate how the design competencies contribute to identifying latent needs and later discovered that design competencies related to mindset will lead into discovering latent needs. To obtain latent needs in product emotional quality such as aesthetic part, Yanagisawa (2008) developed an interactive shape generation system therefore a non-designer customer might be able to choose a suitable pattern and design from samples. Nishiwaki (2002) discovered that more latent needs are able to be obtained when they asked patient quality of life (QOL) questionnaire compare to direct open-ended questions about patient needs. Durgee (2001) introduces two approaches involving verb-object combinations representing new product functions and casting ideas as “CADWOs” new products that people feel they cannot live without to uncover the latent needs of customers. In the methods of using online product reviews by Zhou (2015), the method was based on use-case analogical reasoning without directly interviewing users. But to finalize latent needs, effective evaluation strategies are still needed and might influence directly by reuse behaviour and prior experience of expert engineers. Therefore, we are able to conclude here that customers need assistance for them to be able to express their latent needs.

A good assisting method is needed to be identified in overcoming the challenge of elicitation and understanding the latent needs to create a valuable product to help the consumers in this modern society. There was various kind of research conducted previously to create a guideline for creating valuable inventions for society. For example, Tsutsui et al. (2020) developed an empathy formation model as other design methodologies had low practicality of empathy. This model consisted of 4 steps of discovery, immersion, connection, and detachment and was expected to contribute to improving the empathy formation upon the innovative design. Yokoi et al., (2021) improvised the design thinking process and introduced a prescriptive model of the cognitive design process that consisted of 5 steps which were requirement finding, design solution finding, verification, documentation, and implementation that will assist design thinking processes. By referring to both the empathy formation model and the cognitive design process by both researchers, we are able to say that empathy is among the most important elements in the process of discovering the latent needs of consumers.

3.1.2 Identifying Latent Needs

In this research, we assumed that by introducing a working prototype of the product to the consumers, more latent needs are able to be elicited from the consumers. Although the needs obtained from the introduced and interviewed consumers become explicit needs, the obtained needs are still latent for the majority of the market. Prototyping was usually conducted for various purposes such as acquiring consumers or possible lead users' reactions, finding potential customers, avoiding costly iterations, integration and system testing, and feasibility study. There are a few types of prototyping which are analytical, comprehensive, focused, and physical prototyping. Physical prototyping will assist in visualizing and developing an idea or verifying a design concept and function by providing a working prototype. A working prototype usually represents all or nearly all of the functionality of the final product.

As shown in Fig 3-1, the purpose of this research is to verify the method in the elicitation of latent needs from consumer needs by conducting the working prototype-based interview and collecting raw data which is responses from the consumer. After conducting a consumer feedback questionnaire via the internet, a working prototype was created. The working prototype then was used as material to prepare presentation slides. The first presentation slides were focused on the background problems and ideas for the solutions while the second presentation slides provided consumers with a working prototype and story of the product that was believed would be one of the solutions to the problems. We assumed that by introducing the working prototype to the consumer, more latent needs are able to be elicited from the consumers. The interview and interpretation results were analyzed to compare the volume of consumers' latent needs gained after the interviews.

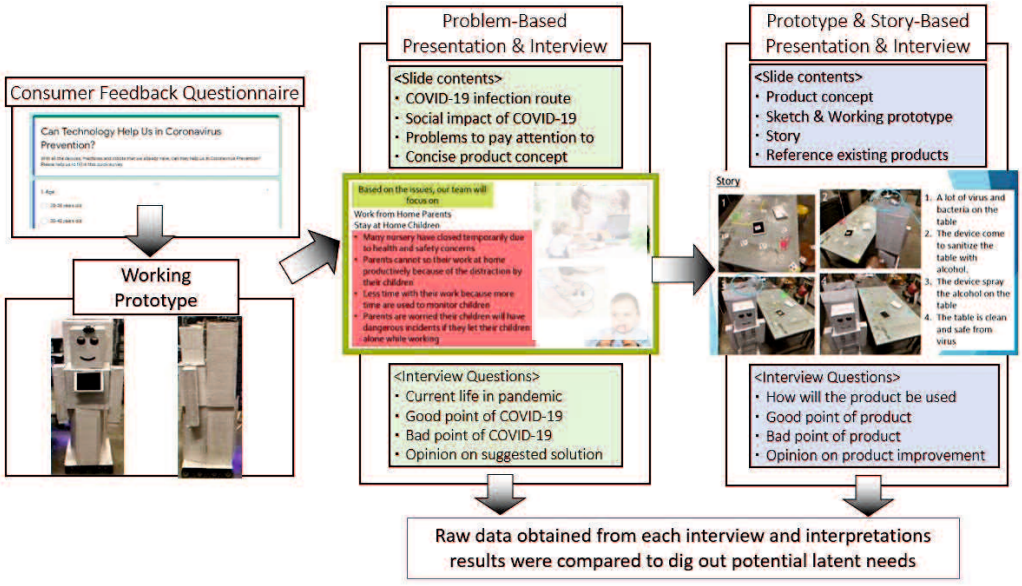

Fig 3-1 Research purpose. The method in the elicitation of latent needs from consumer needs by conducting the prototype-based interview and collecting responses from the consumer is verified and compared with the non-prototype interview.

3.1.3 An applied design target for validation - The effects of the COVID-19 pandemic on parents, child caretakers and children

This research was conducted in the year 2020 during the COVID-19 pandemic. COVID-19 which stand for Coronavirus Disease (2019 was the year it was first identified) has caused a lot of death and infected patients all over the world. This COVID-19 could be transmitted in 3 ways, through person-to-person contact, large droplets spread, and contaminated objects or surfaces (Wiersinga et al., 2019). Transmission through a person mainly occurs when an infected person is in contact with another person while transmission through objects and surfaces occurs because the virus is able to live on surfaces for up to 4 hours to a few days depending on the type of surface. As the pandemic spread, most countries were forced to go into lockdown or declare an emergency state. Business organizations and companies needed to switch to working from home to prevent the spread (Bick et al., 2020). Moreover, in this pandemic, 99% or 2.36 billion of the world's children experienced movement restrictions as schools and childcare institutions were closed. Based on a survey by Kaur and Sharma (2020), most working parents were worried about their family safe and their children at home while they also struggled to balance their responsibilities for their child and their employer. It also showed that working mothers are impacted twice more as fathers by work and childcare while 52% of single parents responded that trying to earn while taking care of their children had become extremely stressful.

Therefore, in this research, the issue regarding the effects of the COVID-19 pandemic on parents, child caretakers, and children was utilized as the research sample. Many childcare institutions and schools have closed temporarily due to health and safety concerns (Gupta et al., 2021; Loganathan et. al., 2021). However, parents were unable to work from home efficiently and productively because of the distraction of their children. Parents were worried their children will involve in dangerous incidents if the children were left by themselves. Other worries were about their education and development while the schools were still closed. However, in the region where the schools and childcare institutions were allowed to be operated, parents and childcare workers were worried about the children's safety to COVID-19 which led to the need to conduct intensive cleaning and sanitizing to ensure the children's safety. Based on this situation, the research was conducted in finding the latent needs of the parents, childcare workers, and children in order to assist them in going through their problems during this COVID-19 pandemic.

3.2 Proposed Method

3.2.1 Consumer feedback questionnaire for gaining consumer needs

In this research, an idea to create a product or service that can help people affected by this COVID-19 pandemic was selected as the research subject. Malaysian people that are

also affected by this pandemic were chosen as a target group and the questionnaire survey was conducted to them. The questionnaire surevey is often conducted to discover problems, investigate current conditions, and confirm cause-and-effect relationships (Ray, 2003). The questionnaire to Malaysian people was distributed to investigate and confirmed Malaysians' consumer needs in online form type regardless of their age, occupation, and marital status. The details of the questionnaires are shown below.

Title: Can Technology Help Us in Corona Prevention?
Date: 2020/10/26 – 2020/10/30
Target Group: Malaysian
Format: Online Form

The main questions that were asked in the questionnaire was to investigate and confirmed Malaysians' consumer needs who were affected in their work and childcare in COVID-19 pandemic are as follow in free descriptive form.

What kind of robot/device do you hope for helping you in this pandemic?
What concerns do you have for children in this COVID-19 pandemic?
What kind of robot/device do you hope for taking care of the children?

50 responses were obtained and the answers for the 3 questions above are shown in Table 3-1 below. Based on the most answers in the questionnaire (highlighted in yellow), most of the parents were concerned about the COVID-19 virus, the safety of their children and the children's education as the schools and childcare institutions were closed due to the pandemic. Some of the parents needed to work from home while taking care of their children.

Table 3-1 Consumer Feedback Results

No.	What kind of robot/device do you hope for helping you in this pandemic?	What concerns do you have for children in this Covid-19 pandemic	What kind of robot/device do you hope for taking care of the children?
1	Virus scanner	-	-
2	A robot that can replace or monitor law enforcer in doing their jobs. This is to bring an end to prejudice and unequal act of law between the common people including students and the higher positioned people like the ministers.	Growing up in a non-efficient environment. This includes their social life, education and also mental/physical health.	I don't hope for a robot to take care of children. They should learn how to communicate and socialize with people. A lot of life skills can't be obtained by having interactions with robot, not in the near future at least.
3	-	-	-
4	Medical robot	-	Medical Robot
5	Time machine	Their healthy	Robot can detect COVID-19
6	Virus scanner	-	-
7	-	Health	-

8	-	The possibility of getting/infected by Covid-19	One that is would assess the air quality and particles in it
9	-	-	Robot to teach them many things in daily life
10	Multifunctional robot	Their health and academic	-
11	-	I heard children and old people are easily infected so I hope parents won't let them go anywhere without knowing.	Protect them from virus
12	-	Covid-19 to disappear before I give birth to my child	-
13	Talking robot	They cannot play outside	Robots that can accompany the children as friends.
14	A device that can create a vaccine for the virus as soon as possible	If schools are closed, children stay at home and have no interaction with their friends and may get depressed or left out.	-
15	Virtual conversation partner	-	Robot that have lovely emotion
16	Robot that can fold clothes	-	clean the house and teach pre-school kids' education
17	Robot to clean the house	kids health and education	-
18	-	Physical Sosial Interaction	Monitoring their distance with another person
19	Robotic Vacuum	The ability for them to keep distance with their friends.	Vacuum cleaner
20	Proper laptop for my kids to do online learning	Academic	Detect and protect child from virus.
21	Detect virus	Protect child from virus	a robot that can help me teach my child to become a good human
22	robot that can help me find money	new virus, new norm, new knowledge is required. i am just afraid that children trust the politician more than the scientist or professionals, where it can lead to bad behaviour of children.	A proximity sensor that goes off when in close contact with other people.
23	-	That they may carry the virus in dormant state and pass it to their offspring.	robot which know children condition
24	auto update nearby case	very sympathy	A robot that can solve human trafficking/kidnaping/rapist

			problems especially for children.
25	A device that can detect and transmit smell senses	Their safety in academic surrounding	Robot/device that can give them some education to learn in the pandemic situation and also device/robot that can examine their health as to reduce contraction between human to human.
26	Robot for sanitizing the place affected with virus	Their health especially mental health because they can't go to school and don't get any interaction with others too	-
27	-	Her safety when going to school	Managing their set healthy schedule
28	Learning for kids	To be able to learn normally	humanoid robot-like big hero 6
29	nanny robot	exposure to covid-19	Can protect them from any diseases especially Covid-19
30	Human robot that become my replacement to be at certain place	Health and academic	education robot
31	House cleaning	education	Playing with the kids and have emotions like a mother
32	Serving food and playing with the kids	Social distancing	Help in study
33	Buying & delivery	Study problem	Robot can detect COVID-19
34	Time machine	Their healthy	Virus scanner
35	-	their environment	Robot that can teach my kids
36	Take care my kids when I am doing my work	Affected by the virus	-
37	-	-	Programmable tablet/laptop where only related apps are accessible on any given time, following teacher/parent set learning timetable.
38	Auto monitoring health device for the elderly (esp. those living alone) on basic checks like BP, sugar level, REM sleep pattern etc.	The lack of in person social interaction due to remote schooling / physical distancing.	-
39	-	Cleanliness	Robot that can take care their need
40	Cooking and cleans the house	Their mental health	Devices that can help detect and monitor any symptoms of ill that my children may or may not show for earlier prevention

41	Helper robot to minimise contact with other people	Difficulty for children to study since studying online and physically going to school is different and hard.	-
42	Apps to detect nearby people infected with covid-19 or glasses than can see high risk infected people	Safety and health	Breast feeding
43	Robot that can detect any person that don't wear mask. The robot is supposed to slap and kick the person who does not wear mask.	-	education robot
44	House cleaning	education	Virus scanner
45	-	their environment	Device that can Keep them sanitized for most of the time.
46	Portable Sanitizer	They play closely with their friends	Device that can monitor them if they are wearing a mask or not
47	Device to alarm others when they get too close to me	Physical distance and wearing a mask	education robot
48	-	education	Virus scanner
49	-	their environment	-
50	-	-	Virus scanner

3.2.2 Working prototype based on consumer feedback

In this research, we assumed that by introducing a physical prototype of the product to the consumers, more latent needs are able to be elicited from the consumers. This physical prototyping will assist in visualizing and developing an idea or verifying a design concept and function. The prototype was created to provide the consumer with a high-quality channel of information and images about the solution idea of the problem. The prototype will be used in the slide presentation in the interview.

Based on the results from the consumer feedback questionnaires, a prototype of a device to help in overcoming the problems in childcare that occurred during the COVID-19 pandemic was created. We were able to observe that the main responses were about the concern of parents for their children's safety and education during this COVID-19 pandemic. The parents also hope that there was a device that is able to assist them in childcare.

Therefore, before designing the prototype, a patent search for a childcare robot was conducted using a patent database that covered patents published in more than 90 countries including Japan, United States, Europe and China. The patents are used to delist explicit needs from collected all needs for screening candidates for latent needs. The search result

indicates a number of patents related to the method and system for creating childcare robots were found. For example, two patents by Oonaka (NEC Corp, 2005 & 2013) were focused on creating a childcare robot that is able to perform an action based on a specific behaviour pattern of a child while the other one is able to detect geographic positions of the object and create floor map memory of the house or childcare institutions. Another patent registered by Takano et al. (NEC Corp and NTT Corp, 2008) was a system to manage the memory of the robot to be able to operate according to the parent's selected instructions. Yun et al. (Korea Institute of Science and Technology, 2016) registered a patent for a medication reminding system by a robot that will be able to transmit health information of children to the medical institutions in case of emergency. Sadamatsu (Social Solution LLC, 2017) focused on developing a childcare robot for assisting childcare in nursery schools or childcare facilities and has equipped with an internal and external network for information transmitting. Liu et al. (Shanghai Changren Information Technology, 2018) created a system of school safety management that consisted of a sensor network, a management server and an interactive robot that might be able to provide safety in the house or childcare institutions. Wang et al. (Harbin Precision Technology Dev Co Ltd, 2018) developed a night-time inspection robot for maternal and child health hospitals that is possible to be utilized in a resident house.

Based on the previous patents published, we were able to see a robot with childcare function is an ongoing innovation. Combining with responses from the consumer feedback questionnaire, a prototype of a robot or device that supports housework and childcare during the COVID-19 pandemic was built. The main functions of this prototype were the childcare function and the disinfection and cleaning function. The functions covered in childcare function were remote-monitoring, body temperature measurement, crime prevention and security and also for entertainment and education. Indoor disinfection and small things disinfection were divided into the disinfection and cleaning functions. Other functions of the prototype were scheduling and monitoring study and bathing time.

3.2.2.1 Childcare function

This prototype is only a prototype of a part of the design. The design covers the entire childcare system, with cameras mounted not only above the head but also in several places, such as on the ceiling of the room. In this prototype model, the camera sensor mounted on the head is shown in Fig 3-2. Cameras and sensors are used for functions such as monitoring children's physical condition, measuring body temperature, and recognizing people, as well as recognizing obstacles during driving and suggesting routes. The prototype is also able to contact medical institutions and authorities in case of emergency. The head is equipped with a speaker and a facial expression recognition mechanism in the actual product in order to provide smooth communication with users by changing voices and facial expressions. The body below the head incorporates a mechanism for supplying power to the entire robot and a power unit for various operations including running. The display mounted on the chest of the prototype model is used to operate the robot and for other functions such as providing songs and videos for education and entertainment. The display is also for communications between children and parents or external institutions. The installation height is a height that can be used by both adults and children, and the angle can be changed in the actual product. The arm of the prototype model is not equipped with power, but it will be in the actual product.

In addition, although basic movements such as forward and backward movements are possible in the prototype model, complicated movements such as turning and small movements will be possible in the actual product.

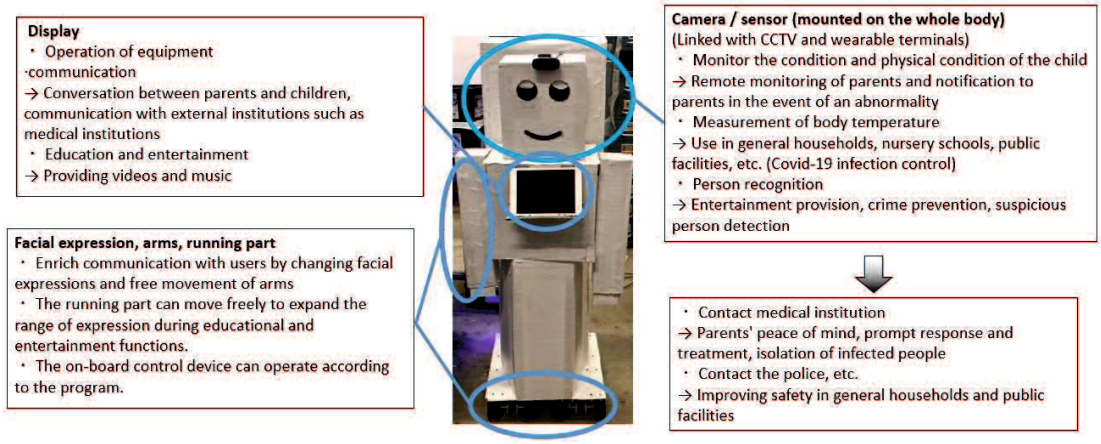

Fig 3-2 Childcare function will be able to monitor the physical condition of a child, measure body temperature and prevent home invasion by contacting the authorities during emergency situations. The display is for operating equipment, communication between parents and children, and for education and entertainment while the running part moves freely during education and entertainment

3.2.2.2 Disinfection and cleaning function

As shown in Fig 3-3, in the prototype model, a disinfection part was created in a format that conducted alcohol disinfection using a spray mechanism with up and down motion. We assumed that in the actual product, not only alcohol disinfection but also multiple disinfection methods such as ultraviolet rays and hydrogen peroxide are installed, and it is possible to operate by switching the appropriate disinfection method that is suitable to the situation. Small items are disinfected by an ultraviolet ray disinfection box in the prototype model. The disinfection time and strength can be set according to the type and size of the small items. The comprehensive design version of this robot is equipped with a brush and a dust-suction tube with a wheel system for cleaning purposes.

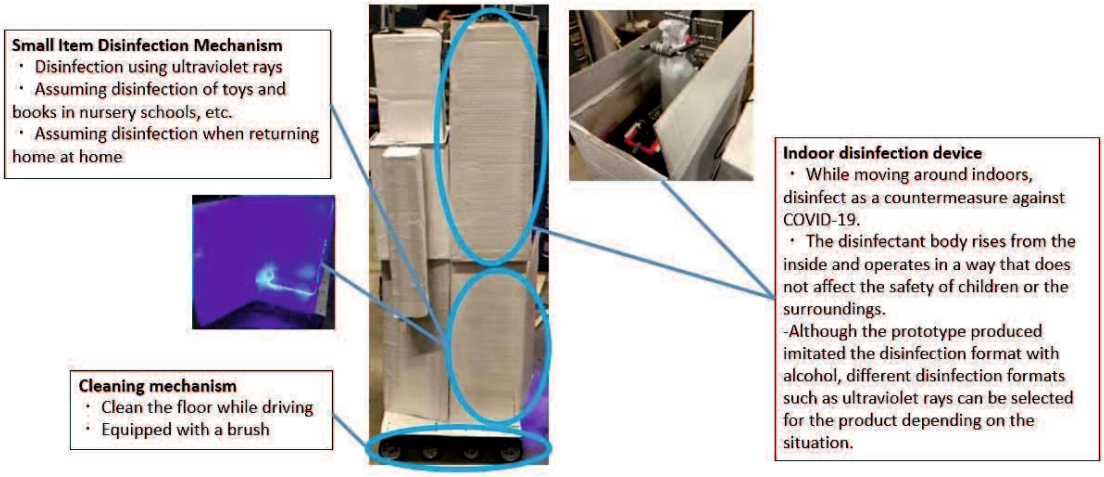

Fig 3-3 Disinfection and cleaning function for indoors and small items. The prototype model will move around the house and the disinfecting part will rise and sanitize. The prototype model provides disinfection by alcohol only but in an actual product, consumers will be able to choose the type of disinfection whether to use alcohol or ultraviolet ray. The ultraviolet rays also disinfect small items such as toys and books. The cleaning mechanism is equipped with a brush and a dust-suction tube to clean the floor while the prototype model moves around the house.

3.2.3 Problem-based interview and prototype and story-based interview

Interviewing lead or extreme users can help identify needs more effectively as lead users are customers who experience requirements earlier before the majority of the market and stand to gain significantly from product advances, according to von Hippel (1988). Therefore, parents with childcare experience were chosen as targets. Joint experience and dialogue with consumers are also important factors in eliciting latent needs (Matsumoto, 2021). According to McLafferty (2004), experiences of conducting focus group interviews demonstrated that smaller groups were more manageable than big group. Some praticioners believe the interactions among the participants of focus groups can elicit more varied needs than one-on-one interviews although this belief does not support by research findings yet (Ulrich, 2015).

Therefore, a total of 13 parents of different genders and nationalities were selected as focus groups as we assumed that parents is potential consumers or lead users. They were divided into smaller groups with the same gender, nationality and occupations to create a more focused group. The summary of each group is shown in Table 3-2.

Table 3-2 The interviewees' basic information

	Gender	Nationality	Occupations	Family structure
Group 1				
Person A	Female	Japanese	Nursery Teacher	Lives with 2 daughters
Person B	Female	Japanese	Nursery Teacher	Lives with husband and 1 daughter
Person C	Female	Japanese	Nursery Teacher	Lives with husband and 2 children
Group 2				
Person D	Female	Malaysian	Student	Lives with husband and 1 son
Person E	Female	Indonesian	Student	Lives with husband and 2 daughters
Person F	Female	Indonesian	Housewife	Lives with husband and 3 children
Group 3				
Person G	Female	Malaysian	Student	Lives with husband and 3 children
Person H	Female	Indonesian	Housewife	Lives with husband and 2 children
Group 4				
Person I	Female	Malaysian	Sales Executive	Lives with husband and 2 daughters
Person J	Female	Malaysian	School Teacher	Lives with husband and 1 son
Group 5				
Person K	Male	Malaysian	Part-timer	Lives with wife and 1 son
Person L	Male	Malaysian	IT Engineer	Lives with wife and 5 children
Person M	Male	Malaysian	Part-timer	Lives with wife and 3 children

3.2.3.1 Problem-based slide presentation and interview

In the interview session, two different slide presentations and interviews were conducted. The first slide presentation was named the "Problem-based" slide presentation. In this "Problem-based" slide, general information about the COVID-19 and the latest cases were introduced in Fig 3-4 - 3-6 while the type of virus transmission were explained in Fig. 3-7 - 3-10. Then, how the pandemic affects the parents were addressed such as school closing or parents needing to work from home were explained in Fig 3-11 – 3-13. The possible impacts and problems that parents and childcare workers might have in childcare and virus prevention during this pandemic were then indicated in Fig 3-14 – 3-16. The last part of the slide in Fig 3-17 – 3-22 were the suggested solution idea and device to help in the problem. The idea was to create a device that will cover two essential functions in house or institutions

which are childcare, sanitizing and cleaning. The slide presentation was conducted for 30 minutes.

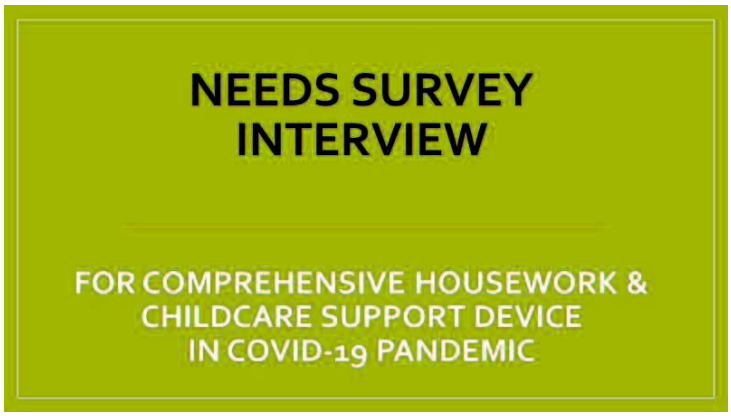

Fig 3-4 Presentation slide page 1 (Problem-based Presentation Slide)

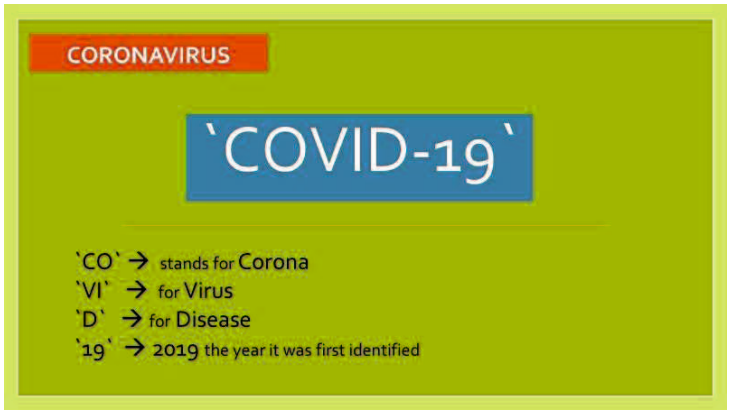

Fig 3-5 Presentation slide page 2. Introduction of COVID-19

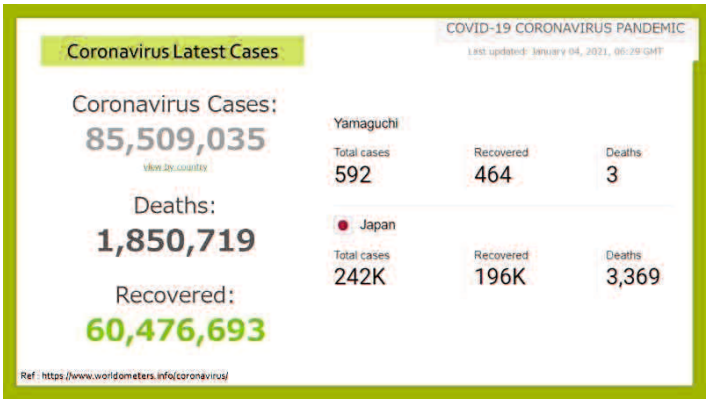

Fig 3-6 Presentation slide page 3. The latest COVID-19 cases in Japan. This part included the total death during the pandemic (4 January 2021)

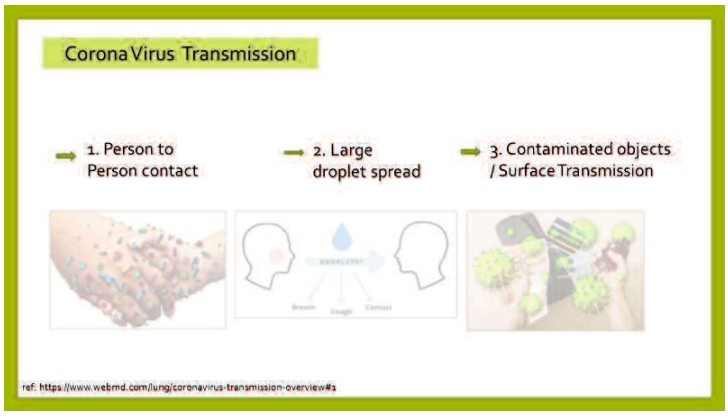

Fig 3-7 Presentation slide page 4. How COVID-19 virus is transmitted

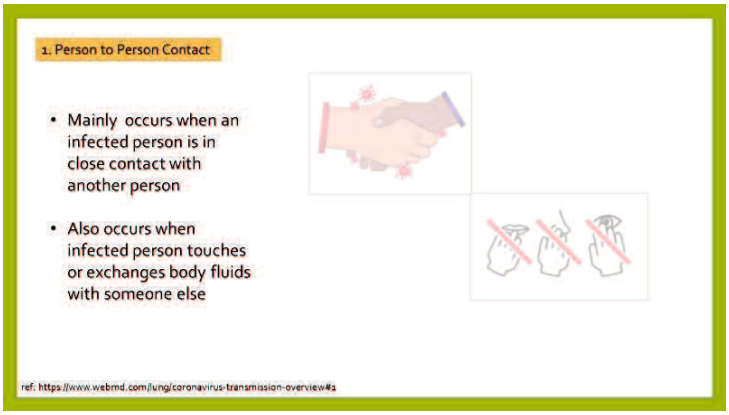

Fig 3-8 Presentation slide page 5. How COVID-19 virus is transmitted (2)

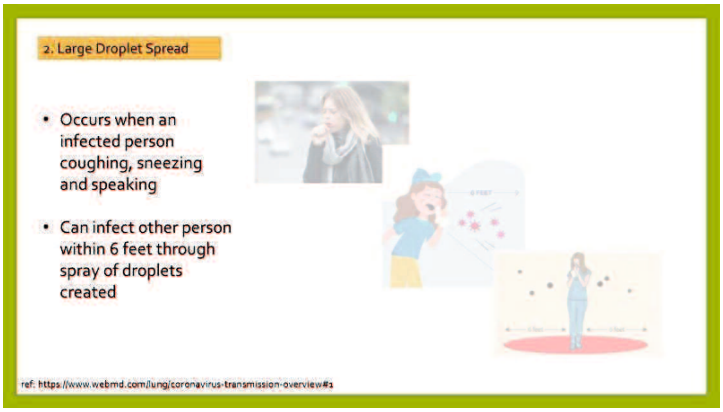

Fig 3-9 Presentation slide page 6. How COVID-19 virus is transmitted (3)

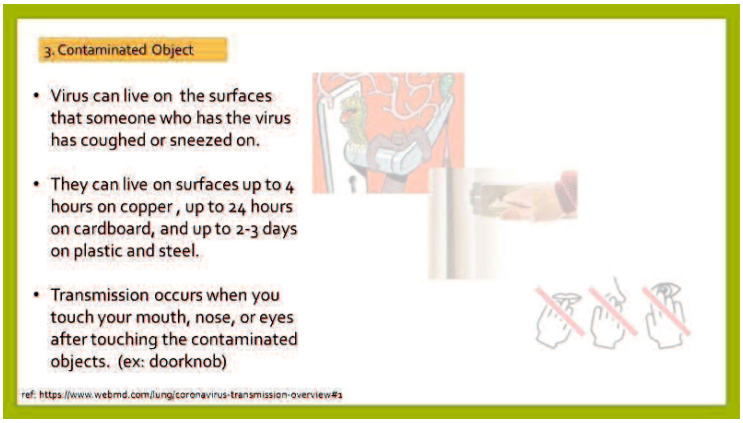

Fig 3-10 Presentation slide page 7. How COVID-19 virus is transmitted (4)

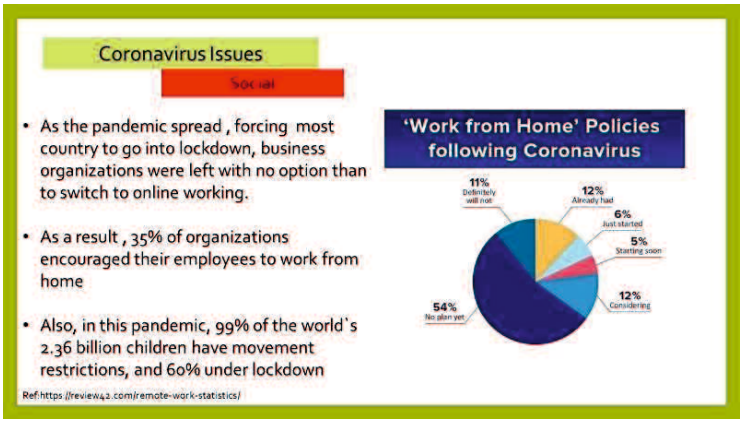

Fig 3-11 Presentation slide page 8. COVID-19 pandemic effect to school and organization.

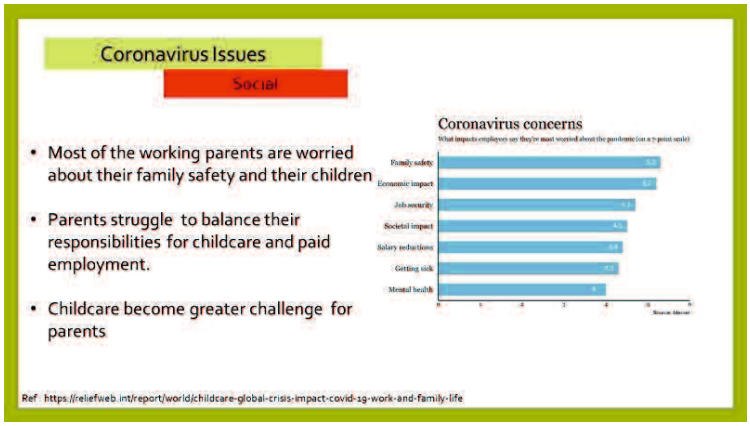

Fig 3-12 Presentation slide page 9. COVID-19 pandemic effect to school and organization (2).

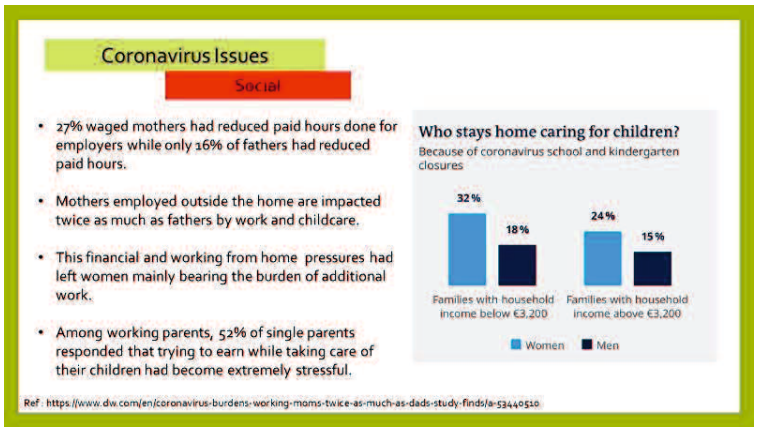

Fig 3-13 Presentation slide page 10. COVID-19 pandemic caused school to close and parents need to start working-from-home

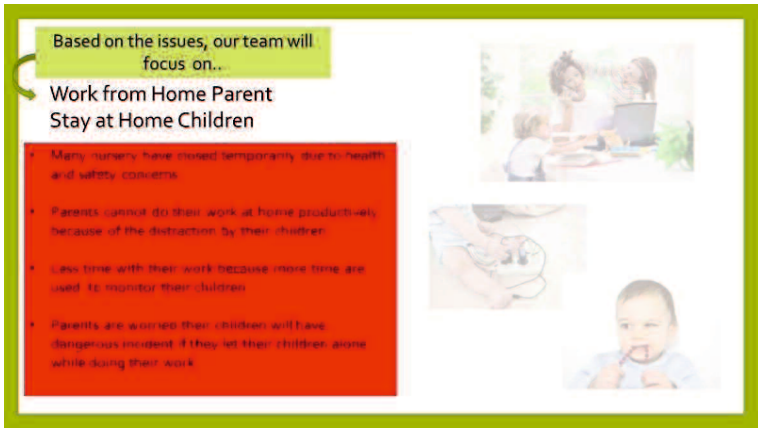

Fig 3-14 Presentation slide page 11. Problem and worries that occurred to work-from-home parents and stay-at-home children (1)

Fig 3-15 Presentation slide page 12. Problem and worries that occurred to work-from-home parents and stay-at-home children (2)

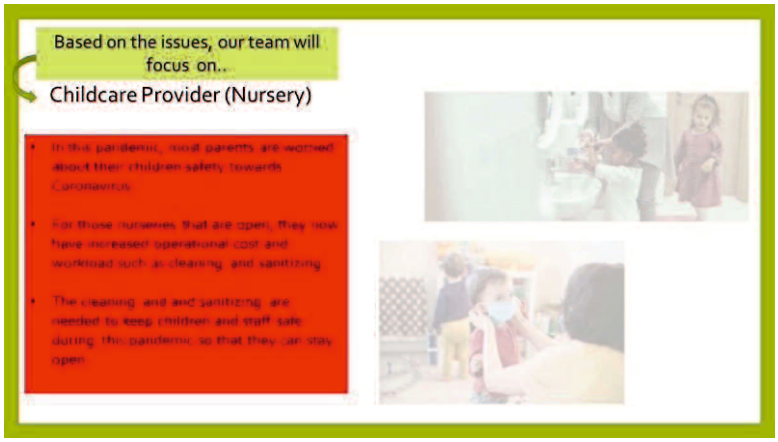

Fig 3-16 Presentation slide page 13. Problem and worries that occurred to childcare institutions and the teachers

Fig 3-17 Presentation slide page 14. Problem and worries that occurred during virus prevention (1)

Fig 3-18 Presentation slide page 15. Problem and worries that occurred during virus prevention (2)

Fig 3-19 Presentation slide page 16. Solution idea for childcare and sanitizing

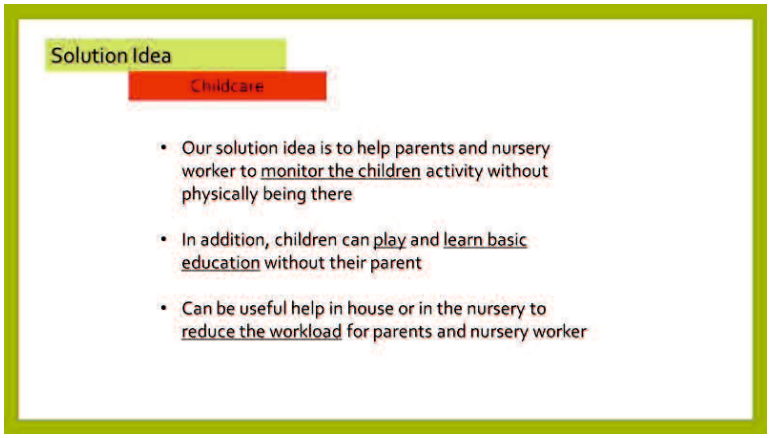

Fig 3-20 Presentation slide page 17. Solution idea for childcare

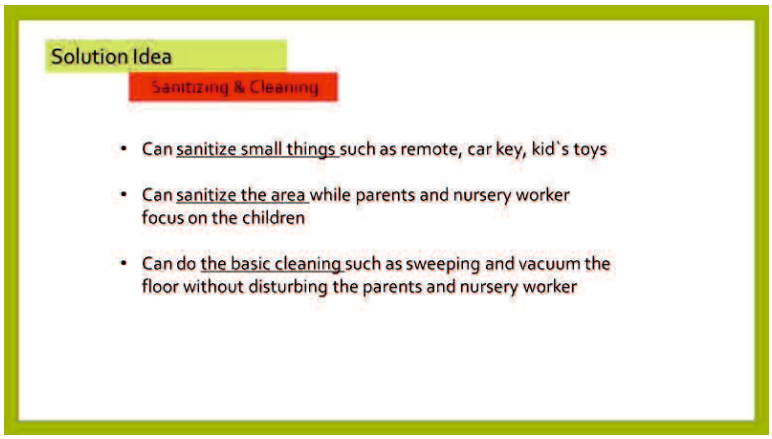

Fig 3-21 Presentation slide page 18. Solution idea for sanitizing and cleaning (1)

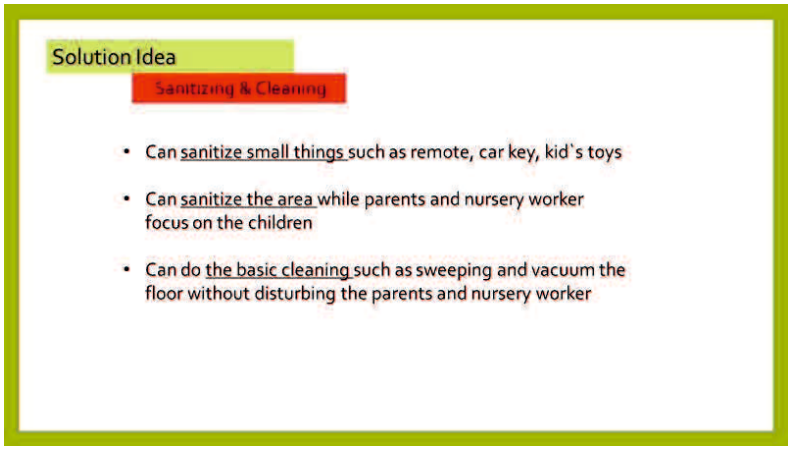

Fig 3-22 Presentation slide page 19. Solution idea for sanitizing and cleaning (2)

In the interview session, interviewees were asked another 30 minutes 4 questions which were how do they feel about their current life in this pandemic, the good points and bad points of COVID-19 pandemic daily life and their opinion regarding the suggested solution idea in the free talk session as suggested by Ulrich et al (2015) in their 'art of eliciting customer needs data'. The question details are shown below.

1. What kind of life are you currently living due to this pandemic? (Housework, Working, etc.)
2. Good points in Covid-19 pandemic daily life
3. Bad points in Covid-19 pandemic daily life
4. Free Talk (Covid-19 pandemic related matters and device-related requests, etc.

3.2.3.2 Prototype and Story-based Slide Presentation and Interview

The `Prototype and Story-based` slide, starts with information about the solution idea, device sketch and prototype which are shown in Fig 3-23 – 3-25. Then, the solution concept by using the prototype and story was explained. In the solution concept, how the remote monitoring concept works in helping the parents to monitor their children was explained in story in Fig 3-26 – 3-34. The second solution concept which is playing and education was shown in Fig 3-35 and 3-36.

Next, the virus sanitizing solution which is an automatic sanitizer spray as shown in Fig 3-35 – 3-40 was explained in the story. Then the UV light sanitizer box solution concept and story was shown in Fig 3-41 – 3-43. The solution for cleaning was shown in Fig 3-44 and 3-45 while other possible functions that the prototype is able to do were also given such as put the child to sleep or ventilating the house are indicated in Fig 3-46. Fig. 3-47 - 3.57 shows the existed products that our team used as references in the solution concepts. The characteristics and functions of the existed products were also being explained in the slides. The slide presentation was conducted for 30 minutes.

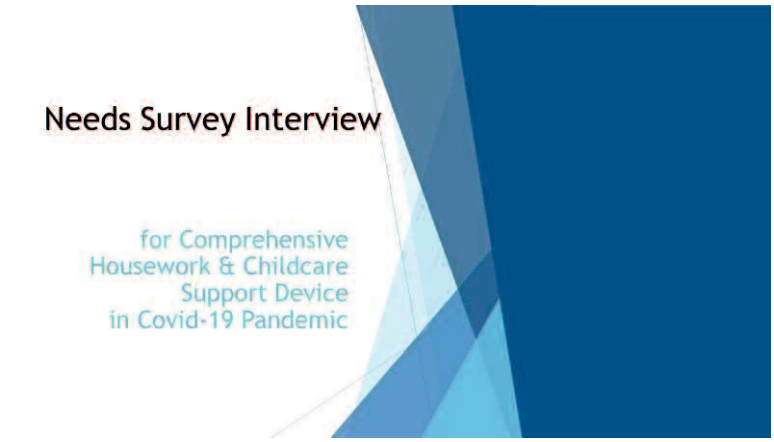

Fig 3-23 Presentation slide page 1 (Prototype and Story-based Presentation Slide)

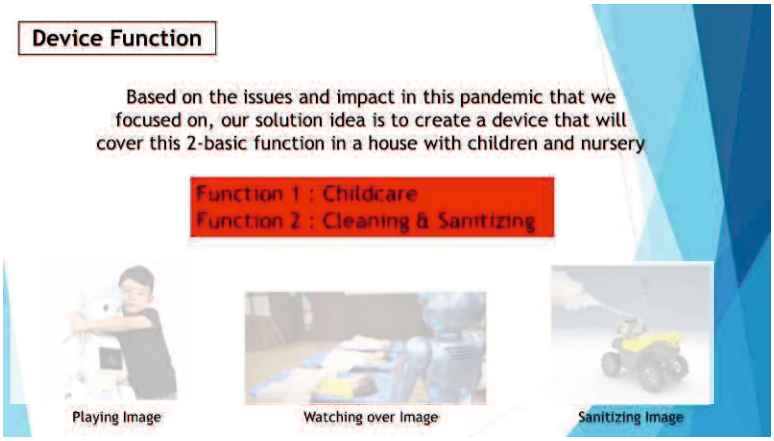

Fig 3-24 Presentation slide page 2. Solution idea for childcare and sanitizing

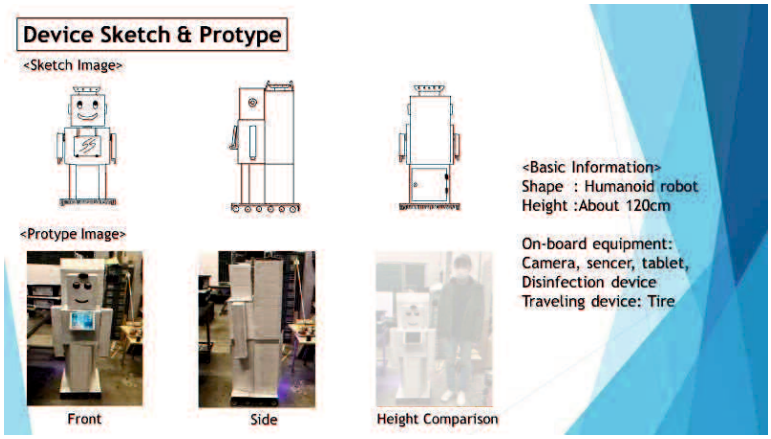

Fig 3-25 Presentation slide page 3. The device's sketch and prototype

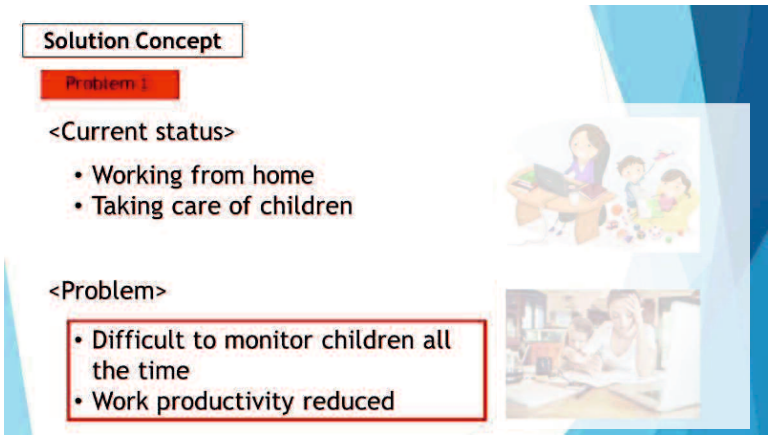

Fig 3-26 Presentation slide page 4. Problem in childcare.

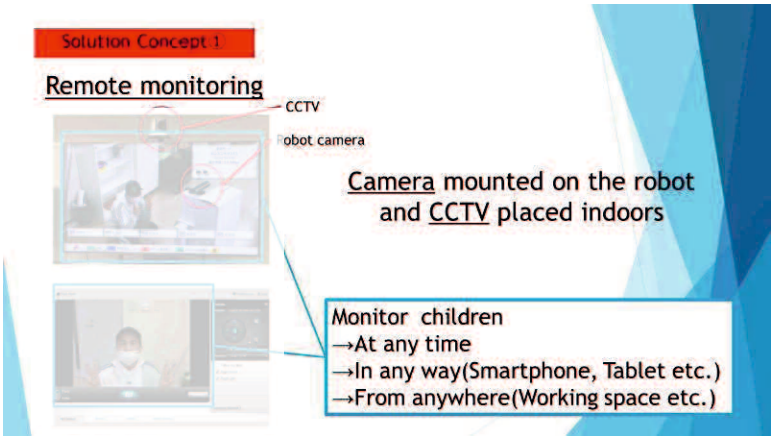

Fig 3-27 Presentation slide page 5. Solution concept for childcare (Remote monitoring) (1)

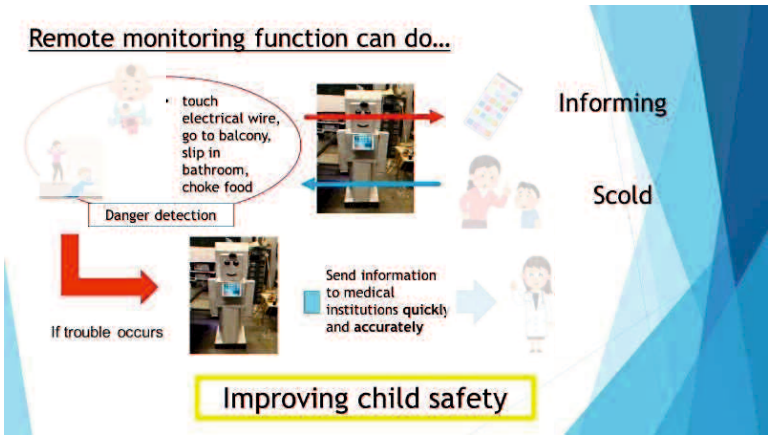

Fig 3-28 Presentation slide page 6. Solution concept for childcare (Remote monitoring) (2)

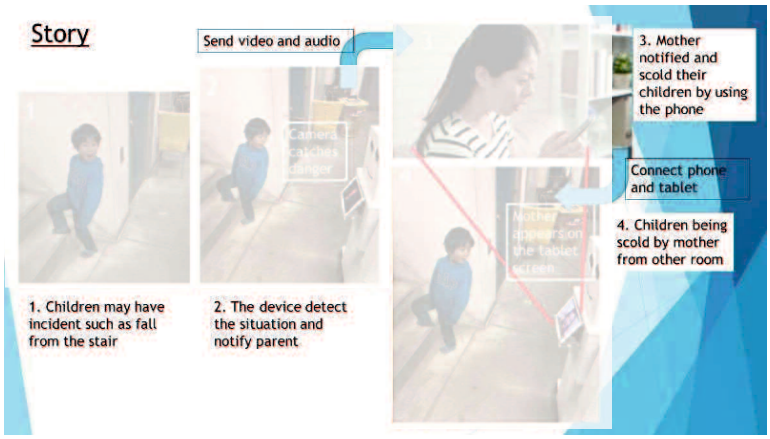

Fig 3-29 Presentation slide page 7. Solution concept and story (Remote monitoring) (1)

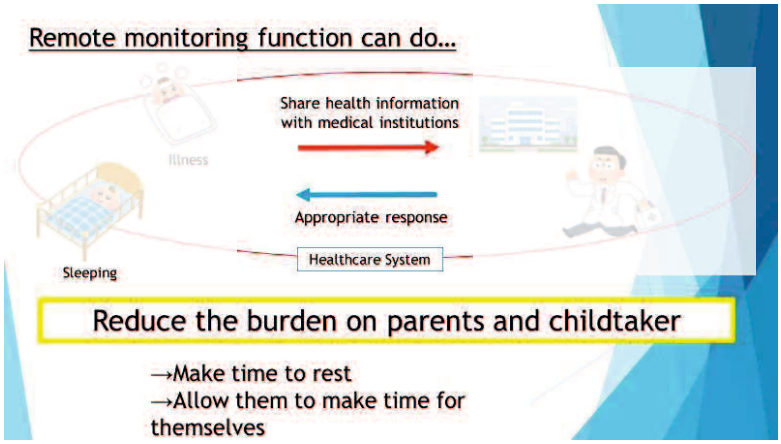

Fig 3-30 Presentation slide page 8. Solution concept and story (Remote monitoring) (2)

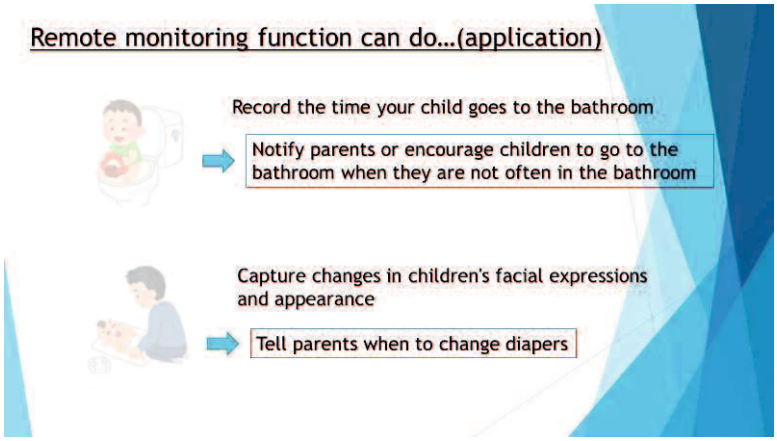

Fig 3-31 Presentation slide page 9. Solution concept and story (Remote monitoring) (3)

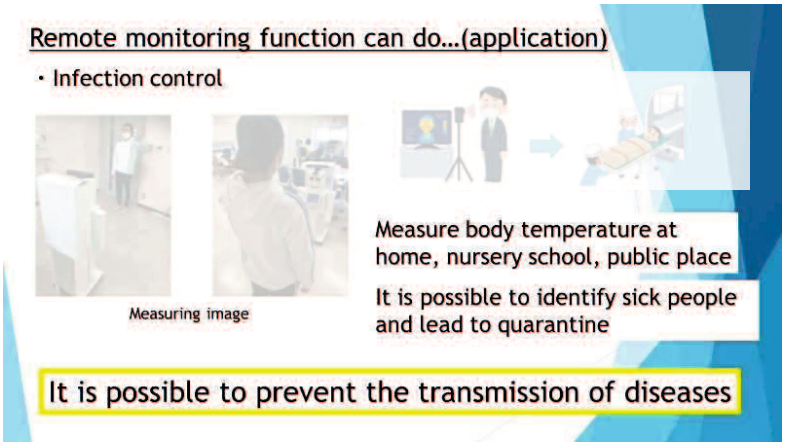

Fig 3-32 Presentation slide page 10. Solution concept and story (Remote monitoring) (4)

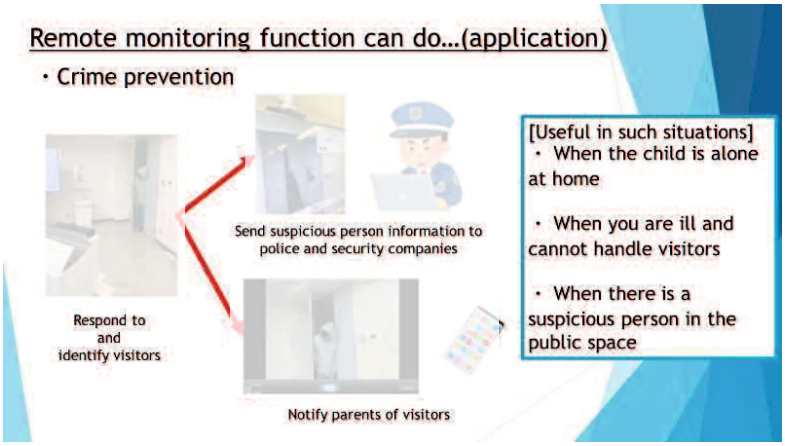

Fig 3-33 Presentation slide page 11. Solution concept and story (Remote monitoring) (5)

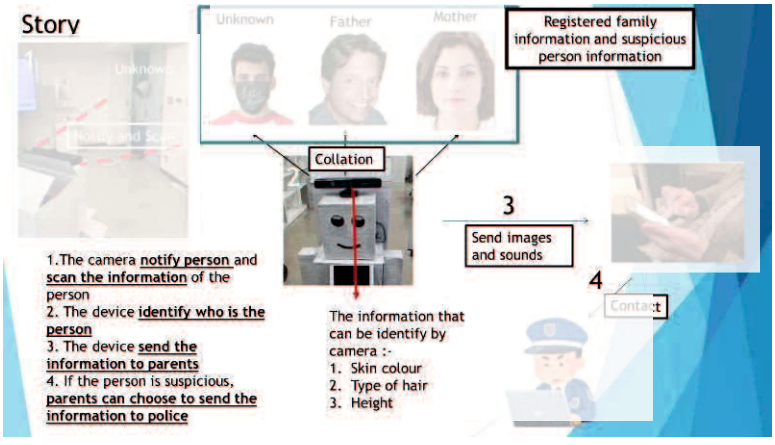

Fig 3-34 Presentation slide page 12. Solution concept and story (Remote monitoring) (6)

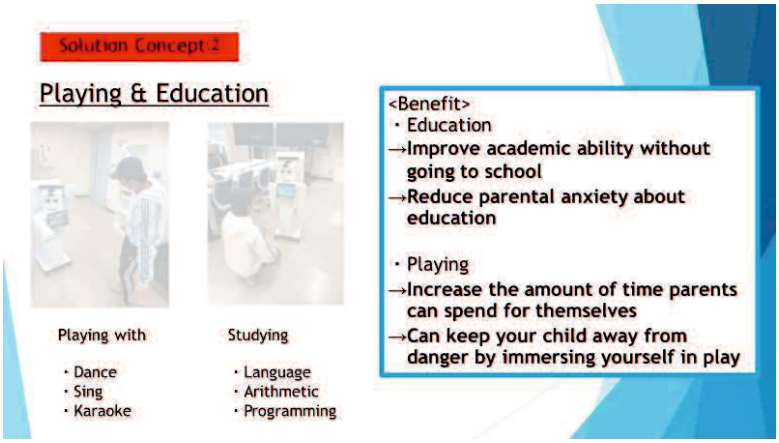

Fig 3-35 Presentation slide page 13. Solution concept and story (Playing & education) (1)

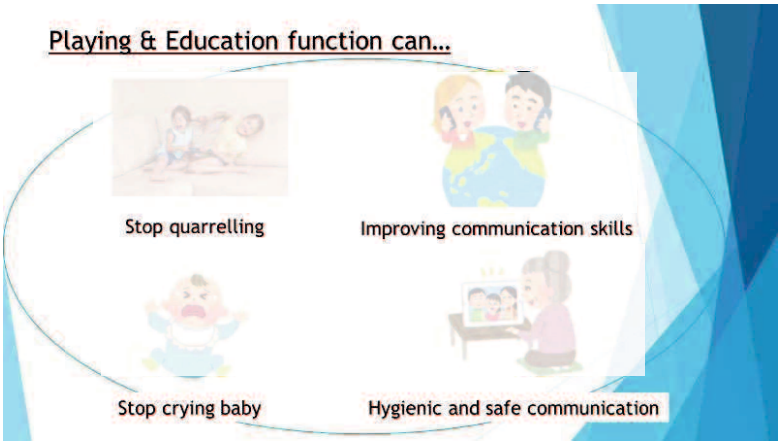

Fig 3-36 Presentation slide page 14. Solution concept and story (Playing & education) (2)

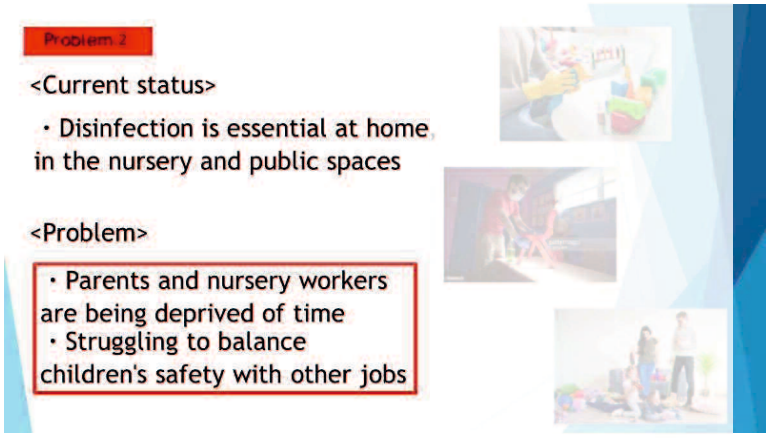

Fig 3-37 Presentation slide page 15. Solution concept and story (Sanitizing) (1)

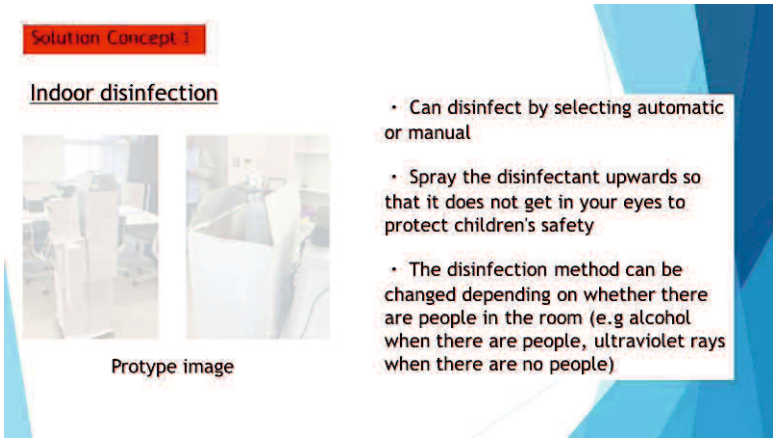

Fig 3-38 Presentation slide page 16. Solution concept and story (Sanitizing) (2)

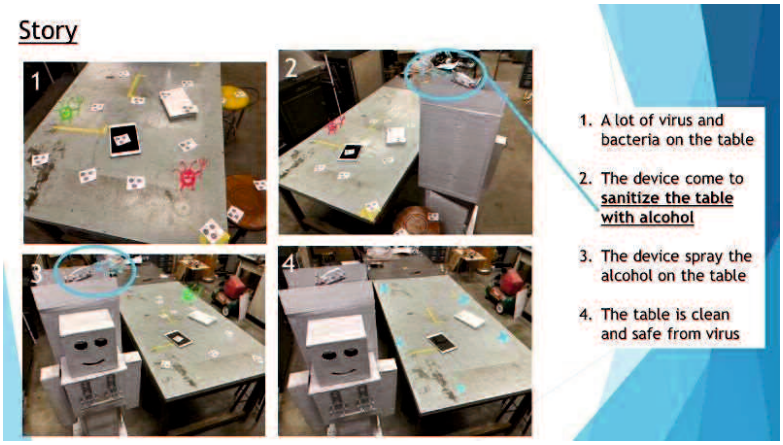

Fig 3-39 Presentation slide page 17. Solution concept and story (Sanitizing) (3)

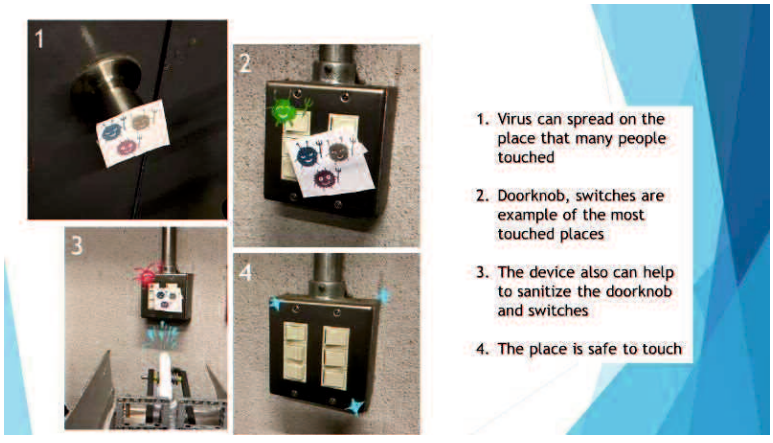

Fig 3-40 Presentation slide page 18. Solution concept and story (Sanitizing) (4)

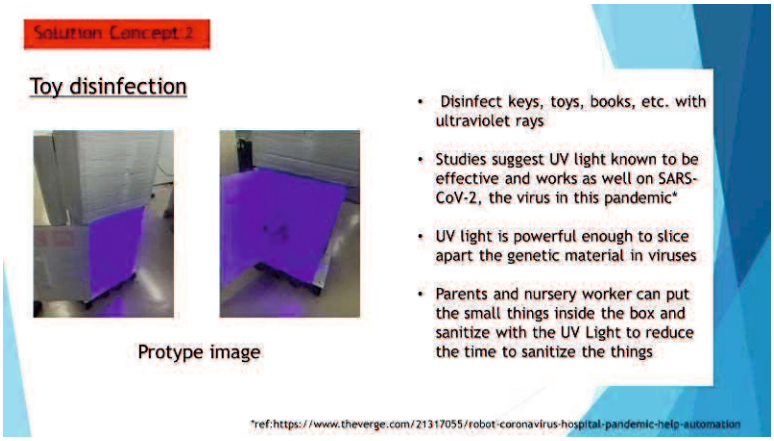

Fig 3-41 Presentation slide page 19. Solution concept and story (Sanitizing box) (1)

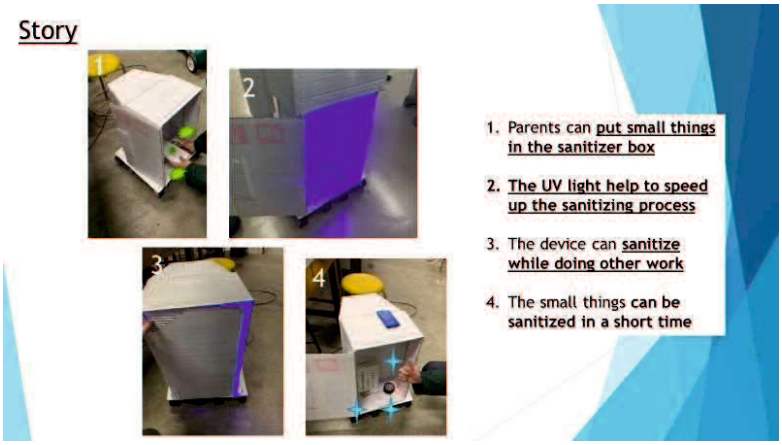

Fig 3-42 Presentation slide page 20. Solution concept and story (Sanitizing box) (2)

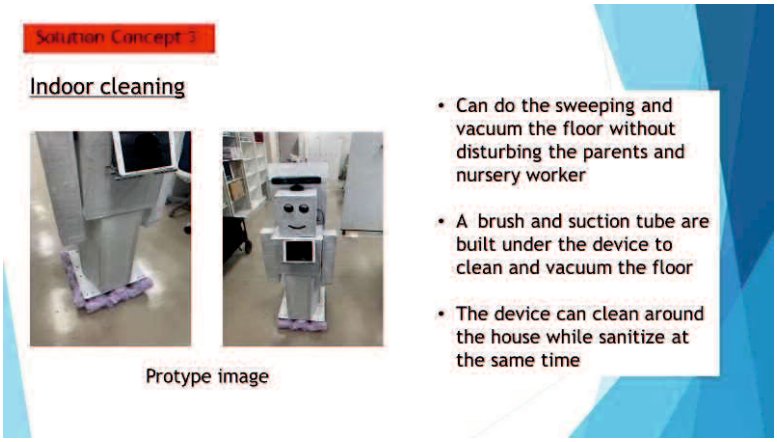

Fig 3-43 Presentation slide page 21. Solution concept and story (Cleaning) (1)

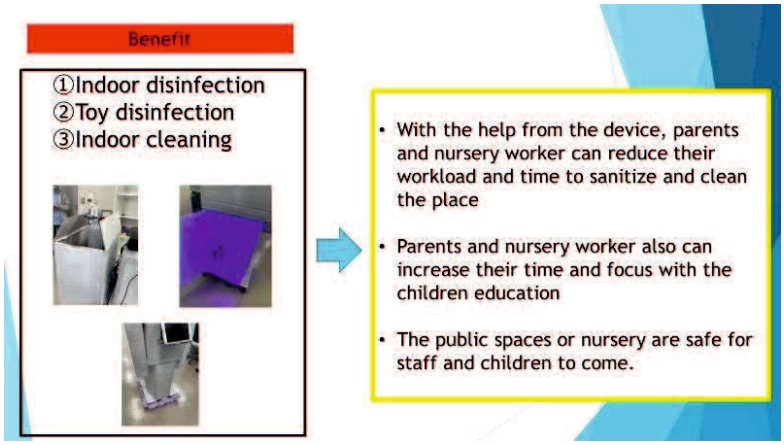

Fig 3-44 Presentation slide page 22. Solution concept and story (Cleaning) (2).

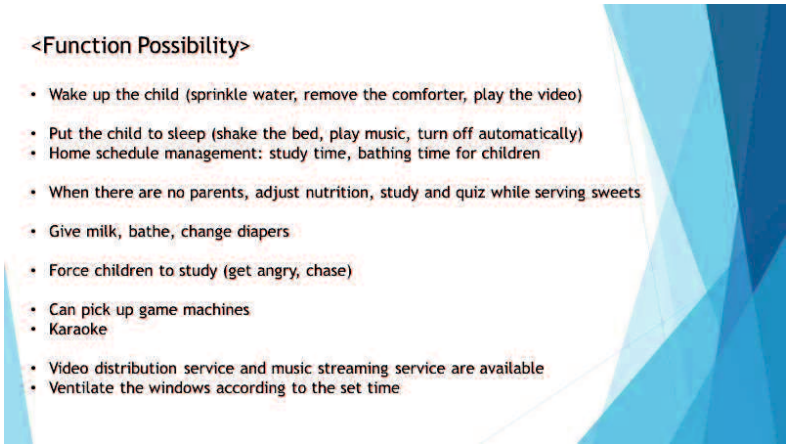

Fig 3-45 Presentation slide page 23. Other possible function for the prototype.

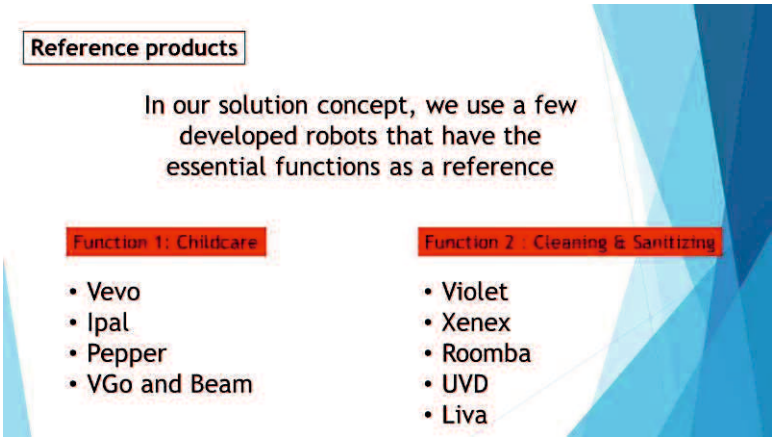

Fig 3-46 Presentation slide page 24. Reference product for the prototype (1)

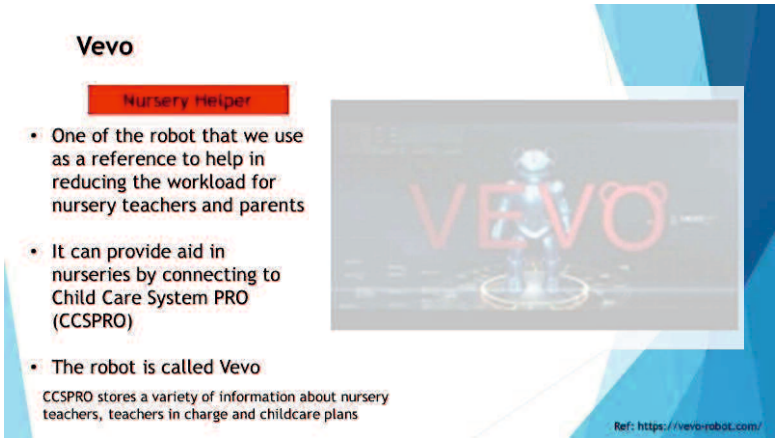

Fig 3-47 Presentation slide page 25. Reference product for the prototype (2)

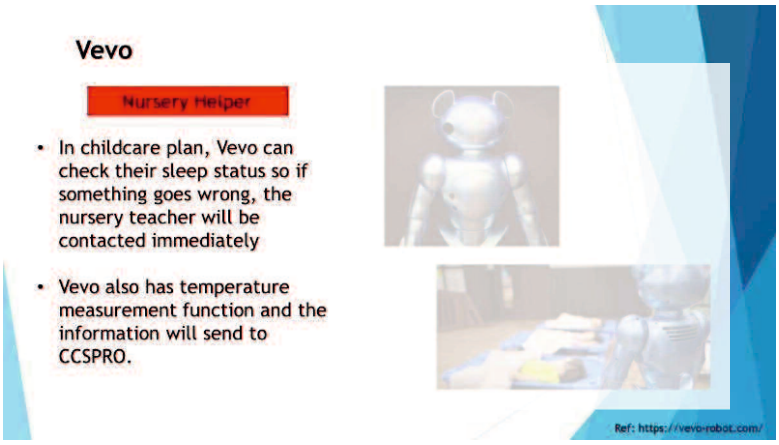

Fig 3-48 Presentation slide page 26. Reference product for the prototype (3)

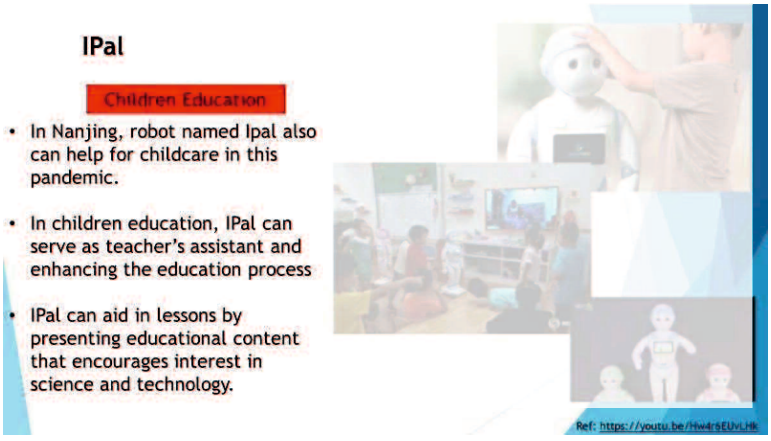

Fig 3-49 Presentation slide page 27. Reference product for the prototype (4)

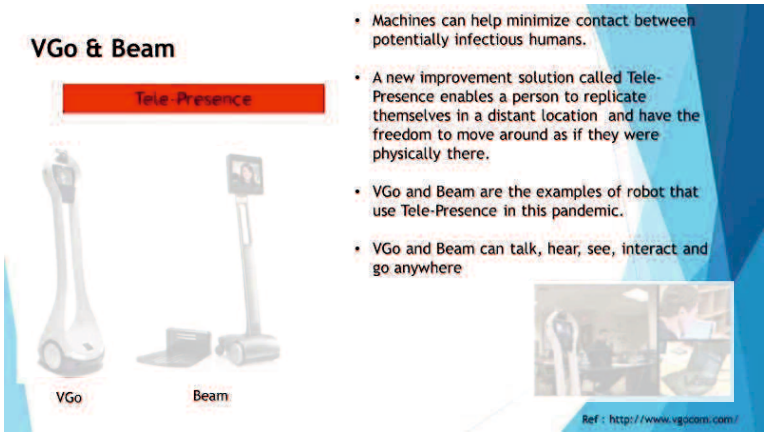

Fig 3-50 Presentation slide page 28. Reference product for the prototype (5)

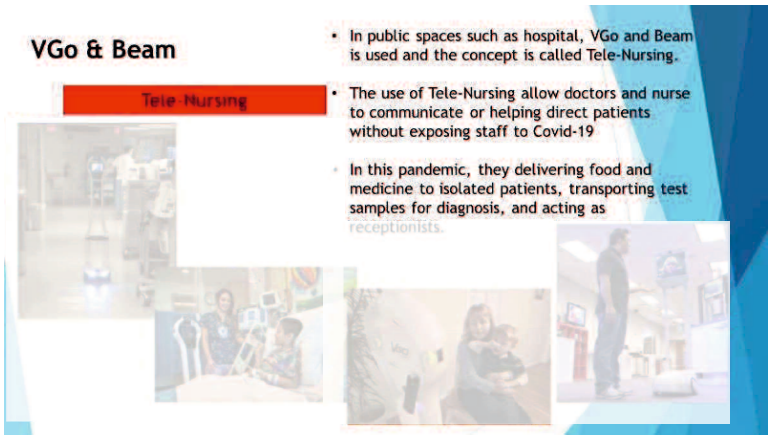

Fig 3-51 Presentation slide page 29. Reference product for the prototype (6)

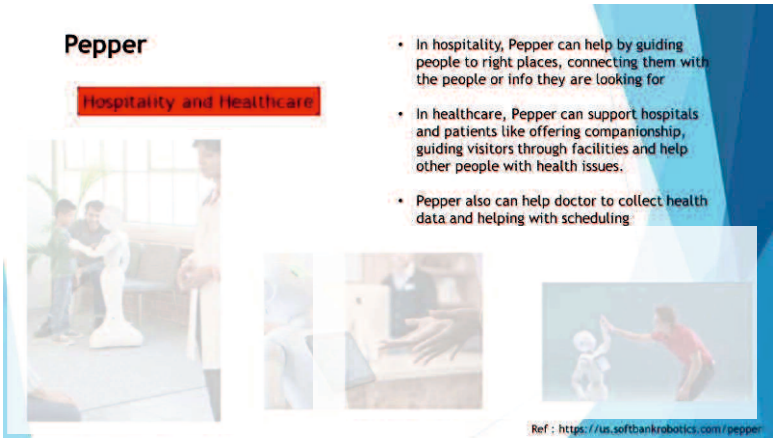

Fig 3-52 Presentation slide page 30. Reference product for the prototype (7)

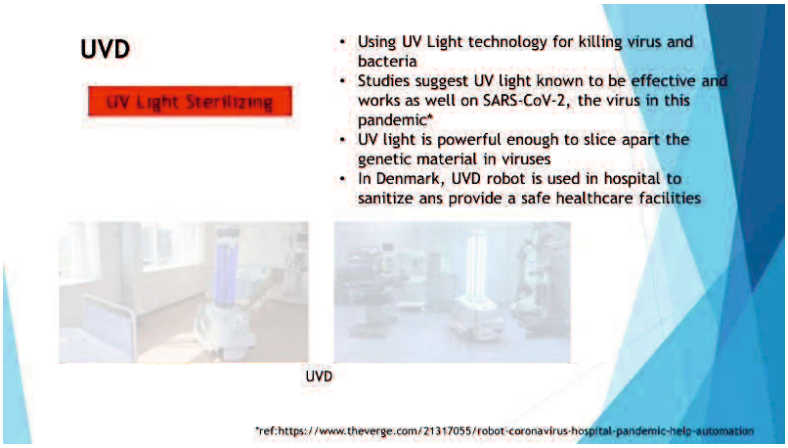

Fig 3-53 Presentation slide page 31. Reference product for the prototype (8)

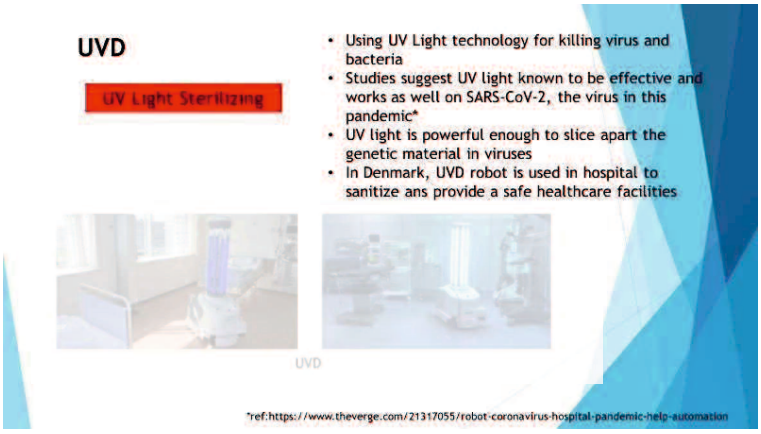

Fig 3-54 Presentation slide page 32. Reference product for the prototype (9)

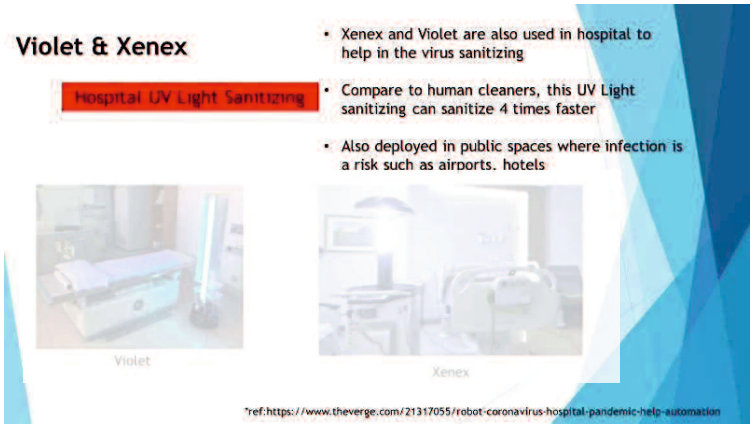

Fig 3-55 Presentation slide page 33. Reference product for the prototype (10)

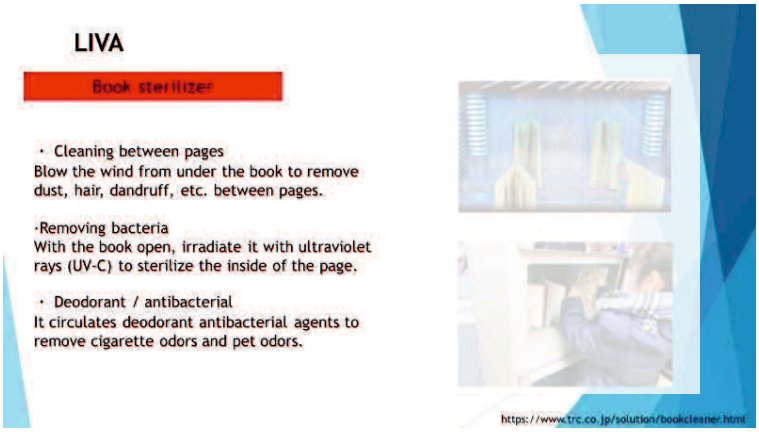

Fig 3-56 Presentation slide page 34. Reference product for the prototype (11)

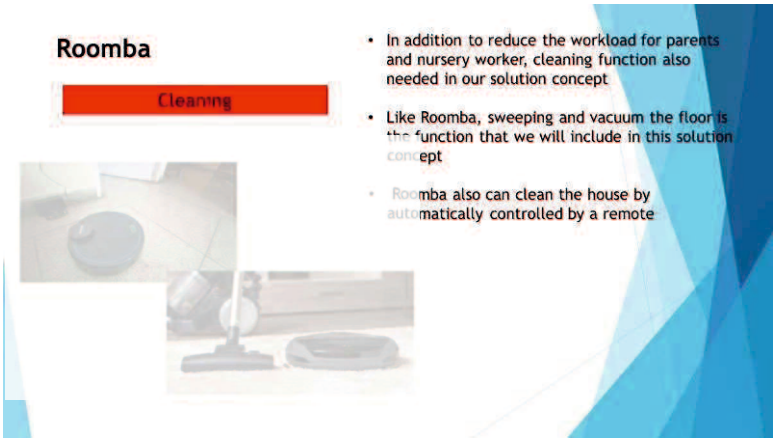

Fig 3-57 Presentation slide page 35. Reference product for the prototype (12)

In the interview session, interviewees were asked another 30 minutes 4 questions with same pattern as first session, the problem-based interview. They were about how do they feel and will use the device, the good points and bad points about the device and their opinion about the improvement of the device in the free talk session as suggested by Ulrich et al 2015) in their 'art of eliciting customer needs data'. The question details for Prototype and Story-based interviews are shown below.

1. How do you use this device?
2. Please tell us what you think is good about this device.
3. Please tell us what you think is bad about this device.
4. Free talk (about improvement points and requests of equipment)

3.2.3.3 Interview Results Interpretation

The interview results were then listed, interpreted, and analyzed according to the 5 guidelines by Ulrich et al (2015). The first guideline is to express the need in terms of what the product has to do, not in terms of how it might do it. Customers frequently describe a solution concept or an implementation strategy to convey their preferences. However, the necessity should be stated without reference to a specific technological advancement. The second guideline is to express the need as specifically as the raw data. There are many different ways to express needs. Express the demand as precisely as the raw data to prevent information loss. The third guideline is to use positive and not negative phrasing. If a need is stated as a positive statement, it is simpler to translate it later into a product specification. However, it is not rigid because using positive language is occasionally challenging and difficult. The forth guideline is to express the need as an attribute of the product. Wording requirements for product statements help to assure consistency and make it easier to translate those requirements into product specifications. The fifth guideline is to avoid the word 'must' and 'should'. It is because the language 'must' and 'should' convey an importance level for the need. It is advised to postpone determining the importance of the needs until the following stage rather than simply giving them a binary importance ranking. The example by Ulrich on how the guidelines were applied during interpretation was shown in Fig 3-58.

Guideline	Customer Statement	Need Statement—Right	Need Statement—Wrong
"What" not "how"	"Why don't you put protective shields around the battery contacts?"	The screwdriver battery is protected from accidental shorting.	The screwdriver battery contacts are covered by a plastic sliding door.
Specificity	"I drop my screwdriver all the time."	The screwdriver operates normally after repeated dropping.	The screwdriver is rugged.
Positive not negative	"It doesn't matter if it's raining; I still need to work outside on Saturdays."	The screwdriver operates normally in the rain.	The screwdriver is not disabled by the rain.
An attribute of the product	"I'd like to charge my battery from my cigarette lighter."	The screwdriver battery can be charged from an automobile cigarette lighter.	An automobile cigarette lighter adapter can charge the screwdriver battery.
Avoid "must" and "should"	"I hate it when I don't know how much juice is left in the batteries of my cordless tools."	The screwdriver provides an indication of the energy level of the battery.	The screwdriver should provide an indication of the energy level of the battery.

Fig 3-58 The guideline by Ulrich (2015) on how to write a need statement

The interview results were interpreted by 4 members of this research. The details of the interpreters are shown in Table 3.3.

Table 3.3 The interpreters' basic information

	Age	Gender	Nationality
Interpreter A	24	Male	Japanese
Interpreter B	22	Male	Malaysian
Interpreter C	37	Female	Malaysian
Interpreter D	22	Male	Japanese

3.2.3.4 Organizing Interpreted Needs into a Hierarchy

The interpreted needs from both interview were then organized separately into a hierarchy. The process of organizing interpreted needs into a hierarchy was adapted from the affinity diagram in KJ Method by Kawakita (1960), and was conducted as follow:

1. Print or write each need statement on a seperate card.
2. Eliminate redundant statement. The cards expressing same need statements can be stapled together and treated as a single card.
3. Group the card according to the similarity of the needs they express. The needs were grouped according to the way customers think about the needs and not the way we think about the product.
4. For each group, choose a label that generalize the needs in the group.
5. Consider creating a super group consisting 2 or 5 groups. The process of creating supergroup is identical to the process of creating group. This supergroups become the primary needs, the group label become the secondary needs and the member of the group become tertiary needs.
6. Review and organized needs statement

The interview results from both interviews that were interpreted into the needs statement based on product functions were then compared together and then compared again with the existed products as shown in Fig 3.46-3.57 to obtain the final number of latent needs.

3.3 Results

3.3.1 Interpreted Needs from Problem-based Interview

The raw data for Problem-based interviews which are the answers to the interview questions are shown in Appendix-A. The interview answers were then translated into English language and interpreted into product function by following the guideline by Ulrich (2015). For example, the interviewee answered, “I want my child to play outside and be involved with friends, but it's difficult.”. The interviewee mentioned 'play outside' and 'with friends', therefore while considering writing as an attribute to the product, we interpret the needs (product function) as “The device can be used indoors and outdoors”, “The device is able to scan virus from outside” and “The device is able to recognize user, guest or stranger”. From the interviewee’s answers “I want to clean the whole house (walls and ceilings too). Viruses go up to the top of the house” and “I want the virus can be seen and detected”, the interviewee mentioned 'clean the whole house', 'walls and ceiling too', 'virus...seen and detected', therefore while considering writing as an attribute to the product, we interpret the needs (product function) as, “The device is able to sanitize from the floor until the ceiling” and “The device is able to scan viruses in the whole house”. From the interviewee’s answers “I ask husband to shower after returning from work” and “I disinfect all clothing from the outside”, the interviewee mentioned 'shower after returning', 'disinfect...from outside', therefore while considering writing as an attribute to the product, we interpret the needs (product function) as, “The device will remind the user to wash hand, sanitize or shower once arrived” and “The device will sanitize clothes brought from outside”.

The interview answers and the interpretations of the needs were shown in Table 3-4 – 3-8 for each interview group.

Table 3-4 Raw data and interpreted needs from the problem-based slide presentation and interview (Group 1)

Question No	Interviewee	Raw Data (Interview Answers)	Interpreted Needs
1	A	- I'm a childcare worker, so my work is on-site - I try not to go out at home - I try not to take my children to the supermarket.	- The device is able to be used at home or nursery - The device is able to conduct tasks in a house or nursery - The device is able to take care of children at home while parents go shopping - The device is able to do the shopping
	B	- Field work - No holidays, work at the daycare center and go home as before.	- The device is able to take care of children while parents are out working - The device is able to take

		– Hand washing is the same as before. – I do all my shopping on weekends. – I don't go to popular places or areas.	care of the house – The device will remind user to wash their hand – The device will do the shopping on weekend – The device will give updated info on highly infected region
	C	– Life hasn't changed much. – School is not in session. – The older child stays home alone and studies, but I don't know what goes on at home at that time. – The younger child is left at a day service when school is not in session.	– The device has no effect to everyday routine before or after having the device – The device able to be used for working days or holiday – The device is able to take care of children at home – The device is able to be used in daycare
2	A	– I have a clean house because I am at home for a long time. – Plenty of time to clean	– The device is able to clean the house while the user is in it – Detailed cleaning task and schedule are able to be programmed to the device
	B	– No outbreak of vomiting and diarrhea (norovirus, cold virus). – No influenza either...because everyone is disinfecting?	– The device is able to detect other virus too (such as norovirus and influenza) – The device is able to sanitize and kill other virus
	C	– Masks and hand washing prevent the spread of influenza and other diseases. – The only thing that costs money is food.	– The device will remind user to wear mask and wash hand – The device will give financial or spending advice
3	A	– I want my child to play outside and be involved with friends, but it's difficult.	– The device can be used indoor and outdoor – The device is able to recognize user, guest or stranger – The device is able to scan virus from outside – The device is able to suggest stress reducing game – The device will guide user how to relax

	B	– I can't go back to my parents' house because it is far away	– The device can take care of the house while users are away – The device able to do a video call
	C	– I regret that I can't hold events. – I can't go out of the prefecture and avoid crowds, so my scope of activities is limited.	– The device is able to detect and inform the place that full of people – The device is able to detect and inform highly infected region – The device is able to advise safe place to go
4	A	– I want to clean the whole house (walls and ceilings too). Viruses go up to the top of the house – I want the virus can be seen and detected (there is a special solution that can be applied to the area where the bacteria are attached, but it is difficult to do this at home). – Item that can be easily obtained – Preparation and clean-up of meals – As a parent and a housewife, it would be helpful if they could do household chores.	– The device is able to sanitize from floor until the ceiling – The device is able to detect viruses – The device is able to scan viruses in whole house – The device is able to do the housework such as preparing food and cleaning kitchen – The device is able to do the chores of mother and housewife
	B	– I am afraid to take my eyes off my child because he is still 2 years old and I don't know what he will do. – I am afraid to take my eyes off my child, whose interests are expanding but who does not yet know what is wrong and what is right.	– The device is able to prevent children from going up the stairs by themselves – The device is able to prevent children from falling of stairs – The device will do the house chores when parents want to take care of children – The device is able to take care of children if parents want to do any house chores
	C	– I want item like a mist that completely sterilizes you	– The device is able to spray with sanitization mist/UV once

		when you pass through it, like before you go into an operating room. - (B: It would be good if there is one at a nursery school), equipment that disinfects when you pass through without damaging your clothes and skin, without the need for disinfection, and without stopping (A and B: After all, hands are rough and stinging, and disinfection that doesn't irritate them is good).	user walk through it - The device's sanitization mist is safe and gentle to user skin and clothes
	Chain of opinion	C: Something simple like PCR to tell if you're pregnant or not. A: A kit that can be used to detect pregnancy by putting saliva on it. B: I'm afraid that asymptomatic people will be found to be infected when they are tested. A: Something that can control room temperature, humidity, and sterilization. C: I have to have a humidifier. A: It's hard to put on a plasma cluster or something like that	- The device that can provide fast result for PCR test - The device is able to adjust temperature and humidity in a room while sanitizing

Table 3-5 Raw data and interpreted needs from the problem-based slide presentation and interview (Group 2)

Question No	Interviewee	Raw Data (Interview Answers)	Interpreted Needs
1	A	- I ask husband to shower after returning from work. - I disinfect all clothing from the outside - I always wash hands after returning from outside - I wash baby's hands after returning from daycare -	- The device will remind user to wash hand, sanitize or shower once arrived - The device will sanitize clothes brought from outside - The device provides sanitizing alcohol for hands
	B	- I separate the clothes you wear outside from the	- The device will remind on laundry schedule

		clothes you wear only inside the house. – I do laundry every day (sometimes twice a day)	– The device will scan for virus and sanitize clothes – The device will alert user if clothes from outside are not placed properly
	C	– I limit the number of time children can play outside, and only play in areas with few people. – I separate clothes after going outside and showered after each return. – I have a special place for everything that comes in from the outside (e.g., parcels from the mailman).	– The device will suggest places that is safe and less congested – The device will suggest outdoor games suitable for short time – The device will remind user to separate clothes and to take shower after going out – The device will remind user to leave things from outside and sanitize it
2	A	– I can work from home (no need to go to college)	– The device is able to be used at home or in campus
	B	– Online classes help me make more time at home while taking care of my children.	– The device is able to conduct video call for online classes – The device will take care of the children during parents' online class or meeting
	C	– Cleanliness improved at home (children wash their hands all the time) – We don't have to ask the children to take showers (they are afraid of viruses and know when to shower) – Children are more obedient when it comes to cleaning	– The device will remind user to shower, wash hand and sanitize – The device will remind children to shower, wash hand and sanitize – The device will clean up and sanitize the house – The device will suggest cleaning schedule
3	A	– We cannot go anywhere for fear of the virus. – I become paranoid (feel like the virus is everywhere) It is difficult to disinfect hands each time – Skin on my hands becomes dry (I need to bring skin moisturizer)	– The device is able to scan and detect virus – The device will remind to sanitize – The device will provide sanitizing option that is safe and gentle to skin – The device is able to provide sanitizer with moisturizer – The device's sanitizing part is able to be taken and carried

		– I need to wipe chairs and tables when eating in restaurants	outside to sanitize
	B	– The children were bored at home because I can't go anywhere.	– The device will suggest fun game and activities
	C	– Children are bored in the house. – Children are always looking for new toys – I need to buy lots of toys (so I do not need to go out often to buy new toys)	– The device will suggest fun activities and game suitable for children – The device is able to suggest new game with toys in the house – The device is able to do shopping for new toys
4	A	– I want a hand sanitizer that does not dry out my skin. – I want a device that can see the virus (visually)	– The device is equipped with sanitizing option that safe and gentle to hands – The device is able to scan virus
	B	– I want an air humidifier disinfectant	– The device is equipped with sanitizing option that include humidifier
	C	– I need a machine that can disinfect the entire room (like an air conditioner, but be careful not to make it difficult to breathe).	– The device is able to sanitize one whole room – The device' sanitizing process is safe to user respiratory system

Table 3-6 Raw data and interpreted needs from the problem-based slide presentation and interview (Group 3)

Question No	Interviewee	Raw Data (Interview Answers)	Interpreted Needs
1	A	– The covid-19 pandemic started last January in Japan. – I started panicking, but the good news is that I live in Ube. – It did not affect my work. (It affected people in Tokyo.) I didn't mind it	– The device is able to be used in any region or any weather – The device is suitable to be used in workplace – The device will remind user to wear mask unless user is in the house – The device is able to be used in shopping mall – The device is able to do

		because I have a habit of wearing a mask at work. – I was not bothered by it compared to other foreigners because I have a habit of wearing a mask depending on my work. – I worked part-time at Animal House at the time. I wore masks with gloves. But it was hard because I had to wear a mask not only at work but also in other places. – I started to refrain from bringing my children to the mall. – I took my son out of daycare for a month. I am afraid that my child is weaker and more susceptible to illness. I am afraid of touching this and that. – I was working at the time, but my husband was taking online classes. – I was most affected when I gave birth to my second child (daughter). – I wanted to be present at the birth of my first child because I was not able to be present at the birth of my first child, but I was disappointed that I could not do so because of the covid-19 –	shopping for user – The device is able to be used in nursery or kindergarten – The device will record places that user/people touch, scan and sanitize – The device is able to be used for online classes – The device is able to be used in hospital – The device is able to connect labor room and family member outside – The device is able to conduct rapid PCR test – The device is able to scan and sanitize labor room fast
	B	– (No answer)	– N/A
2	A	– I have had allergies and hay fever for the past three years, but I have had no allergies or hay fever since covid-19 arrived. – I think it is because I and others are clean.	– The device is able to scan for pollen and spores too to prevent allergic reaction – The device is able to measure air cleanliness – The device is able to clean air – The device will suggest healthy food and lifestyle – The device will monitor

		– My child visited the pediatrician only once last year, and he is doing better than before. Because everyone is working together to keep clean. – The government benefits are also good.	financial expenses and suggest new idea if monthly income changes
	B	– I can spend more time with my family.	– The device will suggest fun activities and game suitable for one whole family
3	A	– I can't go back to my country. I was scheduled to return. – I could not return home because my flight was cancelled and I could not get in and out of Japan. – Shopping became a hassle. I wait in the car with my children while my husband shops. And then we exchange. But there is an advantage here, too: my husband has become a better shopper. He used to forget to buy some of the things on my list.	– The device is able to be used in airport – The device is able to scan viruses and sanitize in big place like airport – The device is able to conduct PCR test and provide fast result – The device is able to do shopping for user – The device is able to take care of children while parents go shopping – The device is able to suggest shopping list based on user routine
	B	– Inability to conduct research. Having to cancel experiments and conferences. – But there is an advantage in that, I discovered that I can do things without face to face	– The device is able to be used in lab or meeting room – The device will suggest or advise on optimizing online meeting or discussion
4	A	– Before the cancellation of the Olympics, the Japanese government appeared to have done fewer PCR tests to make the number of infections appear lower. After the cancellation, the number of cases went up.	– The device is able to do PCR test – The device will advice on safe place to travel – The device will advice to avoid congested area – The device is able to be used in office – The device is able to be used

		– And then they do GoToTravel, etc.... I don't trust the Japanese government because I'm worried. – I'm worried about my husband going to work every day. Worried about sending my child to daycare.	in nursery or kindergarten
	B	– I am worried about my child, and I want to help him go to school with peace of mind. – I want a device that can detect viruses. – I don't feel much that I want support for my children at home because they are ready for school. – I want a device that can confirm that my child is healthy and not infected when he/she comes home from school.	– The device is able to be used in school – The device will scan and detect virus in kindergarten and school – The device will send report on virus scanning status in kindergarten or school to the parents from time to time – The device will scan for viruses once user arrived at home

Table 3-7 Raw data and interpreted needs from the problem-based slide presentation and interview (Group 4)

Question No	Interviewee	Raw Data (Interview Answers)	Interpreted Needs
1	A	– Work sometimes at home, sometimes at the office, sometimes at the hospital (business location) – Children's classes are online only (3rd and 1st graders)	– The device is able to be used in house, office or hospital – The device is able to be used for more than one online class at the same time
	B	– Currently, classes are online and I go to the school occasionally for meetings. – My husband also works from home, so he takes care of the children during online classes.	– The device is able to be used in house or school – The device is able to be used for online class and meeting – The device is able to take care of children while parents have online class/meeting

2	A	– More time with family – The ability to experience homeschooling – Picking and choosing teaching materials in addition to the classes set up by the elementary school.	– The device will suggest family activities or games based on family number and ages – The device is able to provide material for teaching children at home other than material from school – The device is able to teach children at home – The device is able to tutor more than one child at the same time
	B	– I can see my child's growth at home. – Activities can be done with them as they grow. – Not being stuck in traffic jams. – It usually takes me an hour to get to school each way.	– The device is able to record children growth – The device is able to provide child growth report to parents – The device will suggest activities or games based on children ages – The device will provide updated information on congested traffic – The device is able to suggest best route to avoid traffic
3	A	– Financially difficult to afford. – I was worried that my children would not be able to catch up on their studies, so I sent them to cram school as well (online). – I am also working, so I am tired when I come home and sometimes I cannot support my children's study. – I am not a teacher and have no teaching experience, so I don't know how to teach and support children.	– The device is able to give financial advice – The device is able to record children's study growth and performance – The device is able to support and teach student during and after online classes – The device will give proper advice, alarm and warning to avoid parents scolding children – The device will give advice on how to support children study
	B	– I have no time for myself. – Stress is increased by not being able to leave the house.	– The device is able to take care of house and children while parents go out for me-time

		– Limited places to go even if I could get out of the house (park below the house) – Going to meetings at school has become something to look forward to. – I can't think straight? – Mrs. A said, 'Well, it's the same feeling I had when I was on maternity leave. – If I'm going to make a device, I want one that can cook. – I want a device that can cook as soon as I put in the ingredients. – The current products (pressure cookers, etc.) are still inconvenient because you have to cook to a certain extent. – I can clean up my room by myself, but I need help with cooking.	– The device will suggest few types of relaxation method indoor or outdoor – The device is able to take care of house and children while parents are relaxing – The device will suggest new activities in the usual outing spot or in the house – The device is able to suggest schedule that balance parenting and relaxing – The device is able to cook – The device will prepare food just buy putting ingredients in it – The device is able to clean up after cooking
4	A	– (No answer)	N/A
	B	– (No answer)	N/A

Table 3-8 Raw data and interpreted needs from the problem-based slide presentation and interview (Group 5)

Question No	Interviewee	Raw Data (Interview Answers)	Interpreted Needs
1	A	– Always at home except for work – Can't go anywhere (eating out, shopping, etc.)	– The device is able to be used in workplace or home – The device is able to be used in restaurant or supermarket
	B	– I work from home, but still need to go to the office once or twice a week. – I spend a lot of time at home.	– The device is able to be used in office or home – The device will assist on house chores

	C	– I don't like face masks (they make me feel uncomfortable) – I have to do more laundry. – Most of the time, I can't travel and stay at home.	– The device will alert user if user forgot to wear mask outside the house – The device is able to do laundry – The device will advice safe place to go for vacation
2	A	– . I save money because I spend a lot of time at home. – I love it because I am a "stay at home" person – Planning my work is easy (business from home)	– The device is able to provide financial advice – The device is able to be used in workplace or home – The device is able to suggest business plan
	B	– Significant savings on transportation (no travel expenses)	– The device is able to suggest cheap and safe travel plan
	C	– I spend a lot of time on children and household chores, so I realize how difficult it is to be a mother. – It is my habit now to help my wife with the household chores.	– The device is able to do house chores – The device is able to take care of children and house
3	A	– I can't go anywhere (for fear of viruses). – Difficult to disinfect every time	– The device is able to scan detect virus – The device is able to advice safe place from viruses – The device is able to sanitize user and house – The device will remind user to sanitize
	B	– I think about myself and my family so much that I forget the people around me. – I put my family and myself first. – I am unable to care for my friends who need help more than I do.	– The device is able to connect user to friends and family outside the house – The device will remind user to take care of oneself – The device will remind or update user about friends and family outside the house
	C	– · Must limit daily activities – · Cannot go outside to work even with a normal	– The device will suggest activities and area that safe from virus

		cough (people around you will look uncomfortable)	– The device is able to provide rapid PCR test to make sure user cough is normal flu or covid-19
4	A	– Need a device that can detect viruses – Need a device that can warn if a location is safe	– The device is able to scan and detect virus – The device is able to provide update information on safe place to go
	B	– Device to help detect external viruses on clothing or body when entering a home (place device on door)	– The device is able to scan and detect virus before user entering the house
	C	– I need a device that can interact with my child while doing household chores. – I need a cleaning robot that my child can use as a toy.	– The device is able to take care of children while doing house chores – The device is able to clean house – The device is able to play with children – The device is able to play with children while doing the cleaning

3.3.2 Interpreted Needs from Prototype and Story-based Interview

The raw data for Prototype and Story-based interviews which are the answers to the interview questions are shown in Appendix-A. The interview answers were then translated into English language and interpreted into product function by following the guideline by Ulrich (2015). For example, the interviewee answered, "I think it's important to be warm, to change diapers, to touch"and "I think it's important to show warmth". The interviewee mentioned 'warm', 'change diapers', 'touch' and 'show warmth', therefore while considering writing as an attribute to the product, we interpret the needs (product function) as, "The device is able to provide human touch and warmth while changing diaper "The device is able to give warm facial expression". From the interviewee's answers"I don't want to reduce the amount of time I can spend with my baby" and "I think it may be lucky for the mothers, but I don't think it is good for the babies", the interviewee mentioned 'reduce time', 'with my baby' and not good for the babies' , therefore while considering writing as an attribute to the product, we interpret the needs (product function) as, "The device will take care of other house chores while parents with the baby" and "The device's function can be set to take care other things than a baby". From the interviewee's answers "The device has no first action and the child

has already been in an incident", "If a child is involved in an incident, it does nothing for example broken glass", and "Notifying parents is not sufficient because the child may come into contact with the broken glass", the interviewee mentioned 'no first action', 'already in incident', 'notifying parents not sufficient' and 'contact with broken glass'. Therefore, while considering writing as an attribute to the product, we interpret the needs (product function) as, "The device is able to react fast in case of emergency", "The device is able to react fast in case of danger" and "The device will stop a child from touching dangerous thing (broken glass, open wire, fire, etc.)".

The interview answers and the interpretations of the needs were shown in Table 3-9 – 3-13for each interview group.

Table 3-9 Raw data and interpreted needs from the prototype and story—based slide presentation and interview (Group 1)

Question No	Interviewee	Raw Data (Interview Answers)	Interpreted Needs
1	A	– It can be used in day-care centers. – There was a discussion at the nursery school about introducing a function to measure body temperature and to attach a chip to the heart rate.	– The device is able to be used in kindergarten or nursery – The device is able to measure body temperature – The device is able to measure heart beat – The device measure heart beat by connecting to heartbeat sensor placed near the body
	B	– Disinfection is good. – The number of toys is great, it's hard to soak them in liquid and hang them up to dry, it's convenient that you can disinfect them by putting them in, there are a lot of picture books – It is good to be able to measure body temperature, I was very worried when I was a newborn.	– The device is able to sanitize house – The device is able to scan and detect most touch part of the house and sanitize – The device is able to sanitize a lot of toys at the same time – The device is able to sanitize a lot of books at the same time – The device is able to measure temperature
	C	– It is good to open and close the window. – It is good to be able to report when a child is injured. Since the childcare worker cannot leave the injured child, it	– The device is able to open and close window and curtain – The device is able to contact authorities (police/hospital) in case of emergency or accident – The device is able to contact parents in case of emergency

		would be useful if the robot could call or inform the parents or call someone and ask them to bring it back.	– The device is able to follow order from user (to call someone or to bring something etc.)
2	A	– (No answer)	N/A
	B	– (No answer)	N/A
	C	– (No answer)	N/A
3	A	– Childcare is about the relationship between human beings and human beings, and human relationships. – Robots should play the role of a robot, and the part that a robot can never do (changing diapers, human eyesight, checking rough skin, etc.). – I believe that robots can't see small changes, and that only humans can do it. – Robots is for a system that make human pay more attention to children. More time to interact with children	– The device is able to give human-like touch – The device is able to give a human-like warm hug – The device is able to detect small changes of a child while measuring temperature – The device is able to detect small changes of a child while changing diaper – The device will do other house chores while parents take care of children – The device will suggest activities for parents and children to do together – The device's function can be selected by user
	B	– I think it's important to be warm, to change diapers, to touch. – I think it's important to show warmth – I don't want to reduce the amount of time I can spend with my baby. – I think it may be lucky for the mothers, but I don't think it is good for the babies.	– The device is able to provide human touch and warmth while changing diaper – The device is able to give facial expression – The device will take care of other house chores while parents with the baby – The device's functioning time is able to be set by user – The device's function can be set to take care other things than a baby

	C	– It is my job to notice if there is something different from the usual. – (B: Even if there is a sensor, I double-checked) – When the robot can notice such details, childcare workers will not be needed. – I don't want robot as nursery school teachers or nurses, but I want them as assistants. – (B: I think I think this way because I am a childcare worker, and we live in an age when we raise our children while looking at our smartphones)	– The device is able to detect small changes in child compare to other day – The device's function is only to support parents or nursery/kindergarten teacher – The device will remind parents if they did not look after he children (ex. Looking at the phone)
4	A	– (No answer)	N/A
	B	– (No answer)	N/A
	C	– I want mask disinfectant, washable, stinky, mask storage.	– The device is able to sanitize and keep mask
	Chain of opinion	– B: I hope the form is round – A: It would be good if the expression changed. – B: Roundness gives the image of warmth, while a warm face gives the image of coldness. – C: Robot warmth is good, human skin is good – A: Body temperature is very important. – B: That's true. – C: It's cold when you touch it, it should be at least as warm as your body, and it should be something that puts you to sleep when you hold it. – A: It should be made of silicon, close to human skin.	– The device's shape is round – The device is able to give facial expression – The device's texture feels like human skin – The device's temperature is same as human – The device's texture is soft like silicon – The device's hand is able to hold child's hand until he/she falls asleep – The device is able to pat child while slowing the pace until he/she falls asleep – The device able to put blanket on a sleeping child – The device is able to correct the position of blanket – The device is able to correct a child sleeping posture – The device is able to scold or

		– C: If the child cannot fall asleep unless he/she is holding something, when the childcare worker wants to leave the child for a while, the robot should be able to hold the child's hand. – A: A function to hold the hand, like a human hand, not plastic. – C: A function that is about the temperature of a human body, like a human hand. – A: The rhythm of the tapping gets slower and slower, and at the end, cover with the futon. – C: The futon covering function is good. – B: If you put cover with the futon they will sleep. – C: If the futon is kicked off, the robot fix it – A and B: If the child lay on his back, the robot fix it. The function to wake it up is good, and I want to use it for children in elementary school. – C: I want to use it for children in junior high school, after their parents go out. – A: I don't know if it's effective for the robot to get angry instead of parents. – A, B, and C: (They get excited about how to wake them up.) – A: I don't know if it's effective for a human to give milk to the child. – C: Can the robot talk? A: It's interesting when the robot's voice changes, inflection When angry, when kind	warn children – The device is able to give milk to children only when needed

		– A: Function to get angry instead of the parents when it gets irritated.	

Table 3-10 Raw data and interpreted needs from the prototype and story—based slide presentation and interview (Group 2)

Question No	Interviewee	Raw Data (Interview Answers)	Interpreted Needs
1	A	– I want to take it everywhere as a helper – I can make it as a maid/nurse	– The device is able to be used indoor/outdoor – The device's power last long – The device is able to do the task for maid or nurse
	B	– I can use the robot to calm or put my baby to sleep. – It can give a pat action or put baby to sleep – It can sing a lullaby to put baby to sleep	– The device is able to calm the child – The device is able to put to sleep by patting the child – The device is able to sing lullaby to put child to sleep – The device is able to play lullaby song from mother's voice
	C	– I can instruct my children about time using the robot (e.g., time to shower, time to pray, time to study).	– The device is able alert children for their schedule
2	A	– The disinfection part is perfect.	– The device is able to sanitize the house using alcohol sanitizer or UV light – The device is able to sanitize small item in UV box
	B	– I like all the function of the robot	– The device is able to monitor children and notify parent in case of emergency – The device is able to measure body temperature – The device is able to judge the level of sickness and notify parents or authorities (hospital etc.) – The device is able to greet user or stranger at the front

			door – The device is able to scan and recognize user/stranger – The device will send/update the information of people entering/exiting the house to parents – The device will notify authorities (police etc.) if the person in/around the house is suspicious – The device is able to teach user – The device is able to play, dance, sing and karaoke with user – The device is able to sanitize the house using alcohol sanitizer or UV light – The device is able to sanitize small item in UV box – The device can clean the house while moving around the house – The device is able to sweep and vacuum the floor – The device is able to wake the child up – The device is able to put child to sleep – The device is able to give milk and bath, and change diaper – The device is able to make children to study and monitor them – The device is able to ventilate room (All the function listed in the Prototype and Story-based slide)
	C	– It is suitable for children's scheduling	– The device is able to manage the schedule for children
3	A	– The device has no first action (and the child has already been in an incident).	– The device is able to react fast in case of emergency – The device is able to react fast in case of danger

	B	– If a child is involved in an incident, it does nothing (e.g., -broken glass). – Notifying parents is not sufficient because the child may come into contact with the broken glass	– The device will stop child from touching dangerous thing (broken glass, open wire, fire etc.) – The device is able to cut electricity in case of danger – The device is able to stop water in case of danger – The device is able to clean up broken glass, spilled water etc. – The device is able to recognize items (food or not) that a child wants to put in mouth – The device is able to prevent child from choking – The device is able to conduct CPR – The device will notify parents in case of emergency – The device is able to decide who to notify first (parents or authorities)
	C	– It cannot detect people from outside the house – Too large (difficult to move)	– The device is able to monitor people/strangers inside/ outside/ around the house – The device's size is able to be customized according to child age or user preference
4	A	– I prefer a smaller size (easy to carry anywhere in the house) – Not require a cleaning section	– The cleaning part of the device is able to be detached. – The device's weight is suitable to be carried by user around the house
	B	– Can the robot make the first move to save the children? (e.g., collect broken glass) – ·Robot needs to be more active to track children's paces (children get bored easily) – Can it collect and put away toys (separate toys)? – I want touch screen for children to write on	– The device is able to react fast in case of accident (ex. Broken glass) – The device is able to move slow or fast according to the task/activity – The device is able to clean up and arrange toys according to type – The device's display is interactive – The device is able to hold a baby like a mother

		– I want the device to carry the baby like a mother	
	C	– I want the robot to detect people outside the door (no point if the robot only scans people who have already entered the house)	– The device is able to scan and recognize people outside /around the house

Table 3-11 Raw data and interpreted needs from the prototype and story—based slide presentation and interview (Group 3)

Question No	Interviewee	Raw Data (Interview Answers)	Interpreted Needs
1	A	- Is it for home? Is it for nursery school? - Long-term? - If this device really exists, I would like to use it. - Whether I can afford it or not depends on the price. - think it's a great idea...because children are very good at distracting themselves from my work. I'm worried that if I don't watch them all the time, the older ones will push the younger ones. - I like the concept. - It's nice to be able to move from place to place, but sometimes it's nice to be able to sit still.	- The device is able to be used in house or nursery/ kindergarten - The device is able to be used in any situation (post-covid19) - The device price is affordable - The device is able to take care other child while parents taking care the other - The device is able to set to freely move and set to still
	B	– I don't think it is necessary to have a function to change diapers, but I would like to have a function to tell me when it is time to change a diaper. – I think the CCTV is normal, but I think this device is more effective because it can see the mother's face. – I think skin-to-skin contact is important and this device	– The device will tell parents when to change the diaper – The device is able to connect parents and child using the display – The device can be set to use when needed only – The device will monitor children movement in the house – The device will remind to measure temperature – The device is able to

		can support that from time to time. - Another set of eyes in the house. - It can watch my children. - The ability to take body temperature is also good, because sometimes I forget to do it.	measure temperature
2	A	- - I like the fact that the device will sound an alarm if you try to do something dangerous.	- The device will alert user with alarm in case of danger
	B	- I prefer this device to hiring someone else (e.g. a housekeeper) who might invade my family's privacy.	- The device is able to do tasks of house helper - The device can be turn on and off by the user
3	A	- The size is too big, but I found it hard to disinfect if it is not high enough. - Children are tempted to keep looking at the screen of the device, but I don't think that's a good idea. - I bought a tablet for my child now, but I don't show it to him much.	- The size of the device is able to be customized - The device's part can be use and operate separately - The usage time of the device can be set - The usage time of the display by the children can be set
	B	- I think the size is too big. - I think it is too big for a Japanese house. - But if the size is necessary for the function to show the mother's face, etc., it can't be helped. - I think it has too many functions. There are things we have to do as parents. - I don't want to be dependent on the device all the time. - I am not a work-at-home mom, so I don't feel I need it much.	- The device's size is able to be customized according to house size - The device function is able to be customized according to customer preference or budget - The usage time of the device can be set - The device is suitable to support working mom or housewife -
4	A	- It would be nice to have an air purifier function.	- The device is able to purify the air

	B	– I think this device is needed by a work-from-home mom in Malaysia.	– The device is suitable to support working-at-home mother in Malaysia

Table 3-12 Raw data and interpreted needs from the prototype and story—based slide presentation and interview (Group 4)

Question No	Interviewee	Raw Data (Interview Answers)	Interpreted Needs
1	A	- I think the reward function is very good.	- The device is able to give children a treat once they finished their homework, lesson and quizzes
	B	- I think the childcare assistance feature would be great. - If the robot can take care of the child, the parents can do different things.	- The device is able to take care of children when parents need to do other task - The device is able to take care of other house chores when parents is taking care of the children
2	A	– I think the robot would be very useful if my children have to go to school again. – The function of disinfecting small items with ultraviolet rays would be very useful if my children have to go to school again.	– The device is able to give children refreshment after finished class/lesson – The device is able to sanitize bag & books before and after school
	B	– The child can also play with the robot and parents can get away from the children for a while. – I like the play and education function, because now I am doing it myself. – There are a lot of toys, so it would be nice to have a disinfector for small items.	– The device is able to take care of children when parents need to take care of themselves – The device is able to teach and play with children – The device is able to teach with voice and facial expression – The device is able to teach from display – The device is able to sanitize small items

3	A	– Disinfection is done more often by washing hands with soap and water, since neither I nor my children leave the house at present. – I use commercial detergent for floors and table tops. – I also use wet wipes. – I don't have small children at present, so I don't need heartbeat and respiration monitoring functions.	– The device will remind user to wash hand with soap – The device is able to wipe, clean and sanitize table, kitchen counter, shelves, and floor – The function of the device can be customized according to customer preferences or by children age
	B	– I have small child so I need the heartbeat and respiration monitoring functions. –	– The device is able to monitor heartbeat and breath of children
4	A	– I would like to have a function to monitor online classes, not a function to make the robot angry. – I want the robot to make the children focus on the lesson. – Parents don't have to get angry or asking the children to pay attention. – I want the robot that can remind them of the time for the next class, tell them what books they need to prepare, etc. (Parents sometimes get angry when they do not pay attention to the classes) – I have experienced that I don't get angry on one day, but I get angry on the next day. – I want a reminder of time, a reminder of what to prepare, and a reminder of when to get ready. – I need to dress nicely before class because I have to turn on the	– The device is able to scold and alert users – The device is able to make children focus during online class – The device will alert children if they lost focus during classes/lessons – The device will alert children to look at the screen or open the book or listen to the teacher – The device will remind the schedule for next class – The device will remind to finish homework before next class – The device will remind to prepare for next class – The device will remind to dress properly before class – The device is able to give simple guide to get dress before class – The device is equipped with camera with make-up filter – The device is able to scan and detect user's focus in class – The device is able to detect

		camera during the online class. – I would like to have a facial expression detection function so that I can see if my child is concentrating during the class. – Function to detect eye movement and head tilt.	eye contact and head's tilting and turning angle
	B	– (No answer)	N/A

Table 3-13 Raw data and interpreted needs from the prototype and story—based slide presentation and interview (Group 5)

Question No	Interviewee	Raw Data (Interview Answers)	Interpreted Needs
1	A	– Monitor people coming to the house – Cleaning the house – Watching the sleeping children if the wife has to go out (or in another room)	– The device is able to monitor people outside/around the house – The device is able to clean the house – The device is able to monitor children sleeping
	B	– Monitor children in other rooms, especially during online meetings – Should help wake children up in the morning	– The device is able to take care of children in different room from parents – The device is able to wake the children up
	C	– Monitor babies sleeping in other rooms (parents may not realize their children are crying) – Cleaning the house	– The device is able to monitor baby sleeping – The device is able to alert parents when the baby wake up
2	A	– Reduce the burden of household chores – Save your own time	– The device is able to do all house chores – The device is able to advice/suggest how to spend free time
	B	– Can interact with children to replace parents	– The device is only able to do task set up by the user – The device is able to have conversation with children

	C	– Play with the children (parents may not know what to do with their children)	– The device is able to play games with children – The device is able to suggest new/suitable game for parents and children
3	A	– · Electricity (would need to use a lot of electricity to charge the device) – · The size of the device is quite large (the robot may fall on the child / difficult to walk around the house) – Fear that the device will provide doctors with incorrect information about the child	– The device is able to operate with small power – The device size is able to be customized according to children age or number – The device is able to give right/ precise information to authorities (police, hospital etc.)
	B	– Parents fear that if the robot does all the work with the child, it will be worthless – Children will love robots more than their parents – Electricity	– The device's functions are able to be set up by user – The device's functions are able to be set up only for house chores – The device's functions are able to be set up not to connect with children – The device's is able to remind parents and children to communicate to each other – The device is able to operate with small power
	C	– If the robot only has a screen to play with children, it is not enough (children are easily bored) – Robot looks fragile and breakable (children are afraid to break the robot) – The size is too big (children will be scared)	– The device is able to interact with children with voice and facial expression – The device is able to play with children with voice and facial expression – The device is able to interact with children with display – The device is made from strong material – The device's size is customable to suit children age and number
4	A	– Make it in a small size (easy to walk around the house)	– The device's size is customable to suit children age and number – The device is able to provide

		– Make sure the device can provide the correct information	precise information to authorities
	B	– Optimize the source energy of the robot (to save power) – Detect only where viruses are present and clean only specific areas, rather than cleaning all areas – · Do not clean all areas (for fear that the robot will clean areas it should not)	– The device is able to operate with small power – The device is able to scan and detect virus and sanitize the infected part only – The device will only clean the part of the house set by user
	C	– Don't like the "can interact with kids" part (afraid kids will follow the robot's way of talking) – Will be small and cute size (safe for kids) – Would be nice if it could be created at an affordable price (looks very expensive)	– The device is able to operate with small power – The device is able to scan and detect virus and sanitize the infected part only – The device will only clean the part of the house set by user

3.3.3 Organizing Interpreted Needs into a Hierarchy Comparing needs from both interviews to existing products function

Based on the interpreted needs, the data were arranged in a separate hierarchical list according to KJ Method by Kawakita (1960) for both Problem-based interviews and Prototype Story-based interviews according to the steps below:

① Each need statement was written on a separate card. The card was grouped according to the similarity of the needs they express.

② Redundant statement was eliminated.

③ For each group, a label that generalize the needs in the group was chosen.

④ A super group consisting 2 or 5 groups was considered to be created. The process of creating super group is identical to the process of creating group. This super groups become the primary needs, the group label become the secondary needs.

The process is shown in Fig 3-59 and Fig 3-60. The hierarchical list for both interviews are shown in Table 3-14 and 3-15.

Fig 3-59 The process of organizing interpreted needs to hierarchy list for the problem-based interview

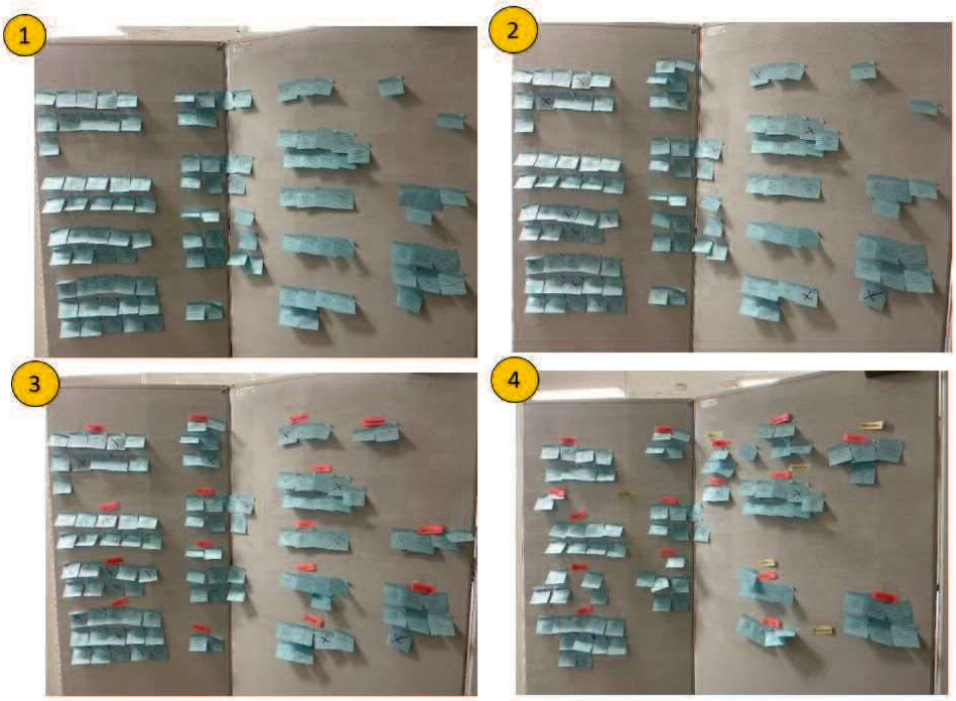

Fig 3-60 The process of organizing interpreted needs to hierarchy list for the prototype and story-based interview

Table 3-14 The hierarchical list of interpreted needs from the problem-based interviews

Categories	Interpreted Needs in Problem-based Interviews
Childcare	**When you`re away**
	-can watch the safety of children who parents are away for shopping etc.
	-When parents go out to meetings, the device can take care of the child
	Study and play with children
	-can see the state of children's study and play remotely
	-Supervise children's studies
	-Equipment that teaches education instead of school
	-Can provide entertainment for children in the house
	-When the children have finished disinfecting and cleaning, they will give them sweets.
	- Can detect children's boredom
	- Can automatically provide entertainment according to boredom
	-Provide new entertainment with existing toys
	-Can make new toys
	-When a mother teaches other children online from home, the device can see the child
	- A function that provides entertainment that parents and children can play together
	-The device can teach children to study on behalf of parents when they need rest
	- You can switch between the cleaning function and the function to play with children
	-The device dances and plays video songs to keep kids hooked
	- You can change the educational support and play according to your age
	- The device is equipped with teaching materials that parents can use to teach their children.
	-Free educational materials are registered
	-The device provides parents with an educational guide with teaching materials
	-Provide basic learning for children
	Online lesson management
	-The device can manage the schedule of children's online classes
	-The device can measure children's level of study understanding
	- If children are not concentrating on online lessons, the device can warn (scold) children
	Watching over children
	- Can teach children what is dangerous in the home
	-Do not let children enter the balcony alone
	-Do not let children go to the stairs alone
	-Do not let children enter the bathroom alone
	- If your child is playing in a place with a lot of people, the device will alert you
	- When the mother needs rest, the device can take care of the child
	-The device can take the child to a nearby park
	Child Growth Management
	- Record and organize children's growth

House Chores (Family)	**Shopping**
	-The device will act as a shopping agent
	-The device assists in carrying a large amount of luggage for shopping
	- This device assists in online shopping of foodstuffs (management of grocery lists)
	-Do your shopping instead
	Cleaning
	- Can clean ordinary homes
	- Equipment that can be used for general purpose cleaning of floors, walls, and ceilings
	-Device can clean
	-The device can wash
	-Parents can spend more time with their children by supporting in cleaning
	-The device encourages members of the house to do housework in a more enjoyed way, such as playing a song about cleaning
	Dishes
	-The device provides a menu that saves food costs
	-The device can record food costs
	- The device prepares and cleans up meals
	- You can make dishes automatically with what you have at home
	- Automatically think about menus from what is in the house (refrigerator)
	- This device can register only the items and groceries you need in the house as a list
	Others
	-The device can take a bath
	- The device can do housework other than related to children in the home
	-The device scans clothes based on location and alerts you if they are placed in the wrong place
	-Notify the other partner of the housework you want your partner to do
Work	**Work from Home**
	-The device proposes events that can be made online
	-Can do online meetings
	-The device can be used for online meetings and meetings
	-Devices can manage work schedules
	- Get up-to-date information and schedules from your workplace through your device
	Schedule management
	-The device manages work scheduling
	-The device informs about classes and meetings
	-Devices manage online class schedules
	-Devices help you plan your work by giving your ideas about the latest issues at work
	Workplace
	-Can do all the work of a nursery teacher
	-can work as a nursery teacher while using equipment at home
	-can work as a nursery teacher at home
	-The device disinfects the nursery
	-The device disinfects schools and nurseries before children arrive
Economy	**Robot Prices**

	-Affordable price for the home
	Traffic
	-Equipment that teaches you how to drive while saving gasoline
	-Inform the traffic situation of the day in a timely manner
	-The device can suggest the cheapest route on the drive
Sanitizing (sterilization)	**Disinfection outside the house**
	-Can prevent infection during shopping
	-Can disinfect outdoor playground
	-The device will notify you to wear a mask before going out
	-The device provides reliable disinfection that can be easily carried
	-The device can scan all people's clothing and body temperature and alert them if a person brings a virus from the outside
	Provision of infection information
	-The device provides detailed data on epidemic areas and infected people
	-Provide information on the possibility of infection in each region
	-can know the infected area immediately
	-The device provides information about where to move safely
	-The device is connected to GPS and advises on crowded places
	-The device can provide information about the route to work, whether there is a possibility of infection
	-Provide information on routes that are less likely to be infected by the time you go to the office
	-The device provides information about where to move safely
	Disinfection through the house
	-Disinfection and sterilization that can be used even for people with disabilities
	-The device can encourage children to wash and disinfect their hands
	-The device can disinfect the clothes without damage
	-Can disinfect and sterilize with short preparation and working time
	-The device can disinfect without damage to the skin of the person
	-possible to detect scratches on clothing after disinfection
	-Can moisturize the skin after disinfection
	-The device can adjust the room temperature, humidity, and disinfection indoors
	-The device sounds an alarm until you touch the hand sanitizer
	-The device disinfects the whole body and clothing of people entering the house
	-Devices that can quickly disinfect the whole body
	-Can disinfect parcel that arrived home
	-The device moistens the hand after using a hand sanitizer
	-After using disinfectant, the device moistens our hands
	-The device can be humidified and disinfected while moving around the house.
	-Indoor disinfection equipment that does not affect the respiratory organs
	-The device can automatically disinfect all spaces by spraying alcohol
	-If there are no people in the place, the device can disinfect the space with ULTRAVIOLET rays
	-The device advises to wash and disinfect hands
	-Absorbs air allergens
	-Purify bacteria and germs in the air

	-This device disinfects bags of groceries after returning from shopping
	-This device disinfects the family before and after they leave the house
	-This device disinfects children's things (books, bags, etc.) before and after going to school
	-Instantly disinfect indoors to create a space that does not require a mask
	Virus detection
	-Equipment that can be purchased and used at home, where you can see the part where viruses and bacteria are attached
	-The device can detect the type of virus in the clothes we are wearing when going outside the house
	-The device can measure your infection status immediately and accurately
	-Can immediately detect if you have been infected with a virus
	-Can scan and detect place where only viruses are present
	-The device scans for the most touched objects
	-This device detects bacteria and bacteria in the air
	-The device can quickly detect viruses by examining children returning home
	-Detection of viruses on clothing
	-The device detects the type of cough and allows you to go out or not
	-Has a personal virus detection function
	Disinfection outside the house
	-The device can be used at airports and airplanes
	-The device disinfects all routes from the airport to the plane before the plane takes off
	-The device examines the infected status and physical condition of all passengers before boarding the flight
	-The device disinfects schools and nurseries before children arrive
Health (Health Management)	
	-Equipment to prevent norovirus and influenza outbreaks
	-The device is faster than PCR and has a reliable inspection function
	-Connect the delivery room and the outside husband during labor
	-The device connects sick people in hospital with families outside
	-PCR testing can be performed
	-Check the cough status with a medical institution and notify the appropriate diagnosis
Mental Care	-Can provide a variety of entertainment in the home
	-Communicate with friends on your device
	-Mental care for parents
	-Provide mental care for parents
	-Has the function of entertainment to entertain adults
	-Has a mental care function for parents
	-The device informs you of the latest news and issues with friends and people around you
	-The device can give advice on how to survive this pandemic and help others
Others	-Size that do not bring danger to children while playing

Table 3-15 The hierarchical list of interpreted needs from the prototype and story-based interviews

Categories	Interpreted Needs in Prototype and Story-based Interviews
Childcare	**Management of children physical condition**
	The device can measure a child's temperature and heart rate
	The device can immediately measure a child's body temperature
	The cuddle function is not required
	The device is able to change diaper
	The device can check for rough skin and rash when changing diapers
	The device can notice that it is different in the atmosphere of the child from usual
	There is no need to notice detailed changes in children
	The device is able to notify of diaper change time
	The device warns parents of diaper change times
	The device informs parents to measure body temperature
	This device records the body temperature of members of the house
	The device can closely monitor a person's movements and facial expressions to determine their condition.
	This device can identify the sound and facial expressions of children and warn parents about the condition
	Emergency
	The device will Immediately contact parents and medical institutions
	The device is able to keep children out of danger before an incident occurs
	In the event of an incident, the device can take the first action
	The device can collect broken glass
	The device can block children's paths and keep them away from dangerous things
	The device is able to warn the child that it is dangerous by voice
	The device can turn off the electricity if the child is electrocuted
	The device is able to rescue children if they are drowning
	The device can detect and collect toys on the floor
	If the child tries to act dangerously, the device alarm will be turned on
	The device able to provide accurate information provision to medical institutions
	The device can accurately identify the information to be sent to the doctor.
	The device can check the contents of the information sent to medical institutions, etc. later
	When you're away.
	The device can respond to visitors
	The device can guarantee that you are work well as a nursery teacher and as a parent
	The devices can be connected to a parent's phone even when they are outside the home
	The device can detect people outside from inside the house
	The device can be connected to CCTV outside the house to detect people
	The device can be connected to external CCTV to detect strangers outside the home
	The device can identify individuals

	The device displays the face and voice of the mother or father when the children make a call
	The device is able to operate and monitor 24 hours a day
	The device is able to detect visitors and notify parents and companies
	The device will notify parents at work if there is an abnormality /emergency/ danger in the child
	The device is able to connect parents and child with a video
	Study and play with children
	The device has the function of scolding children on behalf of parents
	The device has many variations of children song
	The device can play smooth melodies or read bedtime stories to put your baby to sleep
	The device can play lullaby made from mother's voice
	The device will continuously providing entertainment that children never get tired of
	The device has a touch panel that at a height that the child touches
	The device touch panel is interactive
	The device screen can be used for children to practice writing
	The device can play with their children when parents are busy
	The device provides activities using only audio and songs (turn off the touch panel)
	The device will reward your children when they are done studying
	The device allows parents to play and educate their children when they need rest or when they need to do other things
	The device is able to scold children on behalf of parents
	The device can play with children with some interesting activities
	The device will provide parents with ideas that parents and children can play with
	The device allows you to dance, sing and play fun games with children
	Device facial expressions
	The device can be reproduced human expression
	The device can treat children with love (can express love)
	The device has a facial expression change function that gives a sense of security to children
	The device can express emotions by changing the voice
	The device is able to communicate with children like a human being
	The device can speak normally like a normal person
	Online lesson management
	The device rewards children with a few snacks after finishing each class to keep them motivated
	The device can check the nutritional status of children
	The device can provide clothes and makeup online
	The device can monitor children during online classes
	The device allows children to focus on online classes
	The device sometimes issues a warning "Look straight at the screen, open the correct page of the book, stop talking and listen to your teacher."
	The device informs you of the schedule and preparation of materials for the next class

	The device will teach children to prepare for online classes and dress up properly
	The device has a facial recognition function that can recognize if the child is not in focus (recognizes the movement of the eyes, pupil, and head)
	Watching over children
	The device can be used to touch the child while putting them to sleep.
	The device can check the child's sleeping posture and correct it to an appropriate posture
	The device can hold the baby and put it to bed
	The device has a strong hand for carrying the baby
	The device is able to move quietly
	The device can wake the child up without hurting the child
	The device is able to monitor children
	The device will function up to parent's assistance
	The device does not take away its value as a parent
	The device will measure parental sentiment and notify parents
	The device will notify parents if the child is lonely
	Child Growth Management
	The device will record the length of time that children, nursery teachers, and parents interacted
	The device has function to convey the growth and reaction of children's minds to parents and nursery teachers
	Children's schedule management
	The device will manage schedule at home
	The device informs the children of the activities they must do
	The device will notify both parents of the children daily schedules
	The device can inform your child of the schedule.
House Chores (Family)	**Ventilation**
	The device automatically ventilates the house
	The device informs the ventilation time
	Cleaning
	The device is able to do floor cleaning
	The device is equipped with an air purifier
	The device warns parents to clean the house
	The device can automatically vacuum the floor of the house
	The device is able to clean the home
	The device is able to schedule and operate efficient disinfection and cleaning can be automatically
	The device can scan the most touched objects for efficient disinfection
	Tiding up
	The device can determine the type of toy
	The device can register a place to clean up and be automatically cleaned up
	The device is able to support work from home
	Others
	The device can operate by listening to and understanding the instructions of the parent
Work	**Work from Home**
	The device can work as copy machine
	Schedule management

	The device will provide a schedule management system for working from parents at home
Economy	**Robot Prices**
	The price of the device is affordable
	Affordable price for the home
	Power saving
	The device can be used for a long time on a single charge
	The device is equipped with a long-life battery
	Can be used for a long time on single charge
	The price that are affordable for home
	The device uses affordable materials that are worth the price
Sanitizing (sterilization)	**Disinfection through the house**
	The device has space to disinfect many toys and picture books at once
	The device can dry disinfected things
	The device provides therapeutic tools such as disinfectant solutions
	Can disinfect facemask
	Can disinfect indoors
	The device can disinfect small items
	The device automatically disinfects all areas
	The device can disinfect your children when they come back from school, etc.
	The device can disinfect children's toys daily by spraying disinfectants or disinfection boxes
	The device is large enough to disinfect many toys
	The device can do quick disinfection of toys
	The device can order soap for hand washing automatically
	The device will notify children to wash their hands with soap
	The device can notify children to put books, bags and toys inside the disinfection box whenever they return home
	The device can disinfect the house
	Virus detection
	The device can detect if there are any viruses or bacteria left after cleaning
Health (Health Management)	The device can be used in hospitals
Others (Other)	**Robot shape and size**
	Round shape
	The part that touches humans is warm
	The part that touches humans is made of a soft material.
	The device is light that can be carried by people
	Size that can be carried by people
	Size that can move smoothly indoors
	Size that can be carried
	Size suitable for moving around the house
	Compact for the home
	The device is high enough to disinfect
	The device size is available in variations depending on the size of the consumer's home
	The device must be the right size for the home

	The device screen is large enough for a person's face to move
	The device size can be customized according to the size of the consumer's home
	Size that does not endanger children
	Size suitable for moving around the house
	Sturdy enough to break even when playing with children
	The device is not harmful to children if broken
	The size that does not give fear to the child
	Made of excellent long-lasting material
	Size suitable for moving around the house
	Be a safe size for children
	Where to use the robot
	The device can be used in homes and nurseries
	Can be used even after the pandemic is over
	Robot settings
	The device can be set to not move when needed
	When the device does not work, you can update the behavior and functions by looking at the home screen
	The device is only useful when called by the owner
	If the owner needs privacy, the device's camera, voice recorder, or switch can be turned off
	There is a function that allows you to check and delete recorded information
	The device can limit children's usage time
	The device function is able to be customize
	The device will works only when the owner instructs
	The function of the device can be customized according to the consumer's needs.
	The device switch can be turned on and off as needed
	The device comes when called
	The device can understand many languages so that it can be used in many countries
	The device can identify the correct situation and information to be delivered
	The can set the function to talk with the robot

3.3.4 Comparing needs from both interviews to existing products function

The hierarchical list of interpreted needs from both Problem-based and Prototype Story-based interviews in Table 3-14 and 3-15 were then compared to eliminate the same needs from Problem-based interview in Prototype-based interview. It is because that new interpreted needs obtained from Prototype-based interview are considered possible latent needs as it is assumed by introducing working prototype to the consumers, latent needs are possible to be obtained. Table 3-16 shows the comparing results of interpreted needs in Problem-based interview from Prototype-based interview. On the other hand, Table 3-17 shows the comparing results of interpreted needs in Prototype-based interview and functions from existing products. It is because, by eliminating interpreted needs that is similar to the

functions in existing products, more possible latent needs are able to be obtained. Table 3-18 shows the functions of existing products.

The functions of Vevo, Pepper and Lovot and other products were first enlisted in the Table 3-18 based on the functions stated in their product manuals and in patents' claims. Then, the remained interpreted needs in Prototype and Story-based interviews in Table 3-17 were compared with the functions of these existing products to clarify the final latent needs. Needs such as "The device can measure a child's temperature and heart rate", "The device can notice that it is different in the atmosphere of the child from usual", "The device can closely monitor a person's movements and facial expressions to determine their condition" and "This device can identify the sound and facial expressions of children and warn parents about the condition" were delisted from the interpreted needs list because there are similar functions in existed products. The total number of finally identified latent needs are 89 needs and the number of needs based on categories after the comparison with existed products are shown in Table 3-19.

Table 3-16 The interpreted needs from the problem-based interviews that exist and not in the prototype and story-based interview

Categories	Interpreted Needs in Problem-based Interviews	**Needs in PSI**
Childcare	**When you`re away**	
	-can watch the safety of children who parents are away for shopping etc.	Yes
	-When parents go out to meetings, the device can take care of the child	No
	Study and play with children	
	-can see the state of children's study and play remotely	No
	-Supervise children's studies	No
	-Equipment that teaches education instead of school	No
	-Can provide entertainment for children in the house	Yes
	-When the children have finished disinfecting and cleaning, they will give them sweets.	Yes
	- Can detect children's boredom	No
	- Can automatically provide entertainment according to boredom	Yes
	-Provide new entertainment with existing toys	No
	-Can make new toys	No
	-When a mother teaches other children online from home, the device can see the child	Yes
	- A function that provides entertainment that parents and children can play together	Yes
	-The device can teach children to study on behalf of parents when they need rest	No
	- You can switch between the cleaning function and the function to play with children	Yes
	-The device dances and plays video songs to keep kids hooked	Yes

	- You can change the educational support and play according to your age	No
	- The device is equipped with teaching materials that parents can use to teach their children.	No
	-Free educational materials are registered	No
	-The device provides parents with an educational guide with teaching materials	No
	-Provide basic learning for children	No
	Online lesson management	
	-The device can manage the schedule of children's online classes	Yes
	-The device can measure children's level of study understanding	No
	- If children are not concentrating on online lessons, the device can warn (scold) children	Yes
	Watching over children	
	- Can teach children what is dangerous in the home	No
	-Do not let children enter the balcony alone	Yes
	-Do not let children go to the stairs alone	Yes
	-Do not let children enter the bathroom alone	Yes
	- If your child is playing in a place with a lot of people, the device will alert you	No
	- When the mother needs rest, the device can take care of the child	Yes
	-The device can take the child to a nearby park	No
	Child Growth Management	
	- Record and organize children's growth	Yes
House Chores (Family)	**Shopping**	
	-The device will act as a shopping agent	No
	-The device assists in carrying a large amount of luggage for shopping	No
	- This device assists in online shopping of foodstuffs (management of grocery lists)	No
	-Do your shopping instead	No
	Cleaning	
	- Can clean ordinary homes	Yes
	- Equipment that can be used for general purpose cleaning of floors, walls, and ceilings	No
	-Device can clean	Yes
	-The device can wash	No
	-Parents can spend more time with their children by supporting in cleaning	No
	-The device encourages members of the house to do housework in a more enjoyed way, such as playing a song about cleaning	No
	Dishes	
	-The device provides a menu that saves food costs	No
	-The device can record food costs	No
	- The device prepares and cleans up meals	No

	- You can make dishes automatically with what you have at home	No
	- Automatically think about menus from what is in the house (refrigerator)	No
	- This device can register only the items and groceries you need in the house as a list	No
	Others	
	-The device can take a bath	No
	- The device can do housework other than related to children in the home	No
	-The device scans clothes based on location and alerts you if they are placed in the wrong place	No
	-Notify the other partner of the housework you want your partner to do	No
Work	**Work from Home**	
	-The device proposes events that can be made online	No
	-Can do online meetings	No
	-The device can be used for online meetings and meetings	No
	-Devices can manage work schedules	Yes
	- Get up-to-date information and schedules from your workplace through your device	Yes
	Schedule management	
	-The device manages work scheduling	Yes
	-The device informs about classes and meetings	Yes
	-Devices manage online class schedules	Yes
	-Devices help you plan your work by giving your ideas about the latest issues at work	No
	Workplace	
	-Can do all the work of a nursery teacher	No
	-can work as a nursery teacher while using equipment at home	No
	-can work as a nursery teacher at home	No
	-The device disinfects the nursery	Yes
	-The device disinfects schools and nurseries before children arrive	Yes
Economy	**Robot Prices**	
	-Affordable price for the home	Yes
	Traffic	
	-Equipment that teaches you how to drive while saving gasoline	No
	-Inform the traffic situation of the day in a timely manner	No
	-The device can suggest the cheapest route on the drive	No
Sanitizing (sterilization)	**Disinfection outside the house**	
	-Can prevent infection during shopping	No
	-Can disinfect outdoor playground	No
	-The device will notify you to wear a mask before going out	No
	-The device provides reliable disinfection that can be easily carried	No
	-The device can scan all people's clothing and body temperature and alert them if a person brings a virus from the outside	No

	Provision of infection information	
	-The device provides detailed data on epidemic areas and infected people	No
	-Provide information on the possibility of infection in each region	No
	-can know the infected area immediately	No
	-The device provides information about where to move safely	No
	-The device is connected to GPS and advises on crowded places	No
	-The device can provide information about the route to work, whether there is a possibility of infection	No
	-Provide information on routes that are less likely to be infected by the time you go to the office	No
	-The device provides information about where to move safely	No
	Disinfection through the house	
	-Disinfection and sterilization that can be used even for people with disabilities	No
	-The device can encourage children to wash and disinfect their hands	Yes
	-The device can disinfect the clothes without damage	No
	-Can disinfect and sterilize with short preparation and working time	Yes
	-The device can disinfect without damage to the skin of the person	No
	-possible to detect scratches on clothing after disinfection	No
	-Can moisturize the skin after disinfection	No
	-The device can adjust the room temperature, humidity, and disinfection indoors	No
	-The device sounds an alarm until you touch the hand sanitizer	No
	-The device disinfects the whole body and clothing of people entering the house	No
	-Devices that can quickly disinfect the whole body	No
	-Can disinfect parcel that arrived home	No
	-The device moistens the hand after using a hand sanitizer	No
	-After using disinfectant, the device moistens our hands	No
	-The device can be humidified and disinfected while moving around the house.	No
	-Indoor disinfection equipment that does not affect the respiratory organs	No
	-The device can automatically disinfect all spaces by spraying alcohol	Yes
	-If there are no people in the place, the device can disinfect the space with ULTRAVIOLET rays	No
	-The device advises to wash and disinfect hands	No
	-Absorbs air allergens	No
	-Purify bacteria and germs in the air	No
	-This device disinfects bags of groceries after returning from shopping	No
	-This device disinfects the family before and after they leave the house	No

	-This device disinfects children's things (books, bags, etc.) before and after going to school	Yes
	-Instantly disinfect indoors to create a space that does not require a mask	Yes
	Virus detection	
	-Equipment that can be purchased and used at home, where you can see the part where viruses and bacteria are attached	No
	-The device can detect the type of virus in the clothes we are wearing when going outside the house	No
	-The device can measure your infection status immediately and accurately	No
	-Can immediately detect if you have been infected with a virus	No
	-Can scan and detect place where only viruses are present	No
	-The device scans for the most touched objects	No
	-This device detects bacteria and bacteria in the air	Yes
	-The device can quickly detect viruses by examining children returning home	No
	-Detection of viruses on clothing	Yes
	-The device detects the type of cough and allows you to go out or not	No
	-Has a personal virus detection function	No
	Disinfection outside the house	
	-The device can be used at airports and airplanes	No
	-The device disinfects all routes from the airport to the plane before the plane takes off	No
	-The device examines the infected status and physical condition of all passengers before boarding the flight	No
	-The device disinfects schools and nurseries before children arrive	Yes
Health (Health Management)		
	-Equipment to prevent norovirus and influenza outbreaks	No
	-The device is faster than PCR and has a reliable inspection function	No
	-Connect the delivery room and the outside husband during labor	No
	-The device connects sick people in hospital with families outside	Yes
	-PCR testing can be performed	No
	-Check the cough status with a medical institution and notify the appropriate diagnosis	No
Mental Care	-Can provide a variety of entertainment in the home	Yes
	-Communicate with friends on your device	Yes
	-Mental care for parents	No
	-Provide mental care for parents	No
	-Has the function of entertainment to entertain adults	No
	-Has a mental care function for parents	No
	-The device informs you of the latest news and issues with friends and people around you	No

	-The device can give advice on how to survive this pandemic and help others	No
Others	-Size that do not bring danger to children while playing	Yes

Table 3-17 The interpreted needs from the prototype and story-based interviews that exist and not in the problem-based interview (PBI) and the existing products' functions

Categories	Interpreted Needs in Prototype and Story-based Interviews	Needs in PBI	Needs in Existed Product
Childcare	**Management of children physical condition**		
	The device can measure a child's temperature and heart rate	No	Yes
	The device can immediately measure a child's body temperature	No	Yes
	The cuddle function is not required	No	No
	The device is able to change diaper	No	No
	The device can check for rough skin and rash when changing diapers	No	No
	The device can notice that it is different in the atmosphere of the child from usual	No	Yes
	There is no need to notice detailed changes in children	No	No
	The device is able to notify of diaper change time	No	No
	The device warns parents of diaper change times	No	No
	The device informs parents to measure body temperature	No	No
	This device records the body temperature of members of the house	No	Yes
	The device can closely monitor a person's movements and facial expressions to determine their condition.	No	Yes
	This device can identify the sound and facial expressions of children and warn parents about the condition	No	Yes
	Emergency		
	The device will Immediately contact parents and medical institutions	No	Yes
	The device is able to keep children out of danger before an incident occurs	No	No
	In the event of an incident, the device can take the first action	No	No
	The device can collect broken glass	No	No
	The device can block children's paths and keep them away from dangerous things	No	No
	The device is able to warn the child that it is dangerous by voice	No	No
	The device can turn off the electricity if the child is electrocuted	No	No
	The device is able to rescue children if they are drowning	No	No

	The device can detect and collect toys on the floor	No	Yes
	If the child tries to act dangerously, the device alarm will be turned on	No	Yes
	The device able to provide accurate information provision to medical institutions	No	Yes
	The device can accurately identify the information to be sent to the doctor.	No	Yes
	The device can check the contents of the information sent to medical institutions, etc. later	No	Yes
	When you're away.		
	The device can respond to visitors	No	No
	The device can guarantee that you are work well as a nursery teacher and as a parent	No	Yes
	The devices can be connected to a parent's phone even when they are outside the home	Yes	
	The device can detect people outside from inside the house	No	Yes
	The device can be connected to CCTV outside the house to detect people	Yes	
	The device can be connected to external CCTV to detect strangers outside the home	Yes	
	The device can identify individuals	Yes	
	The device displays the face and voice of the mother or father when the children make a call	Yes	
	The device is able to operate and monitor 24 hours a day	No	No
	The device is able to detect visitors and notify parents and companies	Yes	
	The device will notify parents at work if there is an abnormality/emergency/danger in the child	Yes	
	The device is able to connect parents and child with a video	Yes	
	Study and play with children		
	The device has the function of scolding children on behalf of parents	No	No
	The device has many variations of children song	No	Yes
	The device can play smooth melodies or read bedtime stories to put your baby to sleep	No	No
	The device can play lullaby made from mother's voice	No	No
	The device will continuously providing entertainment that children never get tired of	Yes	
	The device has a touch panel that at a height that the child touches	No	No
	The device touch panel is interactive	No	No
	The device screen can be used for children to practice writing	No	No
	The device can play with their children when parents are busy	No	No

	The device provides activities using only audio and songs (turn off the touch panel)	No	Yes
	The device will reward your children when they are done studying	Yes	
	The device allows parents to play and educate their children when they need rest or when they need to do other things	Yes	
	The device is able to scold children on behalf of parents	No	No
	The device can play with children with some interesting activities	Yes	
	The device will provide parents with ideas that parents and children can play with	Yes	
	The device allows you to dance, sing and play fun games with children	Yes	
	Device facial expressions		
	The device can be reproduced human expression	No	No
	The device can treat children with love (can express love)	No	No
	The device has a facial expression change function that gives a sense of security to children	No	No
	The device can express emotions by changing the voice	No	No
	The device is able to communicate with children like a human being	No	Yes
	The device can speak normally like a normal person	No	Yes
	Online lesson management		
	The device rewards children with a few snacks after finishing each class to keep them motivated	No	No
	The device can check the nutritional status of children	No	No
	The device can provide clothes and makeup online	No	No
	The device can monitor children during online classes	Yes	
	The device allows children to focus on online classes	Yes	
	The device sometimes issues a warning "Look straight at the screen, open the correct page of the book, stop talking and listen to your teacher."	Yes	
	The device informs you of the schedule and preparation of materials for the next class	Yes	
	The device will teach children to prepare for online classes and dress up properly	Yes	
	The device has a facial recognition function that can recognize if the child is not in focus (recognizes the movement of the eyes, pupil, and head)	No	Yes
	Watching over children		
	The device can be used to touch the child while putting them to sleep.	No	No
	The device can check the child's sleeping posture and correct it to an appropriate posture	No	No
	The device can hold the baby and put it to bed	No	No

	The device has a strong hand for carrying the baby	No	No
	The device is able to move quietly	No	No
	The device can wake the child up without hurting the child	No	No
	The device is able to monitor children	Yes	
	The device will function up to parent's assistance	No	No
	The device does not take away its value as a parent	No	No
	The device will measure parental sentiment and notify parents	No	No
	The device will notify parents if the child is lonely	No	No
	Child Growth Management		
	The device will record the length of time that children, nursery teachers, and parents interacted	Yes	
	The device has function to convey the growth and reaction of children's minds to parents and nursery teachers	No	Yes
	Children's schedule management		
	The device will manage schedule at home	Yes	
	The device informs the children of the activities they must do	Yes	
	The device will notify both parents of the children daily schedules	Yes	
	The device can inform your child of the schedule.	Yes	
House Chores (Family)	**Ventilation**		
	The device automatically ventilates the house	No	No
	The device informs the ventilation time	No	No
	Cleaning		
	The device is able to do floor cleaning	No	No
	The device is equipped with an air purifier	Yes	
	The device warns parents to clean the house	No	No
	The device can automatically vacuum the floor of the house	Yes	
	The device is able to clean the home	Yes	
	The device is able to schedule and operate efficient disinfection and cleaning can be automatically	No	No
	The device can scan the most touched objects for efficient disinfection	No	No
	Tiding up		
	The device can determine the type of toy	No	Yes
	The device can register a place to clean up and be automatically cleaned up	No	Yes
	The device is able to support work from home	No	No
	Others		
	The device can operate by listening to and understanding the instructions of the parent	No	No
Work	**Work from Home**		
	The device can work as copy machine	No	No
	Schedule management		

	The device will provide a schedule management system for working from parents at home	Yes	
Economy	**Robot Prices**		
	The price of the device is affordable	Yes	
	Affordable price for the home	Yes	
	Power saving	No	No
	The device can be used for a long time on a single charge	No	No
	The device is equipped with a long-life battery	No	No
	Can be used for a long time on single charge	No	No
	The price that are affordable for home	No	No
	The device uses affordable materials that are worth the price	No	No
Sanitizing (sterilization)	**Disinfection through the house**		
	The device has space to disinfect many toys and picture books at once	No	Yes
	The device can dry disinfected things	No	No
	The device provides therapeutic tools such as disinfectant solutions	No	No
	Can disinfect facemask	No	No
	Can disinfect indoors	Yes	
	The device can disinfect small items	Yes	
	The device automatically disinfects all areas	Yes	
	The device can disinfect your children when they come back from school, etc.	Yes	
	The device can disinfect children's toys daily by spraying disinfectants or disinfection boxes	No	Yes
	The device is large enough to disinfect many toys	No	Yes
	The device can do quick disinfection of toys	Yes	
	The device can order soap for hand washing automatically	No	No
	The device will notify children to wash their hands with soap	Yes	
	The device can notify children to put books, bags and toys inside the disinfection box whenever they return home	No	No
	The device can disinfect the house	Yes	
	Virus detection		
	The device can detect if there are any viruses or bacteria left after cleaning	Yes	
Health (Health Management)	The device can be used in hospitals	Yes	
Others (Other)	**Robot shape and size**		
	Round shape	No	No
	The part that touches humans is warm	No	Yes
	The part that touches humans is made of a soft material.	No	Yes

	The device is light that can be carried by people	No	Yes
	Size that can be carried by people	No	Yes
	Size that can move smoothly indoors	No	No
	Size that can be carried	No	Yes
	Size suitable for moving around the house	No	No
	Compact for the home	No	No
	The device is high enough to disinfect	No	No
	The device size is available in variations depending on the size of the consumer's home	No	No
	The device must be the right size for the home	No	No
	The device screen is large enough for a person's face to move	No	No
	The device size can be customized according to the size of the consumer's home	No	No
	Size that does not endanger children	Yes	
	Size suitable for moving around the house	No	No
	Sturdy enough to break even when playing with children	No	No
	The device is not harmful to children if broken	No	No
	The size that does not give fear to the child	No	No
	Made of excellent long-lasting material	No	No
	Size suitable for moving around the house	No	No
	Be a safe size for children	Yes	
	Where to use the robot		
	The device can be used in homes and nurseries	Yes	
	Can be used even after the pandemic is over	No	No
	Robot settings		
	The device can be set to not move when needed	No	No
	When the device does not work, you can update the behavior and functions by looking at the home screen	No	No
	The device is only useful when called by the owner	No	No
	If the owner needs privacy, the device's camera, voice recorder, or switch can be turned off	No	No
	There is a function that allows you to check and delete recorded information	No	No
	The device can limit children's usage time	No	No
	The device function is able to be customize	No	No
	The device will works only when the owner instructs	No	No
	The function of the device can be customized according to the consumer's needs.	No	No
	The device switch can be turned on and off as needed	No	No
	The device comes when called	No	Yes
	The device can understand many languages so that it can be used in many countries	No	No
	The device can identify the correct situation and information to be delivered	No	Yes
	The can set the function to talk with the robot	No	Yes

Table 3-18 The functions in the existing products

LOVOT	Know the whole room condition looks like and know exactly where the person who called the device
	Based on the map of the room, observe the situation while moving. Detected person and reported to the owner
	Remotely head to the designated location. Also reported on the kitchen and pets you are aware of while you are out
	Record your daily life, such as your situation and bedtime, with privacy in check. Share with family members who alive apart. So, you can quickly notice daily changes
	Only one power button to move
	Highly privacy safe design that can be moved without internet connection
	Recognizing the word “I`m home”, detect eyes and movements
	Detected owner has approached near home, device moved to front door to greet
	Make own map, recognize the spatial situation, adjust the speed, and direction, and move around the house
	Even the room is little cluttered, it detects objects and move them without having to hit them
	The sensor detects the tag on the clothes and recognizes that you have been changed. In addition, you will like people who recognize people's faces at the same time and let them change.
	Recognize people's faces and positions
	Remember the people who loved me and the people who took care of me, and I would approach them and spoil them.
	Sense that your body is in a cuddle and approach you for a hug.
	Automatically returns to the charger. While you’re asleep, organize the events of the day and update your information.
	At the moment of lifting, it senses inclination and automatically stores the wheel, and a comfortable LOVOT fits in your arm.
	Recognize people's movements and follow them according to your walking speed.
	A unique body that combines warmth and softness with an air circulation system that circulates warmth through the whole body
	A natural icon that looks back when you stare at it.
	Answering the call or changing your own calls every time depending on the state of LOVOT, it's as if you're alive.
	The design to put away the wheel at the moment of being lifted is designed so that you can enjoy the kinship comfortably without staining your clothes.
Vevo	Can greet and identify children
	Can record children body temperatures using thermography
	During naps, sensors embedded in cots can monitor heart rates and body movements of children to make sure they are breathing. An alarm system will notify teachers if any abnormalities are detected.
	Manage the attendance of children at school" and "attendance of nursery staff
IPAL & Pepper	Conversational speech dialog, natural language understanding
	Detection of sound direction, detection of emotion, question, and answer

	Face recognition, Object tracking and following, Maze-running
	Learning capability to adapt behaviour to improve interactions with its environment
	Remote Control and safety monitoring by smart phone, telepresence
	Numerous entertainment applications (songs, stories, dances, etc.) and educational applications (teach English, math, science, technology, etc.)
	Content editor to enable non-programmers to develop robot content combining media (like a song), robot motions, expressions, etc.)
	Emotion Recognition and Response
	A constant companion for seniors that supplements personal care services and provides security with alerts for many medical emergencies such as falling down.
	Can greet people in stores, restaurants, banks, etc, provide information and directions, answer questions, and entertain and attract consumers.
	Can serve in school as a teacher's assistant in such areas as taking roll and enhancing the education process.
VGo & Beam (Telepresence robot)	Robot with a screen that a person can remotely control and use to communicate via video
	A display that provides a realistic, life-size representation of the user's face
	Robot will speak in its computer voice anything that you type
	Robot can be controlled easily using a mouse when driving
UVD, Xenex and Violet	Able to be used to sterilize hospital, factory, school, institutions, shop, hotels, and airport
	Able to eliminate 99.99% pathogens
	Disinfect everything in the room in 10 minutes
	Moves autonomously in the room
	Disinfection starts when user order using a tablet
	User will receive notifications when the disinfection is finished
LIVA Book Steriliser	The sterilization process is completed in 30 seconds
	The fan installed in the machine room gently blows the bottom of the books and the pages can be blown open to be sterilized by the UV- light.
	Equipped with anti-UV tempered glass to resist the external forces and prevent the release of ultraviolet rays and users can directly observe the sterilization process
	Automatically turn off the UV-light when the door of the sterilization room is opened by users or exterior forces.
Roomba	Automatically clean the room
	Automatic avoid wall and hurdle by turn to other direction

Table 3-19 The number of identified latent needs

Categories	Need remaining in Prototype-Based Interview	Needs similar to a function in existing products	Number of final identified latent needs
Childcare	61	20	41
House chores	10	2	8
Work	1	0	1
Economy	6	0	6

Sanitizing	8	3	5
Health	0	0	0
Mental Care	0	0	0
Others	36	8	28
Total	122	33	89

The example of identified latent needs are:

1. The device part that the children might touch are soft and warm like human skin and made of soft material like silicon.
2. The device turns off electricity when children are electrocuted (quick action) and alerts parents and the hospital.
3. The device reminds consumers (both parents and children) to sanitize and disinfect all small items upon coming home.
4. The device turns off electricity when children are electrocuted (first action).
5. The device will block your child from touching the broken glass.
6. The device has enough space to disinfect many toys and picture books
7. The device will notify children to put their things in the disinfection box each time they return home
8. The device will respond to the owner only
9. Instead of you, the device will scold/remind your children
10. The device will play a lullaby made from the mother's voice to put the baby to sleep

3.4 Discussion

3.4.1 Empathizing by prototyping and story

Based on the results from both interviews in Table 3.17, there are new categories of needs discovered in the Prototype and Story-based interviews which were not in the Problem-based interview. For example, "Management of child physical condition" and "In the state of emergency" sub-categories in the "Childcare" category did not appear in the Problem-based Interview and the examples of latent needs in those categories are "The device is able to detect small changes in a child while watching he/she sleeping", "The device can block children`s path and keep them away from dangerous things", and "The device turn off electricity if children were electrocuted". We were able to observe that the working prototype and story are valuable tools in assisting to explain the concept of the device, empathize with the consumers and stimulate the experience and thoughts of the consumer. Therefore, consumers' needs and the categories obtained from the Prototype and Story-based interviews are more than from the Problem-based interview. This method of combining

a working prototype and story which describes the customer experiences, use case and context in this study can be considered to affect the flexibility and diversity in giving ideas and opinions to the consumers. For example, “The device part that the children might touch is soft and warm like human skin and made of soft material like silicon.” and “The device is able to correct a child’s sleeping posture”. We were able to observe that this method is a good assisting method in discovering consumers’ latent needs.

3.4.2 Group discussion opportunity

There are also possibilities that the results were influenced by the group discussion opportunity in the focus group interview. Interviewees could freely ask other people about experiences and problems that they were having, and new needs appeared upon discussion and communication between them. The discussion helped them in expressing their needs that they are unaware of. For example, as shown in the ‘Chain of Opinions’ row of the ‘Raw Data’ column in Table 3.9, during the discussion at the end of the interview session, the interviewees were sharing the same opinion about the shape of the robot that needed to be round or sphere, about the texture of the robot that needed to feel warm and soft like a human touch. An obtaining process of more deep latent needs was observed by empathizing, exchanging and sharing ideas with other interviewees’ opinions obtained from the functions and problems of the working prototype. The latent needs that were able to be derived were “The device’s part that touches humans is warm like human temperature” and “The device’s part that touches humans is a soft material like human skin”. Then the interviewees were sharing their opinion again that they loved the function of the device which is able to put children to bed, fix their sleep posture and wake the children up. From those responses, the latent needs obtained were “The device can put children to sleep while doing the “ton-ton” patting action “, “The device can cover a child with a futon and fix it if the child kicks it, all night”, “The device can check the child's sleeping posture and correct it to an appropriate posture” and “The device is able to wake the child up and scold if they refuse to wake up”. From the findings above, we were able to observe that by the interviewee empathizing with other interviewees’ opinions on childcare problems or prototype shape in the discussion, more latent needs were able to be obtained in this research.

In addition, the group discussion was also seen to break some fixed concepts. For example, at first the intervewees were sharing their thoughts that a robot should not do a human or a parent job. However, at the end of the interview, they agreed that if a robot can assist them in some of the chores such as to hold the baby hands while they are falling asleep, or instead of parents the robot can scold the child, it will be beneficial. From the phemomena above, we were able to observe that this method is able to break a fixed concept and lead to identifying possible latent needs of consumers.

3.4.3 Limitation of this method

The limitation of this method is that it is a time-consuming method. Each group session required a minimum of 2 hours for both problem-based and prototype-based slide presentations and interviews. We finished 5 group interviews on 3 different days. The interview recording audio files then were transferred into word files which later were interpreted into needs, arranged in the hierarchical list, and compared with the existing product to elicit latent needs. Each of these processes took 1 or 2 days to be completed. Therefore, a large number of consumer responses is difficult to be collected.

Our proposing method uses a working prototype that deepened interviewees' needs but also might restrict them. For example, under the sanitizing category, the number of needs in the problem-based interview is three times higher than in the prototype and story-based interview. The example of needs in that category were 'The device can conduct disinfection without damaging human skin' and 'The device can conduct disinfection without damaging clothing'. We assumed that, there is a possibility that consumers' idea was restricted because there was no mention of the function or further explanation in the prototype and story-based interview. Therefore, it could be said that conducting a prototype and story-based interview with pre-decided functions might limit consumers' ideas in unmentioned functions.

3.5 Conclusion

The purpose of this research is to verify the method in the elicitation of latent needs from consumer needs by conducting the working prototype-based interview and collecting raw data which is responses from the consumer. The results indicated that interpreted needs from interviewees' responses and the categories of the needs obtained from the Prototype-based interviews are more than from the Problem-based interview. The latent needs that we were able to obtain from this research were for example, "The device is able to detect small changes in a child while changing a diaper" and "The device is able to detect small changes in a child while watching he/she sleeping" which could lead into the prevention of unwanted incident such as sudden infant death syndrome (SIDS). This supports our assumption that showing working prototype based materials with story descriptions can be effective in uncovering potential latent needs. We were able to observe that empathizing and exchanging ideas among interviewees with a child of the same age during the discussion sessions leads into discovering a number of latent needs such as "The device can block children`s path and keep them away from dangerous things", "The device is able to recognize items (food or not) before a child put in his/her mouth" and "The device turns off the electricity if a child was electrocuted". However, due to the COVID-19 pandemic, we were unable to give the interviewees chances to touch and look closely at the working prototype therefore latent needs possibly gained from this experience are still uncovered. Although there are still limitations in our findings, the method that we proposed is able to support discovering latent needs in the future.

Chapter 4 - Proposition and Verification of a Design Method to Discover Latent Needs Based on Empathy, Experiences, and Working Prototype

4.1 Introduction

4.1.1 Importance of Latent Needs in the Initial Design Stage

Latent needs are those that many consumers recognize as important in a final product but do not or cannot articulate in advance (Ulrich, 2015). Latent needs also can be defined as a desire or preference of consumers which cannot be satisfied due to a lack of information or availability of a product or service. By understanding latent needs of target consumers, inventors are enable to develop great innovations that are not delivered yet in the marketplace. The challenge in identifying latent needs is finding the method to elicit from consumers' needs which are not clearly addressed by them. The success of a product or a service is largely dependent on how far the product or the service satisfies consumer needs and demands. Therefore, latent needs are particularly critical to product innovation and success.

A good assisting method is needed to be identified in overcoming the challenge of elicitation and understanding the latent needs to create a valuable product to help the consumers in this modern society. There were various types of research conducted previously to create a guideline for creating valuable inventions for society. For example, Tsutsui et al (2020) developed an empathy formation model as other design methodologies had low practicality of empathy. This model consisted of 4 steps of discovery, immersion, connection, and detachment and was expected to contribute to improve the empathy formation upon the innovative design. Yokoi et al (2021) improvised the design thinking process (Plattner, 2011) and introduced a prescriptive model of the cognitive design process that consisted of 5 steps of requirement finding, design solution finding, verification, documentation, and implementation that will assist design thinking processes. In the first step of this prescriptive model of the cognitive design process which is the requirement finding step considered empathy as an important element in the process. Therefore, we are able to observe that empathy is an important and essential element in understanding consumers and finding and designing the best solutions for them and we assumed that it was important to consider empathy in our research.

4.1.2 Interpreting Consumer Responses into Latent Needs

In this research, the consumers' responses from the interviews in our last research in Chapter 2 were utilized. The interviews were conducted in the year 2020 during the COVID-19 pandemic. COVID-19 has caused a lot of death and infected people around the world. As the pandemic spread, a lot of countries were forced to go into lockdown or declare an emergency state. Business organizations and companies promoted working-from-home to prevent the spread. In addition, 99% of the world's 2.36 billion children experienced movement restrictions as schools, childcare institutions, and other facilities were closed.

Most working parents were worried about their family safety and their children at home while they were also struggling to balance their responsibilities to their child and their employer according to a survey. It also indicated that working mothers were affected twice more than fathers regarding work and childcare while 52% of single parents responded that it had become stressful trying to earn while taking care of their children. Therefore, the issue regarding the effects of the COVID-19 pandemic on parents, childcare workers, and children was utilized as a research sample. Parents at home were unable to work efficiently and productively because of the distraction of their children whom their schools were closed. Parents were worried that their children might involve in dangerous incidents if left unattended. In the region where the school and childcare institutions were allowed to operate, parents and childcare workers were concerned about the children's safety towards COVID-19 which led to intensive cleaning and sanitizing. Based on the situations, this research was conducted in finding the latent needs of the parents, childcare workers, and children to assist them in going through their daily life in this COVID-19 pandemic.

Upon interpreting the responses, the 5 'guideline for writing need statement' method by Ulrich et al (2015) was utilized. There are "to focus on 'what is the product' and not 'how the product work'", "to be specific as in original responses", "to write 'positive' and not 'negative' statements", "to list the attribute of the product", and "to avoid 'must' and 'should' in the statement". Then, by considering empathy as an important element, we introduced another 3 new guidelines which are "to write a statement with empathy", "to write a statement as a designer", and "to write a statement as someone with experience" to compare and investigate whether these new guidelines will influence the process of identifying latent needs of the consumers and will be able to elicit important and critical latent needs.

4.2 Method

4.2.1 Method of interpreting consumers' responses to need statement

The consumers' responses from the Problem-based and Prototype and Story-based slide presentations and interviews in our last research in Chapter 3 were utilized. The interview results were listed, interpreted, and analyzed according to the 5 guidelines for writing need statements by (Ulrich et al, 2015) to identify the needs of the consumers. The first guideline is to express the need in terms of what the product has to do, not in terms of how it might do it. Customers frequently describe a solution concept or an implementation strategy to convey their preferences. However, the necessity should be stated without reference to a specific technological advancement. The second guideline is to express the need as specifically as the raw data. There are many different ways to express needs. Express the demand as precisely as the raw data to prevent information loss. The third guideline is to use positive and not negative phrasing. If a need is stated as a positive statement, it is simpler to translate

it later into a product specification. However, it is not rigid because using positive language is occasionally challenging and difficult. The forth guideline is to express the need as an attribute of the product. Wording requirements for product statements help to assure consistency and make it easier to translate those requirements into product specifications. The fifth guideline is to avoid the word 'must' and 'should'. It is because the language 'must' and 'should' convey an importance level for the need. It is advised to postpone determining the importance of the needs until the following stage rather than simply giving them a binary importance ranking. The example by Ulrich on how the guidelines were applied during interpretation was shown in Fig 4-1.

Guideline	Customer Statement	Need Statement—Right	Need Statement—Wrong
"What" not "how"	"Why don't you put protective shields around the battery contacts?"	The screwdriver battery is protected from accidental shorting.	The screwdriver battery contacts are covered by a plastic sliding door.
Specificity	"I drop my screwdriver all the time."	The screwdriver operates normally after repeated dropping.	The screwdriver is rugged.
Positive not negative	"It doesn't matter if it's raining; I still need to work outside on Saturdays."	The screwdriver operates normally in the rain.	The screwdriver is not disabled by the rain.
An attribute of the product	"I'd like to charge my battery from my cigarette lighter."	The screwdriver battery can be charged from an automobile cigarette lighter.	An automobile cigarette lighter adapter can charge the screwdriver battery.
Avoid "must" and "should"	"I hate it when I don't know how much juice is left in the batteries of my cordless tools."	The screwdriver provides an indication of the energy level of the battery.	The screwdriver should provide an indication of the energy level of the battery.

Fig 4-1 The guideline by Ulrich (2015) on how to write need statement

4.2.2 New Guideline Proposition for Writing Need Statements

Ulrich's five guidelines for writing need statements are to be known as effectively working on the interpreting processes of identifying all types of customer needs, not specific for identifying latent needs. Hence, in this paper, we addressed additional guidelines to discover latent needs correctly, precisely, and deeply.

The customers' responses from both interviews were interpreted again while considering the 3 new guidelines which are:

1. To write a statement while empathizing with the customers
2. To write a statement as a designer who understands the concept of the working prototype
3. To write a statement as someone with experience which in this case as a parent in this Covid-19 pandemic

The proposed guideline 3 was outlined as we assumed that by having someone with the similar experience with customers to interpret the raw data from customers' interviews, we will be able to interpret the raw data more precisely. Recent research by Holtta-Olto (2016) indicate that people with lead user like ability to express latent needs, needs that are shared with but not originally found in regular users. von Hippel (2006) defined lead users as users with a higher expectation of innovation-related benefit and are more likely to innovate as they move increasingly ahead of the trend, therefore von Hippel (2006) focused on lead user in his research on finding commercially attractive user innovations. On the other hand, empathic lead users are defined by Lin et al (2007) as ordinary customers or designers who are transformed into lead users by experiencing the product in radically new ways, via user experiences. Empathic lead user interviews were observed to have a significantly positive effect on latent needs discovery in the trial study, and might emerge as a promising tool for supporting innovation and breakthrough concept generation. Therefore, we are able to observe that experience is one of an important element in interpreting latent needs.

However, the guideline 3 is limited to be applied in every case on product development as different experience is required to interpret different raw data. Based on Tsutsui et al (2020) in his empathy formation model, empathy is an essential element in design process. Yokoi et al (2021) considered empathy as important element in the requirement finding step of their prescriptive model of the cognitive design process. Therefore, we assumed that by having empathy to the parents and children in this case, we will be able to interpret the raw data more deeply.

Then, the proposed guideline 2 was outlined as we assumed that the designer who design the prototype and understand deeply the concept of the working prototype will be able to interpret the raw data from customers' interview more correctly. Research by Lin et al (2007) indicate that designers can be transformed into lead users by experiencing the product in radically new ways. Designers that act as lead users are able to demonstrate stronger domain-specific innovativeness than more "ordinary" users (Schreier, 2007) as lead users perceive new technologies as less "complex" and might therefore be better prepared to adopt them.

The results were then compared to see whether these new guidelines will influence the number of interpreted needs.

4.3 Results

4.3.1 Interpretation of Needs with New Proposed Guideline

After the consumers' responses were interpreted in Chapter 3 using Ulrich's five guidelines for writing need statements, they were interpreted again while considering the 3 additional new guidelines which are 'to write statement with empathy', 'to write statement as

designer' and 'to write statement as someone with experience' to see whether these new guidelines will influence the number of interpreted needs. The number of needs interpreted by these proposed guidelines were listed in Table 4-1 below. Table 4-2 and Table 4-3 indicate the list of consumers' responses in both Problem-based interviews and Prototype and Story-based interviews and their interpreted needs while considering the proposed guideline 'to write statement while empathizing consumers'. For example, the interviewee answered, "I want to use the robot to calm or put my baby to sleep by giving a patting action. I want the robot to sing a lullaby to put the baby to sleep ". The interviewee mentioned 'calm', 'put my baby to sleep', 'patting action', and 'lullaby'. Therefore, while emphatizing with parents and child, we interpret the needs (product function) as, "The device is able to put the baby to sleep by imitating the mother's voice, smell, and heartbeat sound, and has soft and warm skin to imitate the mother's arm and its movement". The interviewee also answered, "If a child is involved in an incident, it does nothing (e.g., -broken glass)". The interviewee mentioned 'incident', 'does nothing', and 'broken glass'. Therefore, while emphatizing with parents and child, we interpret the needs (product function) as, "The device is able to detect the sound and the location of broken glass, and able to steer away, save and prevent the child from touching the broken glass and, able to clean the broken glass". Another interviewee answers as an example is "A very good idea. Because children are very good at distracting themselves from my work. I worry that if I don't watch them all the time, the older ones will push the younger ones". The interviewee mentioned 'older ones' and 'younger ones'. Therefore, while emphatizing with parents and child, we interpret the needs (product function) as, "The device is able to take care other child while parents taking care the other".

Table 4-4 and Table 4-5 indicate the list of consumers' responses and interpreted needs while considering the proposed guideline 'to write statement as designer who understand the concept of the prototype' from both Problem-based interviews and Prototype and Story-based interviews. For example, the interviewee answered, "I want a function to get angry instead of myself, when I am annoyed". The interviewee mentioned 'angry function' and 'instead of myself'. Therefore, while thinking as designers, we interpret the needs (product function) as, "The device is able to talk and scold by changing the voice tone and is able to notify and warn by sound, light, movement, and vibration". The interviewee also answered, "Not enough if the robot only has a screen to play with children (children are easily bored)". The interviewee mentioned 'only has a screen' and 'children are easily bored'. Therefore, while thinking as designers, we interpret the needs (product function) as, "The device is able to interact with children with display, facial expression and arm movement". Another interviewee answers as an example is "I don't want you to spend less time with your baby". The interviewee mentioned 'spend less time' and 'with your baby'. Therefore, while thinking as designers, we interpret the needs (product function) as, "The device is able to monitor how much time spent in each of its activities, and how much time spent between the parents and the children, and able to record and analyze the interaction data and notify the parents if they need to communicate more with their children". The interviewee also answered, "It is good to be able to call the police when a child is injured, and since the childcare workers cannot leave the injured child, it would be useful if the robot could call or inform the parents or call someone and ask them to bring this or that". The interviewee mentioned 'cannot leave the injured child', 'robot could call or inform the parents', and 'ask them to bring this or that'.

Therefore, while thinking as designers, we interpret the needs (product function) as, “The device is able to contact authorities (police/hospital) in case of emergency or accident. The device is able to follow order from user (to call someone or to bring something etc.)”.

Table 4-6 and Table 4-7 indicate the list of consumers’ responses in both Problem-based interviews and Prototype and Story-based interviews and their interpreted needs while considering the proposed guideline ‘to write statement as someone with experience’. For example, the interviewee answered, “Let the robot play the role of a robot, and never do the parts that a robot can't do (changing diapers, human eyesight, looking at rough skin, etc., I believe that a robot can't see small changes, I believe that only a human can do it)”. The interviewee mentioned ‘robot can't see small changes’, ‘human eyesight’, and ‘looking at rough skin’. Therefore, while considering our experience in childcare, we interpret the needs (product function) as, “The device is able to detect small changes in a child such as body temperature, facial color, expression and emotion, skin texture and color, voice, etc. by comparing with past day data and able to alert the parents”. The interviewee also answered, “Does the robot talk? Interesting if the robot's voice or intonation changes, when it is angry, when it is kind”. The interviewee mentioned ‘voice or intonation’ and ‘angry’. Therefore, while considering our experience in childcare, we interpret the needs (product function) as, “The device is able to change the voice tone to a warning voice, angry voice and kind voice”. Another interviewee answers as an example is “I think it is important for a baby to feel the warmth from a human. I don't want to reduce the amount of time I can spend with my baby. I think it may be lucky for the mothers, but I don't think it is good for the babies to interact with robots”. The interviewee mentioned ‘time with my baby’, ‘lucky for mother’, and ‘no good for babies’. Therefore, while considering our experience in childcare, we interpret the needs (product function) as, “The device is not for simulating, showing and teaching love and human-like relationship with consumers and their children but for monitoring by watching facial expression, posture, and temperature”. The interviewee also answered, “There are children who can't sleep without holding something so it is good to have robot if teacher wants to leave the nursery for a while. Iwant function that do ‘tonton’ action, like a human hand, not plastic.”. The interviewee mentioned ‘can't sleep without holding something’, “leave the nursery for a while’, and “tonton’ action’. Therefore, while considering our experience in childcare, we interpret the needs (product function) as, “The device’s hand is able to hold child’s hand until he/she falls asleep. The device is able to pat child while slowing the pace until he/she falls asleep”.

Table 4-1 The number of total needs and the number of needs interpreted by proposed guidelines

	Total Needs	Needs by Original Guideline	Guideline 1: With Empathy	Guideline 2: As Designer	Guideline 3: With Experience
Problem-based Interview	144	111	20	12	25
Prototype and Story-based Interview	141	95	23	19	28
Total Interpreted Needs	285	206	43	31	53

Table 4-2 Interpreted needs with the proposed guideline 1: with empathy (the problem-based interview)

No	Raw Data (Interview Answers)	Interpreted Needs
1	I was worried that the kids wouldn't be able to catch up on their studies, so I sent them to cram school as well (online).	The device is able to record children's study growth and performance
2	The child is only 2 years old, so I don't know what he will do. If I take my eyes off him for a moment, he tries to go up the stairs.	The device is able to prevent children from walking up the stairs or falling of the stairs
3	I separate clothes to be worn outside from those worn only inside the house.	The device will alert user if clothes from outside are not placed properly
4	Children get bored in the house Children are always looking for new toys	The device will suggest fun activities and game suitable for children
5	I need to buy lots of toys (so I do not need to go out often to buy new toys)	The device is able to suggest new game with toys in the house
6	I failed to consider contacting friends who need help more than I do	The device will remind or update user about friends and family outside the house
7	I was most affected when I gave birth to my second child (a daughter). PCR testing was required, and my husband was not allowed to be together during delivery	The device is able to connect labor room and family member outside
8	Children's classes are online classes only (3rd and 1st grade elementary school)	The device is able to be used for more than one online class at the same time
9	I have a clean house because I am at home for a long time. Plenty of time to clean.	The device is able to clean the house while the user is in it
10	Too bad we can't do and join events. I can't go out of the prefecture and avoid crowds, which limits my range of activities.	The device is able to detect and inform the place that full of people

11	I'm afraid to take my eyes off my child, whose interests are expanding, but who is not yet old enough to know what's wrong and what's right, so I'd be happy if you could do something else for me to watch him.	The device will do the house chores when parents want to take care of children
12	After going outside, I separated my clothes and took a shower every time I returned from outside.	The device will remind user to separate clothes and to take shower after going out
13	Online classes help me make more time at home while taking care of my children.	The device will take care of the children during parents' online class or meeting
14	I need a machine that can disinfect the entire room (like an air conditioner, but not to make people difficult to breathe).	The device' sanitizing process is safe to user respiratory system
15	I am worried about my child, and I want to help him go to school with peace of mind. I want a device that can detect viruses.	The device will send report on virus scanning status in kindergarten or school to the parents from time to time
16	The children's growth can be seen at home.	The device is able to provide child growth report to parents
17	I have no time for myself. Stress from not being able to leave the house	The device is able to take care of house and children while parents are relaxing
18	I think about myself and my family so much that I forget the people around me.	The device is able to connect user to friends and family outside the house
19	I put my family and myself first.	The device will remind user to take care of oneself
20	I am worried about my child, and I want to help him go to school with peace of mind.	The device will notify when children are away from the specified section (within a few meters from the school)

Table 4-3 Interpreted needs with the proposed guideline 1: with empathy (the prototype and story-based interview)

No	Raw Data (Interview Answers)	Interpreted Needs
1	I like all the functions of the robot	The device will send/update the information of people entering/exiting the house to parents
2	It is good if the robot calls the police when a child is injured, and since the childcare workers cannot leave the injured child, it would be useful to have a robot that can call, contact the parents, call someone, or bring something.	The device is able to contact parents, guardians, and authorities in case of emergency and provide correct information to them
3	Childcare is about people and their relationships with each other.	The device is able to detect small changes of a child while measuring temperature
4	I want to use the robot to calm or put my baby to sleep by giving a patting action. I want the robot to sing a lullaby to put the baby to sleep	The device is able to put the baby to sleep by imitating the mother's voice, smell, and heartbeat sound, and has soft and warm skin to imitate the mother's arm and its movement

5	If a child is involved in an incident, it does nothing (e.g., -broken glass, electric shock).	The device is able to cut electricity and stop water in case of danger
6	If a child is involved in an incident, it does nothing (e.g., -broken glass).	The device is able to detect the sound and the location of broken glass, and able to steer away, save and prevent the child from touching the broken glass and, able to clean the broken glass
7	I want a function to detect facial expressions, so that I can tell if a child is concentrating in class or not. A function that can detect eye movement and head tilt.	The device is able to detect eye contact and head's tilting and turning angle during video calls of classes or meetings
8	Electricity (charging devices requires the use of large amounts of electricity)	The device's power last long
9	A robot should play the role of a robot, and there are some things that a robot can never do (changing diapers, looking at rough skin, etc. with the human eye). I believes that a robot cannot see small changes, and believes that only a human can do it.	The device is able to detect small changes in a child such as body temperature, facial color, expression and emotion, skin texture and color, voice, etc. by comparing with past day data and able to alert the parents
10	Changing diapers, wanting to touch, and warmth are important.	The device is able to provide human touch and warmth while changing diaper
11	A: It is my job to notice if there is something different from the usual. B: Double check even if there is a sensor	The device is able to detect small changes in child compare to other day
12	We live in an age where we raise our children while looking at our phones.	The device will remind parents if they did not look after he children (ex. Looking at the phone)
13	C: There are children who can't sleep without holding something so it is good to have robot if teacher wants to leave the nursery for a while. A: I want function that do 'tonton' action, like a human hand, not plastic.	The device's hand is able to hold child's hand until he/she falls asleep The device is able to pat child while slowing the pace until he/she falls asleep
14	C: Futon covering function is good B: Putting a futon after child fall asleep is good C: If the futon is kicked off, it can fix it. A and B: If you are on your face, it can turn over.	The device is able to correct the position of blanket The device is able to correct a child sleeping posture
15	If a child is involved in an incident, nothing is done (e.g., -break glass). Notifying parents is not sufficient because the child may come into contact with danger	The device is able to recognize items (food or not) that a child wants to put in mouth The device is able to prevent child from choking
16	A very good idea. Because children are very good at distracting themselves from my work. I worry that if I don't watch them	The device is able to take care other child while parents taking care the other

	all the time, the older ones will push the younger ones.	
17	I think the reward function is also very good. They can refresh their mind when they get a snack after one class.	The device is able to give children a treat once they finished homework/quizzes
18	I think the ability to disinfect small items with ultraviolet light would be very useful if they ever have to go to school again.	The device is able to sanitize bag & books before and after school
19	I would like to have a function to monitor online classes, not a function to get angry with the robot. I would like to have a robot that can make my children concentrate.	The device will alert children if they lost focus during classes/lessons
20	Parents fear they will lose value if robots do all the work with their children. Children will love robots more than their parents.	The device's functions are able to be set up not to connect with children
21	Parents fear they will lose value if robots do all the work with their children. Children will love robots more than their parents.	The device's is able to remind parents and children to communicate to each other
22	Not enough if the robot only has a screen to play with children (children are easily bored)	The device is able to interact with children with voice and facial expression
23	Childcare is about people and their relationships with each other, and even if a child is trying to warm up, it is important to hold him or her in your arms and put your hand on his or her forehead, even if he or she is a big boy or girl and doesn't want to do so.	The device is able to give human-like touch and hug

Table 4-4 Interpreted needs with the proposed guideline 2: as designer (the problem-based interview)

No	Raw Data (Interview Answers)	Interpreted Needs
1	I took my son out of daycare for a month. I am afraid of because children are weaker and more susceptible to illness. I am afraid they touch this and that.	The device will record places that user/people touch, scan and sanitize
2	Home is clean because I am at home for a long time. Plenty of time to clean	Detailed cleaning task and schedule are able to be programmed to the device
3	The Japanese Corona pandemic began last January. I started to panic, but the good news is that I live in Ube, Japan.	The device is able to be used in any region or any weather
4	I provide a special place to put everything brought in from the outside (e.g. - parcels from the postman)	The device will remind user to leave things from outside and sanitize it
5	I wanted my husband to be present at the birth of my child, but was disappointed that he could not do so because of the corona.	The device is able to scan and sanitize labor room fast

6	No outbreak of vomiting and diarrhea (norovirus, cold virus). No flu/ because everyone is disinfecting?	The device is able to sanitize and kill other virus
7	Not a mist that completely sterilizes you when you pass through it,but like before you enter the operating room, but sterilized when you pass through it.	The device is able to spray with sanitization mist/UV once user walk through it
8	A: It can control room temperature, humidity, and sterilization. C: Like a humidifier	The device is able to adjust temperature and humidity in a room while sanitizing
9	I don't go to places/areas that are highly infected.	The device will give updated info on highly infected region
10	I want my kids to play outside and be involved with their friends, but it's hard.	The device is able to recognize user or guest
11	Online classes help me make more time at home while taking care of my children.	The device is able to conduct video call for online classes
12	Skin on hands are dry because of sanitizer (need to bring skin moisturizer)	The device will provide sanitizing option that is safe and gentle to skin

Table 4-5 Interpreted needs with the proposed guideline 2: as designer (the prototype and story-based interview)

No	Raw Data (Interview Answers)	Interpreted Needs
1	I fear that the device will provide physicians with incorrect information about the child	The device is able to give right/ precise information to authorities (police, hospital etc.)
2	I want a function to get angry instead of myself, when I am annoyed.	The device is able to talk and scold by changing the voice tone and is able to notify and warn by sound, light, movement, and vibration
3	I think skin to skin contact is important, and I hope this device can support only when needed	The device can be set to use when needed only and the device's operating time is able to be set by user
4	This device is better than hiring someone else (such as a housekeeper) (who may invade the family's privacy)	The device can be turn on and off by the user if the use require privacy
5	Better not to clean all areas (for fear that the robot will clean places it shouldn't)	The device will only clean the part of the house set by user
6	Not enough if the robot only has a screen to play with children (children are easily bored)	The device is able to interact with children with display, facial expression and arm movement
7	I don't want to spend less time with my baby.	The device is able to monitor how much time spent in each of its activities, and how much time spent between the parents and the children, and able to record and analyze the interaction data and notify the parents if they need to communicate more with their children

8	Parents fear they will lose value if robots do all the work with their children	The device's functions are able to be set up only for house chores
9	C: The function to wake you up is good, and I would like to use it for children in elementary school and so on. C: I want to use it for children in junior high school, after their parents go out. A: I don't know if it is effective for the robot to do it, it might be more effective for parents to get angry.	The device is able to scold or warn children
10	It is good to be able to call the police when a child is injured, and since the childcare workers cannot leave the injured child, it would be useful if the robot could call or inform the parents or call someone and ask them to bring this or that.	The device is able to contact authorities (police/hospital) in case of emergency or accident. The device is able to follow order from user (to call someone or to bring something etc.)
11	There was talk at the nursery about introducing a function to take body temperature and to attach a chip to the heart rate, etc.	The device measure heart beat by connecting to heartbeat sensor placed near the body
12	Great number of toys, hard to put liquid in and soak and dry, convenient to disinfect if you put it in, many picture books	The device is able to scan and detect most touch part of the house and sanitize The device is able to sanitize a lot of toys at the same time
13	Good futon covering function If the futon is kicked off, fix it.	The device able to put blanket on a sleeping child
14	Electricity (charging devices requires the use of large amounts of electricity)	The device's power last long
15	Instruct children about time using the robot (e.g., time to shower, time to pray, time to study).	The device is able to alert children for their schedule
16	The disinfection part is perfect.	The device is able to sanitize small item in UV box
17	I like all the functions of the robot	The device is able to monitor children and notify parent in case of emergency The device will send/update the information of people entering/exiting the house to parents
18	No first action (because the child has already been in an incident).	The device is able to react fast in case of emergency
19	Can interact with children to replace parents	The device is able to have conversation with children

Table 4-6 Interpreted needs with the proposed guideline 3: with experience (the problem-based interview)

No	Raw Data (Interview Answers)	Interpreted Needs
1	The child is only 2 years old, so I don't know what he will do. If I take my eyes off	The device is able to prevent children from falling of stairs

	him for a moment, he tries to go up the stairs.	
2	I separate clothes to be worn outside from those worn only inside the house.	The device will alert user if clothes from outside are not placed properly
3	Children get bored in the house. Children are always looking for new toys	The device will suggest fun activities and game suitable for children
4	I need to buy lots of toys (reason: don't have to go out often to buy new toys)	The device is able to suggest new game with toys in the house
5	I took my son out of daycare for a month. I am afraid of because children are weaker and more susceptible to illness. I am afraid they touch this and that.	The device will record places that user/people touch, scan and sanitize
6	I failed to consider contacting friends who need help more than I do	The device will remind or update user about friends and family outside the house
7	Skin on hands become dry (must bring skin moisturizer)	The device will provide sanitizing option that is safe and gentle to skin
8	I sanitize all clothing from the outside.	The device will sanitize clothes brought from outside
9	I have a clean house because I am at home for a long time. Plenty of time to clean.	The device is able to clean the house while the user is in it
10	Too bad we can't do and join events. I can't go out of the prefecture and avoid crowds, which limits my range of activities.	The device is able to detect and inform the place that full of people
11	I'm afraid to take my eyes off my child, whose interests are expanding, but who is not yet old enough to know what's wrong and what's right, so I'd be happy if you could do something else for me to watch him.	The device will do the house chores when parents want to take care of children
12	A: It can control room temperature, humidity, and sterilization. C: Like a humidifier	The device is able to adjust temperature and humidity in a room while sanitizing
13	After going outside, I separated my clothes and took a shower every time I returned from outside.	The device will remind user to separate clothes and to take shower after going out
14	Online classes help me make more time at home while taking care of my children.	The device will take care of the children during parents' online class or meeting
15	We don't have to ask the children to take showers (they are afraid of viruses and know when to shower)	The device will remind children to shower, wash hand and sanitize
16	I need a machine that can disinfect the entire room (like an air conditioner, but not to make people difficult to breathe).	The device' sanitizing process is safe to user respiratory system
17	I was most affected when I gave birth to my second child (a daughter). PCR testing was required, and my husband was not allowed to be together during delivery	The device is able to connect labor room and family member outside

18	I am worried about my child, and I want to help him go to school with peace of mind. I want a device that can detect viruses.	The device will send report on virus scanning status in kindergarten or school to the parents from time to time
19	Children's classes are online classes only (3rd and 1st grade elementary school)	The device is able to be used for more than one online class at the same time
20	The children's growth can be seen at home.	The device is able to provide child growth report to parents
21	I was worried that the kids wouldn't be able to catch up on their studies, so I sent them to cram school as well (online).	The device is able to record children's study growth and performance
22	I have no time for myself. Stress from not being able to leave the house	The device is able to take care of house and children while parents are relaxing
23	I think about myself and my family so much that I forget the people around me.	The device is able to connect user to friends and family outside the house
24	I put my family and myself first.	The device will remind user to take care of oneself
25	I am worried about my child, and I want to help him go to school with peace of mind.	The device will notify when children are away from the specified section (within a few meters from the school)

Table 4-7 Interpreted needs with the proposed guideline 3: with experience (the prototype and story-based interview)

No	Raw Data (Interview Answers)	Interpreted Needs
1	I like all the functions of the robot	The device will send/update the information of people entering/exiting the house to parents
2	I fear that the device will provide physicians with incorrect information about the child	The device is able to give the right/ precise information to authorities (police, hospital etc.)
3	It is good if the robot calls the police when a child is injured, and since the childcare workers cannot leave the injured child, it would be useful to have a robot that can call, contact the parents, call someone, or bring something.	The device is able to contact parents, guardians, and authorities in case of emergency and provide correct information to them
4	A robot should play the role of a robot, and there are some things that a robot can never do (changing diapers, looking at rough skin, etc. with the human eye). I believes that a robot cannot see small changes, and believes that only a human can do it.	The device is able to detect small changes in a child such as body temperature, facial color, expression and emotion, skin texture and color, voice, etc. by comparing with past day data and able to alert the parents
5	Does the robot talk? Interesting if the robot's voice or intonation changes, when it is angry, when it is kind.	The device is able to change the voice tone to a warning voice, angry voice and kind voice.
6	I want to use the robot to calm or put my baby to sleep by giving a patting action to	The device is able to put the baby to sleep by imitating mother's voice, smell and heartbeat sound, and have soft and warm

	put baby to sleep. I want the robot to sing a lullaby to put baby to sleep	skin to imitate mother's arm and its movement
7	I think it is important for a baby to feel the warmth from a human. I don't want to reduce the amount of time I can spend with my baby. I think it may be lucky for the mothers, but I don't think it is good for the babies to interact with robots	The device is not for simulating, showing and teaching love and human-like relationship with consumers and their children but for monitoring by watching facial expression, posture, and temperature
8	If a child is involved in an incident, the robot done nothing (e.g. – broken glass)	The device is able to cut electricity and stop water in case of danger
9	Electricity (charging devices requires the use of large amounts of electricity)	The device's power last long
10	A robot is asked to play the role of a robot, and there are some things that a robot can never do (changing diapers, looking at rough skin, etc. with the human eye). I believes that a robot cannot see small changes, and believes that only a human can do it.	The device is able to detect small changes of a child while changing diaper
11	Changing diapers, wanting to touch, and warmth are important.	The device is able to provide human touch and warmth while changing diaper
12	A: It is my job to notice if there is something different from the usual. B: Double check even if there is a sensor	The device is able to detect small changes in child compare to other day
13	We live in an age where we raise our children while looking at our phones.	The device will remind parents if they did not look after he children (ex. Looking at the phone)
14	C: There are children who can't sleep without holding something so it is good to have robot if teacher wants to leave the nursery for a while. A: I want function that do 'tonton' action, like a human hand, not plastic.	The device's hand is able to hold child's hand until he/she falls asleep The device is able to pat child while slowing the pace until he/she falls asleep
15	C: Futon covering function is good B: Putting a futon after child fall asleep is good C: If the futon is kicked off, it can fix it. A and B: If you are on your face, it can turn over.	The device is able to correct the position of blanket The device is able to correct a child sleeping posture
16	If a child is involved in an incident, nothing is done (e.g., -break glass). Notifying parents is not sufficient because the child may come into contact with danger	The device is able to recognize items (food or not) that a child wants to put in mouth The device is able to prevent child from choking
17	A very good idea. Because children are very good at distracting themselves from my work. I worry that if I don't watch them all the time, the older ones will push the younger ones.	The device is able to take care other child while parents taking care the other

18	I think the reward function is also very good. They can refresh their mind when they get a snack after one class.	The device is able to give children a treat once they finished homework/quizzes
19	I think the ability to disinfect small items with ultraviolet light would be very useful if they ever have to go to school again.	The device is able to sanitize bag & books before and after school
20	I would like to have a function to monitor online classes, not a function to get angry with the robot. I would like to have a robot that can make my children concentrate.	The device will alert children if they lost focus during classes/lessons
21	Parents fear they will lose value if robots do all the work with their children. Children will love robots more than their parents.	The device's functions are able to be set up not to connect with children
22	Parents fear they will lose value if robots do all the work with their children. Children will love robots more than their parents.	The device's is able to remind parents and children to communicate to each other
23	Not enough if the robot only has a screen to play with children (children are easily bored)	The device is able to interact with children with voice and facial expression
24	Childcare is about people and their relationships with each other, and even if a child is trying to warm up, it is important to hold him or her in your arms and put your hand on his or her forehead, even if he or she is a big boy or girl and doesn't want to do so.	The device is able to give human-like touch and hug
25	I don't want them to spend less time with their babies. I think it may be lucky for the mothers, but I wonder if it is not good for the babies.	The device will take care of other house chores while parents with the baby
26	Too large (difficult to move)	The device's size is able to be customized according to child age or user preference
27	Does not like the "It can interact with my child" part (fearing that the child will follow the robot's way of speaking)	The device' function to alert and scold children can be set off
28	I would like to have a function to monitor online classes, not a function to get angry. I want the robot to help children focus on the lesson. Parents don't have to get angry or ask to pay attention.	The device is able to make children focus during online class

4.4 Discussion

Based on the interpretation needs from both interviews, although the number of interpreted needs while applying the new proposed guidelines are lower than the conventional guideline, we were able to obtain a few important latent needs. By applying the proposed guideline 3: 'to write a statement as someone with experience which in this case as a parent in this Covid-19 pandemic', a latent need collected is "The device is not for teaching love and humanity but for monitoring by watching facial expression, posture, and vital signals such as temperature and heart rate", which was interpreted from the raw data "I think it is important for a baby to feel the warmth from a human. I don't want to reduce the amount of time I can spend with my baby. I think it may be lucky for the mothers, but I don't think it is good for the babies to interact with robots". Another latent need collected is "The device is able to detect small changes in a child such as body temperature, facial color, expression and emotion, skin texture and color, voice, breath and heart rate etc. by comparing with past day data and able to alert the parents", which was translated from raw data "Let the robot play the role of a robot, and never do the parts that a robot can't do (changing diapers, human eyesight, looking at rough skin, etc., I believe that a robot can't see small changes, I believe that only a human can do it)". We considered the above need as latent needs as the needs was not found in existing patents confirmed by overall patent survey using a patent database that covers patents published in more than 90 countries. We are able to say that by applying this guideline, we were able to obtain an important latent need.

This guideline 3 is limited to be applied in every case of product development as different experience is needed to interpret different raw data. The proposed guideline 1: 'to write a statement while empathizing with the consumers' was assumed as important as the proposed guideline 3 to interpret consumers' problems or their negative statements by empathizing with the interviewees. By applying this guideline too, we were able to elicit a few important latent needs. By having empathy with children, a latent need collected was "The device is able to put the baby to sleep by imitating the mother's voice, smell, and heartbeat sound, and have soft and warm skin to imitate the mother's arm and its movement", which was translated from raw data "I want to use the robot to calm or put my baby to sleep by giving a patting action to put baby to sleep. I want the robot to sing a lullaby to put baby to sleep". Another latent need collected by having empathy with the parents is "The device is able to detect the sound and the location of broken glass, and able to stay the child away, save and prevent the child from touching the broken glass and, able to clean the broken glass", which was interpreted from raw data "If a child is involved in an incident, it does nothing or do something? (e.g., -broken glass)". We are able to say that although the interpreted needs in both guidelines are 80% similar, the proposed guideline 1: 'to write a statement while empathizing with the consumers' is still considered as important to interpret the needs that were unable to interpret without experience.

On the other hand, by considering the proposed guideline 2: 'to write a statement as a designer who understands the concept of the prototype', we were able to collect a few latent needs. One of the latent needs is "The device is able to talk and scold by changing the voice

tone and is able to notify and warn by sound, light, movement, and vibration", which was interpret from "I want a function to get angry instead of myself, when I am annoyed". Another latent need gained was "The device is able to monitor how much time spent in each of its activities, and how much time spent between the parents and the children, and able to record and analyze the interaction data such as physical distance, eye direction and voice during communications, and notify the parents if they need to communicate more with their children", which was translated from raw data "I don't want you to spend less time with your baby". We are able to say that by applying this guideline 2 we were able to elicit important latent needs from the consumers as the needs was not found in existing patents confirmed by overall patent survey too.

In addition, by applying this 3 new guideline in interpreting consumers needs, the fixed concepts may be affected or destroyed. For example, when an interviewee said "A robot should play the role of a robot, and there are some things that a robot can never do (changing diapers, looking at rough skin, etc. with the human eye). I believe that a robot cannot see small changes, and believes that only a human can do it.". After applying the proposed guideline 1: 'to write a statement while empathizing with the consumers', the consumer need was interpreted as "The device is able to detect small changes in a child such as body temperature, facial color, expression and emotion, skin texture and color, voice, etc. by comparing with past day data and able to alert the parents", which might affect the fixed concept that a human should do a human job. Another example is when an interviewee said "I don't want to spend less time with my baby". After applying the proposed guideline 2: 'to write a statement as a designer who understands the concept of the prototype', the need was interpreted as "The device is able to monitor how much time spent in each of its activities, and how much time spent between the parents and the children, and able to record and analyze the interaction data and notify the parents if they need to communicate more with their children". This might affect the fixed concept that a robot will reduce the time between parent and child.

Other examples are when applying the proposed guideline 3: 'to write a statement as someone with experience which in this case as a parent in this Covid-19 pandemic', an interviewee said "I want to use the robot to calm or put my baby to sleep by giving a patting action to put baby to sleep. I want the robot to sing a lullaby to put baby to sleep", the need was interpreted as "The device is able to put the baby to sleep by imitating mother's voice, smell and heartbeat sound, and have soft and warm skin to imitate mother's arm and its movement". This might affect the fixed concept that a robot should not put a baby to sleep. Another example is when an interviewee said "I think it is important for a baby to feel the warmth from a human. I don't want to reduce the amount of time I can spend with my baby. I think it may be lucky for the mothers, but I don't think it is good for the babies to interact with robots". The need was interpreted as "The device is not for simulating, showing and teaching love and human-like relationship with consumers and their children but for monitoring by watching facial expression, posture, and temperature" which might affect the fix concept that a robot might replace a mother's love and attention. From the example above, we were able to say that by applying this new peoposed guideline, we might able to interpret consumers' needs although their interview responses were influenced by fixed concepts.

4.5 Conclusion

In this research, we were able to interpreted raw data of consumers' interviews to the consumer needs. We were able to conclude that the number of interpreted needs increase when we additionally applied the new proposed guideline. Although the number of increased needs are small, the needs might not be interpreted if these 3 new guidelines were not considered. We were also able to obtain a few important latent needs when we applied these new guidelines. We could conclude that by including these guidelines upon interpreting raw data of consumers interviews might lead into discovering important and critical latent needs of the consumers.

This prototype based experimental approach also recorded a customer-device relationships including movement, voice, and interactions as some movies and voice data. In the future, by observing the raw data on relationships and utilizing this new proposed guidelines, more latent needs that could not even figured by customers could be discovered.

Chapter 5 - A quantitative evaluation method for identifying essential latent needs

5.1 Introduction

5.1.1 Recent Research Works on Latent Needs Quantitative Analysis

Customers' voices, responses, and needs are subjective therefore it is difficult to analyze quantitatively and eliciting latent needs from them. There are ongoing researchers regarding this matter. Jiao et al (2009) introduced an analytical Kano (A-Kano) model, which was a calculation and categorizing method of customer needs by using the Kano classifier. This method was adapted from the traditional Kano model (Kano, 1984), which has been widely practiced in industries as an effective tool for understanding customer preferences but is not equipped with quantitative assessment. Ohtomi (2015) classified three kinds of design according to Kano model. One of them is called a delight design that is equivalent to attractive quality in the traditional Kano model. The delight design analysis was performed by measuring the degree of attainment (comfort) and was applied upon designing product sound by using 1D-CAE tool. On the other hand, Sakata et al (2007) introduced a customer satisfaction calculation method that consisted of 3 perspectives of satisfaction, expectation, and significance, and the product functions were classified into eight spaces using a three-dimensional positioning map. Product functions with low expectations were considered as latent needs despite having a low satisfaction level too however, the functions with high significance were considered as true latent needs. Another quantitative evaluation approach in product development was introduced by Okamoto et al (2022) who calculated the degree of exploration and exploitation in product design by extracting and analyzing product function from design documents.

Failure Mode and Effect Analysis (FMEA) also is one of the renowned quantitative analysis in product design and development. Dhillon (1992) traced the history of FMEA back to the early 1950s, when it was used for the design of flight control systems. FMEA emerged as a formal technique in the aerospace and defense industries. It is a structured approach for identifying all possible failures in a design, a manufacturing or assembly process, or a product or service (Stamatis, 2003). Failures are any errors or defects, especially ones that affect the customer, and can be potential or actual, while effects analysis refers to studying the consequences of those failures. By scoring the severity of the effect, the occurrence and the detection rate of the failure and calculating the risk priority number (RPN), FMEA is able to assist on discovering failure at its earliest possible point in product or process design. On the other hand, Fault Tree Analysis (FTA) is also an alternative method to investigate failure behavior (Peeters, 2018). A fault tree is a logic diagram that represents the relationships between an event (typically a system failure) and the causes of the event (typically component failures). It uses logic gates and events to model how the component states relate to the state of the system as a whole. Other FMEA alternatives include DFMEA (Design Failure Mode and Effect Analysis), which looks at failures in product design, and PFMEA (Process Failure Mode and Effect Analysis), which investigates process-related failure. We believed that the methods above are able to be applied as assisting tools for product

development therefore we assumed that the research on quantitative analysis for identifying latent needs is important.

5.1.2 Quantification of Importance of Product Function for Identifying Critical Latent Needs

In product design, the designers are needed to select the function and features to be implemented in the products. However, if all the various functions are combined into the product, it will be expensive and/or heavy and will be unchosen by customers. On the other hand, even if the product is based on a latent need but the necessary functions are overlooked, customers might not consider to choose the product. Therefore, it is necessary to evaluate the importance of the product functions including the functions that is based on latent needs. However, the method to evaluate the importance of functions based on latent needs is insufficient. Therefore, this study attempts to a method to quantify the importance of functions based on latent needs.

In this research, to quantitatively evaluate the importance of functions based on latent needs, we first defined the degree/scoring/rating of whether the customer has specifically stated it or is abstractly aware of it) and called it latent-ness. Then to evaluate the importance of product functions based on latent needs we introduced another two perspectives which is importance: whether the function is unnecessary or indispensable; and technological feasibility: whether it is possible or impossible with existing technology, and each index was scored in five levels. Each of all interpreted needs was given scores of each perspective. Then, by adapting calculation method from Failure Mode Effect Analysis (FMEA) (Stamatis, 2003), the three perspectives of importance, latent-ness, and technological feasibility is multiplied to indicate that all three perspectives are essentials. This proposed method was called Degree of Latent Needs (DLN). The DLN results were then analyzed to ensure that all interpreted needs that we considered as important were received high DLN and therefore we can indicate that this method is applicable as supporting method in identifying critical latent needs.

In our previous research (Issa, 2022), the method in the elicitation of latent needs from customer needs was verified by first applying and executing the ‘guideline for writing need statement’ method by (Ulrich et. al, 2015) to interpret customers’ responses from the interviews into product functions. The list of guidelines is to focus on ‘what is the product’ not ‘how the product work’, to be specific as in original responses, to write ‘positive’ not ‘negative’ statement, to list the attribute of the product and to avoid using ‘must’ and ‘should’ in the statement. Then, the functions of existing products were enlisted based on the functions stated in their product manuals and in patents’ claims. The interpreted needs in the interviews were compared with the functions of these existing products to clarify the final latent needs. In this research, the same interpreted needs before the comparison with existing products are used to identify latent needs.

5.2 Method

5.2.1 Method of interpreting consumers' responses to need statement

The consumers' responses from the Problem-based and Prototype and Story-based slide presentations and interviews in our last research in Chapter 3 were utilized. The interview results were listed, interpreted, and analyzed according to the 5 guidelines for writing need statements by (Ulrich et al, 2015) to identify the needs of the consumers. The first guideline is to express the need in terms of what the product has to do, not in terms of how it might do it. Customers frequently describe a solution concept or an implementation strategy to convey their preferences. However, the necessity should be stated without reference to a specific technological advancement. The second guideline is to express the need as specifically as the raw data. There are many different ways to express needs. Express the demand as precisely as the raw data to prevent information loss. The third guideline is to use positive and not negative phrasing. If a need is stated as a positive statement, it is simpler to translate it later into a product specification. However, it is not rigid because using positive language is occasionally challenging and difficult. The forth guideline is to express the need as an attribute of the product. Wording requirements for product statements help to assure consistency and make it easier to translate those requirements into product specifications. The fifth guideline is to avoid the word 'must' and 'should'. It is because the language 'must' and 'should' convey an importance level for the need. It is advised to postpone determining the importance of the needs until the following stage rather than simply giving them a binary importance ranking. The example by Ulrich on how the guidelines were applied during interpretation was shown in Fig 5-1.

Guideline	Customer Statement	Need Statement—Right	Need Statement—Wrong
"What" not "how"	"Why don't you put protective shields around the battery contacts?"	The screwdriver battery is protected from accidental shorting.	The screwdriver battery contacts are covered by a plastic sliding door.
Specificity	"I drop my screwdriver all the time."	The screwdriver operates normally after repeated dropping.	The screwdriver is rugged.
Positive not negative	"It doesn't matter if it's raining; I still need to work outside on Saturdays."	The screwdriver operates normally in the rain.	The screwdriver is not disabled by the rain.
An attribute of the product	"I'd like to charge my battery from my cigarette lighter."	The screwdriver battery can be charged from an automobile cigarette lighter.	An automobile cigarette lighter adapter can charge the screwdriver battery.
Avoid "must" and "should"	"I hate it when I don't know how much juice is left in the batteries of my cordless tools."	The screwdriver provides an indication of the energy level of the battery.	The screwdriver should provide an indication of the energy level of the battery.

Fig 5-1 The guideline by Ulrich (2015) on how to write need statement

5.2.2 Proposed Quantitative Evaluation Method for Identifying Latent Needs from Product Function

The latent needs of customers are subjective and difficult to evaluate quantitatively therefore the method to quantify latent needs from product function is insufficient. One of the similar quantitative evaluation methods is Failure Mode Effect Analysis (FMEA) (Stamatis, 2003) which is a well-known and proven method in the product development process. On the other hand, Fault Tree Analysis (FTA) is also an alternative method to investigate failure behavior (Peeters, 2018). A fault tree is a logic diagram that represents the relationships between an event (typically a system failure) and the causes of the event (typically component failures). It uses logic gates and events to model how the component states relate to the state of the system as a whole. Other FMEA alternatives include DFMEA (Design Failure Mode and Effect Analysis), which looks at failures in product design, and PFMEA (Process Failure Mode and Effect Analysis), which investigates process-related failure. However, this paper proposes a method for quantifying latent needs from product functions with reference to the method in the original FMEA. FMEA concept is to quantify based on three aspects which are severity, occurrence, and detection to measure product failure risk. This paper also set three metrics to measure latent needs from product function. One of the metrics is importance: whether the function is unnecessary or indispensable; which can be compared to the severity in FMEA. Then the technological feasibility: whether it is possible or impossible with existing technology, is recognized as the occurrence in FMEA. The detection aspect in FMEA is then compared to the latent-ness in our paper which we defined as whether the customer has specifically stated it or is abstractly aware of it. Certainly, there are other important aspects in discovering latent needs such as customer satisfaction and expectation, manufacturing cost, ergonomics, and aesthetics, comfortableness that were not applied in this paper as it is assumed that these aspects are similar or included in our three chosen metrics.

In this evaluation method, each metric was scored in five levels, and the basis or rating of each level is described in Table 5-1, 5-2, and 5-3 respectively for each metric. In FMEA, the risk priority number is calculated by multiplying the three metrics in FMEA to assess the risk priority level of a failure cause. In this paper, with reference to the calculation method in FMEA, the degree of latent needs is calculated as follows

$$\mathrm{V}^{DLN} = I_i \times L_i \times T_i \tag{1}$$

$$\mathrm{E}^{DLN} = \sum_{i=1}^{n} \left(I_i \times L_i \times T_i\right)/n \tag{2}$$

where V^{DLN} : A degree of latent need in a product function
E^{DLN} : Average of the degree of latent needs in a design
n : Number of latent needs (product function) in a design
I_i : Importance of a latent needs (product function) in a design
L_i : Latent-ness of a latent needs (product function) in a design
T_i : Technological feasibility of a latent needs (product function) in a design

10 evaluators with mechanical engineering background and age between 22 to 47 years old used this method to evaluate the degree of latent needs for all the product functions. The details of the evaluators were shown in Table 5-4. The average of the degree of latent needs in a product function and its standard deviation was calculated as follow

$$A^{DLN} = \sum_{i=1}^{a}(I_i \times L_i \times T_i)/a \quad (3)$$

$$\sigma^{DLN} = \sqrt{\frac{1}{a}\sum_{i=1}^{a}(x_i - A^{DLN})^2} \quad (4)$$

where A^{DLN} : Average of the degree of latent needs in a product function
σ^{DLN} : Standard deviation of the degree of latent needs in a product function
a : Number of evaluator

Table 5-1 Basis of rating for importance of the need in the product design

Basis of Rating	Rate
It is not attractive as the function. The function does not affect the customer's purchasing decision	1
The function might be attractive. The customer might purchase the product because of the function.	2
It is attractive as a function, but the customer might purchase the product even if it does not have a function.	3
If this function is provided, the customer strongly considers purchasing the product.	4
If this function is not provided, the customer will not purchase the product.	5

Table 5-2 Basis of rating for latent-ness

Basis of Rating	Rate
Customers are able to specifically articulate the need for functions by themselves.	1
Customers are unable to specifically state the need for functions by themselves, but they can articulate some fraction of the function concretely in an abstract manner.	2
Customers are unable to specifically state the necessity of the function by themselves, but they can state it abstractly.	3
Customers have the needs of the function but do not clearly recognize it. They can only state it very abstractly not specifically by themselves.	4
Customers are suspected to have the need for the function, but they do not recognize and are unable to state it at all	5

Table 5-3 Basis of rating for technological feasibility

Basis of Rating	Rate
It does not exist as an established technology such as a patent, paper, or product and is not under research and development. There is no projection of a specific number of years for it to be available	1

It does not exist as an established technology, but it is under research and development. However, it is on the academic roadmap or the specific number of years it will be available is unknown	2
It does not exist as an established technology, but it is on the academic roadmap or expected to be available for a specific number of years	3
It is not feasible at the present time but can be developed by using existing technologies	4
It can be achieved by combining existing technologies at the present time	5

Table 5-4 The evaluators basic information

	Nationality	Gender	Age
Evaluator A	Malaysian	Female	37
Evaluator B	Japanese	Male	47
Evaluator C	Japanese	Female	22
Evaluator D	Japanese	Male	22
Evaluator E	Japanese	Male	24
Evaluator F	Japanese	Female	22
Evaluator G	Japanese	Female	22
Evaluator H	Japanese	Male	23
Evaluator I	Japanese	Male	23
Evaluator J	Japanese	Male	22

5.3 Results

5.3.1 Distribution of Degree of Latent Needs Values

After the consumers' responses were interpreted in Chapter 3 using Ulrich's five guidelines for writing need statements, the interpreted needs from Prototype and Story-based interviews were utilized again in this chapter.

The interpretations obtained from the interviews were rated based on the basis of rating in Tables 5-1, 5-2, and 5-3 for importance, latent-ness, and technological feasibility of the Degree of Latent Needs (DLN) by 10 evaluators with mechanical engineering background and age between 22 to 47 years old. The evaluation results by the 10 evaluators were shown in Appendix section in Table A-1 – A-10. The needs with the DLN values (V^{DLN}), the average of the Degree of Latent Needs (DLN) in a product function (A^{DLN}), and the standard deviation of the Degree of Latent Needs (DLN) in a product function (σ^{DLN}) are shown in Tables 5-5 in descending order. Then the average of the degree of latent needs in a design, E^{DLN} for each evaluator, and its average and standard deviation were calculated and are shown in Table 5-6.

Table 5-5 Interpreted Needs with DLN values (V^{DLN}), the average (A^{DLN}) and the standard deviation (σ^{DLN}) of the Degree of Latent Needs (DLN) in a product function

No	Interpreted Needs	A	B	C	D	E	F	G	H	I	J	Average (A^{DLN})	STDEV (σ^{DLN})
1	The device's texture is soft like silicon	75	100	60	60	45	80	10	40	32	60	56.2	25.80
2	The device will tell parents when to change the diaper	60	64	60	48	36	80	64	32	48	40	53.2	14.97
3	The device is able to make children to study and monitor them	100	100	48	36	45	30	20	60	16	48	50.3	29.41
4	The device will remind parents if they did not look after the children (ex. Looking at the phone)	75	100	36	36	36	40	100	16	16	40	49.5	31.13
5	The device's hand is able to hold child's hand until he/she falls asleep	80	80	45	48	24	45	45	36	24	60	48.7	19.75
6	The device is able to pat child while slowing the pace until he/she falls asleep	60	80	45	48	18	45	45	36	48	60	48.5	16.26
7	The device is able to wake the child up	100	100	48	32	30	45	10	30	60	30	48.5	30.24
8	The device is able to alert parents when the baby wake up	80	80	48	36	36	50	16	30	64	40	48.0	21.10
9	The device is able to detect small changes in child compare to other day	80	80	60	32	36	60	12	27	36	40	46.3	22.74
10	The device is able to correct a child sleeping posture	100	100	18	48	12	40	45	27	24	48	46.2	31.02
11	The device is able to give human-like touch	75	75	60	48	60	20	48	24	16	30	45.6	22.10
12	The device's is able to remind parents and children to communicate to each	80	80	30	45	24	80	20	32	24	40	45.5	24.94

	other													
13	The device's texture feels like human skin	64	80	60	24	45	16	36	45	24	60	45.4		20.65
14	The device will alert children if they lost focus during classes/lessons	80	80	36	36	48	20	60	45	18	24	44.7		22.71
15	The device is able to monitor baby sleeping	100	80	75	16	36	25	30	25	20	25	43.2		29.98
16	The device's temperature is same as human	45	75	60	30	45	50	16	30	16	60	42.7		19.59
17	The device is able to calm the child	75	100	36	32	36	40	24	24	36	24	42.7		25.02
18	The device is able to give facial expression	48	48	60	36	30	60	60	20	24	40	42.6		15.03
19	The device is able to teach user	80	75	36	32	45	30	10	48	40	30	42.6		21.15
20	The device is able to give a human-like warm hug	80	80	48	36	45	20	48	18	24	24	42.3		22.88
21	The device is able to be used indoor/outdoor	48	64	40	40	30	75	20	25	60	20	42.2		19.27
22	The device's part can be use and operate separately	36	36	50	48	45	40	30	45	40	50	42.0		6.72
23	The device is able to follow order from user (to call someone or to bring something etc.)	36	48	16	40	20	75	20	75	75	15	42.0		25.20
24	The device is able to detect small changes of a child while changing diaper	75	75	32	48	18	60	60	12	16	24	42.0		24.58
25	The device will alert children to look at the screen or open the book or listen to the teacher	45	60	40	36	48	20	60	45	30	30	41.4		12.95
26	The device will alert user with alarm in case of danger	75	60	20	30	30	50	16	75	32	25	41.3		22.11
27	The usage time of the display by the children can be set	60	45	40	30	40	40	10	45	60	40	41.0		14.30

28	The device is able to detect small changes of a child while measuring temperature	60	60	32	36	12	80	15	18	32	64	40.9	23.58
29	The device is able to interact with children with voice and facial expression	60	60	30	48	24	40	60	15	30	40	40.7	16.12
30	The device is able to take care other child while parents taking care the other	48	64	48	36	32	80	48	18	16	12	40.2	21.84
31	The device's function can be selected by user	25	25	60	40	30	75	20	36	60	30	40.1	18.53
32	The device is able to connect parents and child using the display	25	25	60	40	30	25	20	60	75	40	40.0	18.86
33	The device is able to make children focus during online class	60	60	36	36	60	32	32	36	24	24	40.0	14.48
34	The device will only clean the part of the house set by user	20	20	20	48	64	60	30	36	60	40	39.8	17.50
35	The device's function is only to support parents or nursery/kindergarten teacher	75	75	36	48	24	40	24	24	16	36	39.8	20.79
36	The device is able to decide who to notify first (parents or authorities)	60	60	20	48	24	50	32	48	30	25	39.7	15.17
37	The device relaxes the baby	50	50	48	32	36	40	24	45	24	48	39.7	10.24
38	The device is able to play lullaby song from mother's voice	45	60	30	30	10	45	40	45	30	60	39.5	15.17
39	The device is able to provide human touch and warmth while changing the diaper	100	100	48	36	27	6	15	27	24	12	39.5	34.05
40	The device is able to scold or warn children	80	80	36	32	30	30	12	30	40	24	39.4	22.65
41	The device is able to detect eye contact and head's tilting and turning angle	48	64	45	45	32	40	30	24	30	30	38.8	12.00
42	The device is able to scan and recognize	60	60	48	30	30	25	15	75	20	25	38.8	20.41

	user/stranger												
43	The device is able to hold a baby like a mother	75	75	64	18	36	16	24	36	32	12	38.8	24.05
44	The device's functions are able to be set up not to connect with children	40	30	30	32	80	20	30	24	60	40	38.6	18.26
45	The device is able to play games with children	48	48	36	30	27	40	30	36	30	60	38.5	10.58
46	The device is able to set to freely move and set to still	25	25	15	48	45	45	30	36	30	60	38.4	16.68
47	The device is able to give children a treat once they finished homework/quizzes	60	45	36	36	30	15	20	45	36	60	38.3	14.89
48	The device is able to greet user or stranger at the front door	64	48	48	48	45	20	20	30	12	48	38.3	16.71
49	The device is able to scan and detect user's focus in class	60	60	36	36	60	16	30	36	36	12	38.2	17.29
50	The device's shape is round	45	45	40	24	40	20	15	45	60	40	37.4	13.70
51	The device is able to play, dance, sing and karaoke with user	80	80	36	36	24	10	25	27	32	12	37.2	23.31
52	The device is able to manage the schedule for children	15	20	60	30	45	60	15	45	30	45	36.5	17.00
53	The device is able to give children refreshment after finished class/lesson	60	45	36	36	16	15	20	45	45	45	36.3	14.89
54	The device is able to teach and play with children	80	80	36	36	24	10	25	27	32	12	36.2	24.69
55	The device is suitable to support working mom or housewife	40	50	48	36	60	50	8	36	12	20	36.0	17.46
56	The device is able to be used in kindergarten or nursery	40	50	48	36	30	40	10	60	8	36	35.8	16.48
57	The device able to put blanket on a sleeping child	48	64	36	48	30	15	20	36	36	24	35.7	14.71

58	The device is able to stop water in case of danger	48	48	25	48	30	40	20	12	60	25	35.6	15.39
59	The device is able to correct the position of blanket	80	64	30	48	16	10	30	18	24	36	35.6	22.31
60	The device is able to teach with voice and facial expression	48	64	27	48	36	45	10	15	32	30	35.5	16.33
61	The device will monitor children movement in the house	75	48	40	32	45	25	20	25	25	20	35.5	17.16
62	The device is able to monitor children and notify parent in case of emergency	75	75	20	24	24	50	20	25	15	25	35.3	22.89
63	The device is able to suggest new/suitable game for parents and children	36	48	36	64	15	25	18	36	30	45	35.3	14.63
64	The device is able to sing lullaby to put child to sleep	60	60	12	36	20	30	40	45	4	45	35.2	18.90
65	The device is able to give milk to children only when needed	40	40	48	48	24	20	12	36	60	24	35.2	14.94
66	The device is able to be used in any situation (post-covid19)	20	20	24	48	24	100	32	32	32	20	35.2	24.35
67	The device is able to advice/suggest how to spend free time	45	60	36	36	24	25	9	45	32	40	35.2	13.97
68	The device is able to prevent child from choking	80	80	32	32	24	40	15	0	20	25	34.9	26.09
69	The device is made from strong material	20	15	45	32	30	75	15	30	60	25	34.7	19.74
70	The device will remind to finish homework before next class	60	60	30	30	30	30	30	45	16	15	34.6	15.76
71	The device's size is able to be customized according to child age or user preference	36	48	36	48	45	40	20	18	40	15	34.6	12.48
72	The device's functions are able to be set	30	30	40	20	60	60	20	36	24	20	34.0	15.32

	up only for house chores													
73	The device is able to put child to sleep	60	75	48	24	36	30	15	12	32	8	34.0		21.60
74	The device will stop child from touching dangerous thing (broken glass, open wire, fire etc.)	32	32	50	48	36	50	20	20	20	25	33.3		12.40
75	The device is able to judge the level of sickness and notify parents or authorities (hospital etc.)	75	50	20	48	36	50	20	20	20	25	33.2		20.35
76	The cleaning part of the device is able to be detached.	15	20	30	36	60	20	15	30	75	30	32.9		19.76
77	The device is able to play with children with voice and facial expression	36	60	30	36	36	30	20	9	32	40	32.9		13.20
78	The device is able to recognize items (food or not) that a child wants to put in mouth	80	60	16	20	27	25	25	36	20	20	32.9		20.84
79	The device's function to interact with children can be turned off	25	25	15	25	30	80	15	36	24	20	32.6		21.39
80	The device will suggest activities for parents and children to do together	48	64	24	36	30	25	18	36	24	20	32.5		14.26
81	The device is able to do the task for maid or nurse	50	50	36	36	36	20	16	27	16	36	32.3		12.44
82	The device is able to cut electricity in case of danger	50	50	25	48	20	32	20	12	40	25	32.2		13.96
83	The device is able to conduct CPR	45	60	25	48	20	40	20	12	36	16	32.2		15.92
84	The device is able to scan and detect most touch part of the house and sanitize	40	50	32	48	30	30	20	36	16	20	32.2		11.60
85	The device is able to teach from display	25	25	48	24	30	20	20	30	60	40	32.2		13.17
86	The device is able to clean up and arrange toys according to type	36	36	32	64	36	30	15	18	24	30	32.1		13.45
87	The device will do other house chores	48	80	24	24	40	30	16	27	16	12	31.7		20.25

	while parents take care of children														
88	The device will remind user to wash hand with soap	30	40	32	24	40	30	45	30	30	15	31.6	8.59		
89	The device is able to measure heart beat	48	36	30	20	15	25	20	40	60	20	31.4	14.49		
90	The device will remind to dress properly before class	18	27	36	36	30	20	60	45	20	20	31.2	13.48		
91	The device' function to alert and scold children can be set off	25	25	15	25	20	60	15	30	15	80	31.0	21.71		
92	The device's function can be set to take care other things than a baby	27	36	40	48	27	10	48	18	16	40	31.0	13.47		
93	The device will take care of other house chores while parents with the baby	48	80	24	24	40	30	16	18	16	12	30.8	20.68		
94	The device is able to give simple guide to get dress before class	27	36	18	36	30	15	45	45	40	16	30.8	11.50		
95	The device is able to move slow or fast according to the task/activity	20	20	30	32	24	40	20	36	40	45	30.7	9.41		
96	The device will notify authorities (police etc.) if the person in/around the house is suspicious	50	32	20	48	40	32	16	25	20	20	30.3	12.26		
97	The device measure heart beat by connecting to heartbeat sensor placed near the body	40	30	30	20	30	25	20	40	48	20	30.3	9.71		
98	The device's weight is suitable to be carried by user around the house	25	25	30	48	15	40	45	15	40	20	30.3	12.24		
99	The device is able to have conversation with children	40	32	45	32	24	45	15	20	15	32	30.0	11.29		
100	The device's display is interactive	25	25	24	36	32	60	10	36	30	20	29.8	13.17		
101	The device will remind to prepare for next class	30	40	30	30	15	30	30	45	16	20	29.6	9.09		
102	The device is able to monitor people/	16	16	40	48	36	25	45	25	20	25	29.6	11.79		

	stranger inside/ outside/ around the house												
103	The device is able to sanitize a lot of toys at the same time	20	25	30	40	40	45	5	36	32	20	29.3	12.07
104	The device function is able to be customized according to customer preference or budget	20	15	36	36	50	25	25	36	25	25	29.3	10.15
105	The device is able to contact authorities (police/hospital) in case of emergency or accident	50	50	25	20	20	40	16	25	20	25	29.1	12.75
106	The device's functioning time is able to be set by user	20	25	20	25	45	45	10	45	30	25	29.0	12.20
107	The device is able to contact parents in case of emergency	40	40	50	30	12	25	25	20	20	25	28.7	11.46
108	The device is able to alert children for their schedule	15	15	30	45	30	15	15	45	45	30	28.5	13.13
109	The device is able to ventilate room	15	15	30	48	30	40	30	30	32	15	28.5	10.96
110	The device is able to give milk and bath, and change diaper	50	50	36	27	18	32	20	18	16	18	28.5	13.14
111	The device is able to sanitize bag & books before and after school	50	50	30	48	10	15	10	36	15	20	28.4	16.61
112	The device's power last long	25	25	10	100	20	20	20	24	16	20	28.0	25.69
113	The device is able to sanitize the house using alcohol sanitizer or UV light	30	40	30	40	30	15	20	24	30	20	27.9	8.28
114	The device is able to interact with children with display	15	25	40	48	30	25	20	15	25	32	27.5	10.49
115	The device will send/update the information of people entering/exiting the house to parents	24	24	24	36	10	50	20	40	16	30	27.4	11.89
116	The device is able to sanitize and keep	10	15	40	40	20	45	5	30	48	20	27.3	15.37

	mask															
117	The device is able to open and close window and curtain	15	15	30	36	15	40	30	36	16	40	27.3	10.90
118	The device is able to react fast in case of emergency	40	40	20	32	36	25	12	20	20	25	27.0	9.57
119	The device is equipped with camera with make-up filter	10	15	30	45	40	25	5	30	20	50	27.0	14.94
120	The device is able to wipe, clean and sanitize table and floor	40	40	40	32	40	15	20	12	16	15	27.0	12.40
121	The device can clean the house while moving around the house	20	20	24	48	15	30	20	45	27	20	26.9	11.17
122	The device will remind the schedule for next class	15	15	30	30	30	30	10	45	30	30	26.5	10.29
123	The device price is affordable	20	20	24	15	25	75	25	16	20	25	26.5	17.43
124	The device can be set to use when needed only	15	15	20	25	32	30	30	30	45	20	26.2	9.19
125	The device is able to operate with small power	6	4	15	32	20	60	20	24	60	20	26.1	19.62
126	The device is able to measure temperature (room and body)	20	25	40	20	30	25	20	20	40	20	26.0	8.10
127	The device is able to sanitize small item in UV box	15	10	30	45	45	30	30	30	9	15	25.9	13.22
128	The device is able to react fast in case of danger	40	40	20	32	24	25	12	20	20	25	25.8	9.05
129	The device is able to clean up broken glass, spilled water etc.	25	25	40	32	15	50	15	15	20	20	25.7	11.76
130	The device is able to scan and recognize people outside /around the house	16	16	32	32	36	25	30	20	20	25	25.2	7.11
131	The device puts out soap for hand washing	15	15	15	45	10	15	5	45	16	60	24.1	18.63

132	The device will remind to measure temperature	10	15	40	30	20	25	15	15	60	10	24.0	15.78
133	The device has a power saving mode	5	5	15	20	15	60	20	36	40	20	23.6	17.08
134	The device is able to sanitize house	25	20	30	48	18	20	15	24	20	15	23.5	9.76
135	The device can be turn on and off by the user	15	15	25	25	25	20	5	45	30	25	23.0	10.59
136	The device is able to measure body temperature	15	15	30	20	10	25	15	20	60	20	23.0	14.18
137	The device is able to purify the air	10	10	40	24	40	25	20	15	20	15	22.9	11.09
138	The device is able to change the voice tone.	15	30	16	10	9	20	20	30	45	30	22.5	11.18
139	The device is able to give right/ precise information to authorities (police, hospital etc.)	24	16	24	36	16	24	20	32	16	15	22.3	7.21
140	The device is able to sanitize a lot of books at the same time	15	15	30	40	30	5	5	30	30	20	22.0	11.83
141	The device is able to sweep and vacuum the floor	20	20	15	40	30	10	10	12	30	15	20.2	10.08

Table 5-6 The average of the degree of latent needs in a design, E^{DLN} for each evaluators and its average and standard deviation

No	Evaluators	A	B	C	D	E	F	G	H	I	J	Average of E^{DLN}	STDEV of E^{DLN}
1	Average of the degree of latent needs in a design (E^{DLN})	44.3	46.5	34.7	36.8	31.1	36.1	23.9	31.3	31.3	29.7	34.6	6.45
2	Variance of the degree of latent needs in a design	591	628	163	131	163	352	216	173	258	198		
3	Standard deviation of the degree of latent needs in a design	24.3	25.1	12.8	11.4	12.8	18.8	14.7	13.2	16.1	14.1		

5.4 Discussion

5.4.1 Average and Variance of E^{DLN} for Each Evaluator

As shown in the Table 5-6, the standard deviation of E^{DLN} for each evaluator was 6.4 for an average of 34.5, which is sufficiently small compare to the DLNs rate at the top of the ranking. However, there were two evaluators whose average exceeded 44.0. Since both of the value is close to +2σ, there is a strong possibility of unexplained by only statistical fluctuations, and it is strongly suspected that there is a reason.

We examined the two evaluators and found that they were the only two who had experience in childcare. Since it is natural to assume that the presence or absence of childcare experience has a significant impact on the evaluation, we recalculated the mean and standard deviation for the eight evaluators excluding these two.

The results indicate that the average decreased to 31.8 and the standard deviation was 3.9. By considering the objective of identifying important potential needs, since the DLNs rate at the top of the ranking are above 60 points, the standard deviation from the average and the need for average score adjustment is small enough. This indicates that the proposed basis of rating in DLN is effective.

5.4.2 Comparison between Interpreted Needs' DLN values (V^{DLN}) Distribution, Normal Distribution, and t-Distribution

The DLN values (V^{DLN}) of each interpreted needs (141 needs) by all evaluators (10 evaluators) was plotted in Fig 5-2 and the distribution was compared with normal distribution graph in Fig 5-3 and Fig 5-4. The comparison indicates that the distribution of DLN values of each interpreted needs is similar to normal distribution. Therefore, we can consider the DLN values (V^{DLN}) of interpreted needs as normal distribution.

Then, the distribution was compared with t-distribution graph with degree of freedom 1409 ((141 needs x 10 evaluator) – 1) in Fig 5-5. The comparison indicates that the distribution of DLN values of each interpreted needs is within the range of t-distribution. Therefore, we can consider the DLN values (V^{DLN}) of interpreted needs as normal distribution

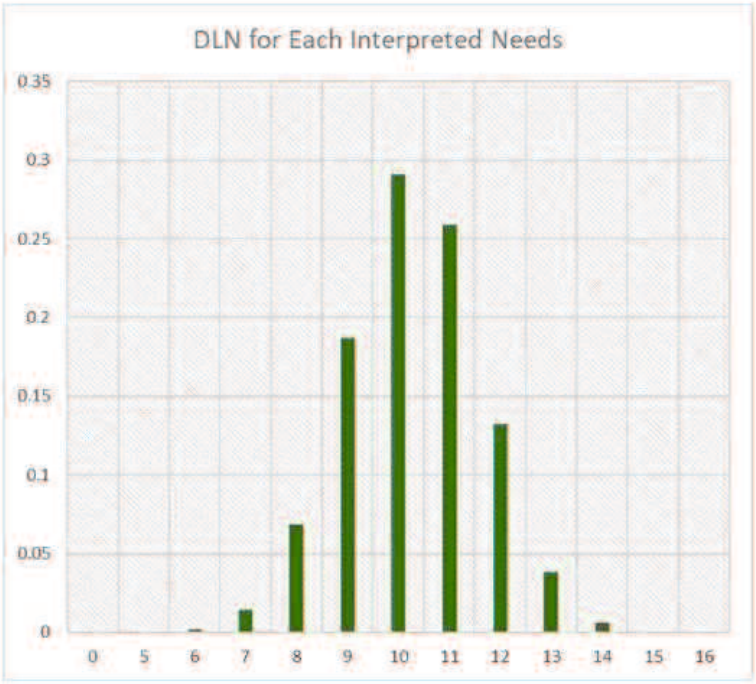

Fig. 5-2 DLN values distribution

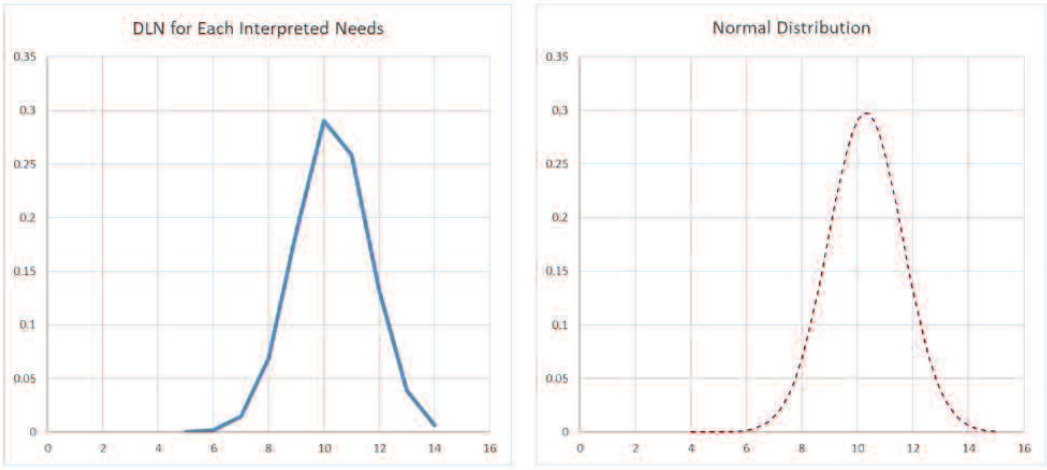

Fig. 5-3 Comparison of DLN values distribution (left) and Normal Distribution (right)

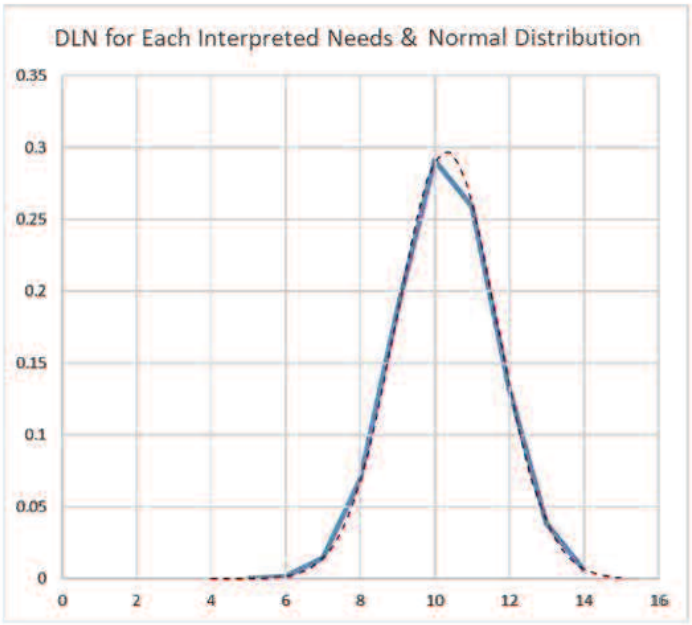

Fig. 5-4 Comparison of DLN values distribution and Normal Distribution (combined graph)

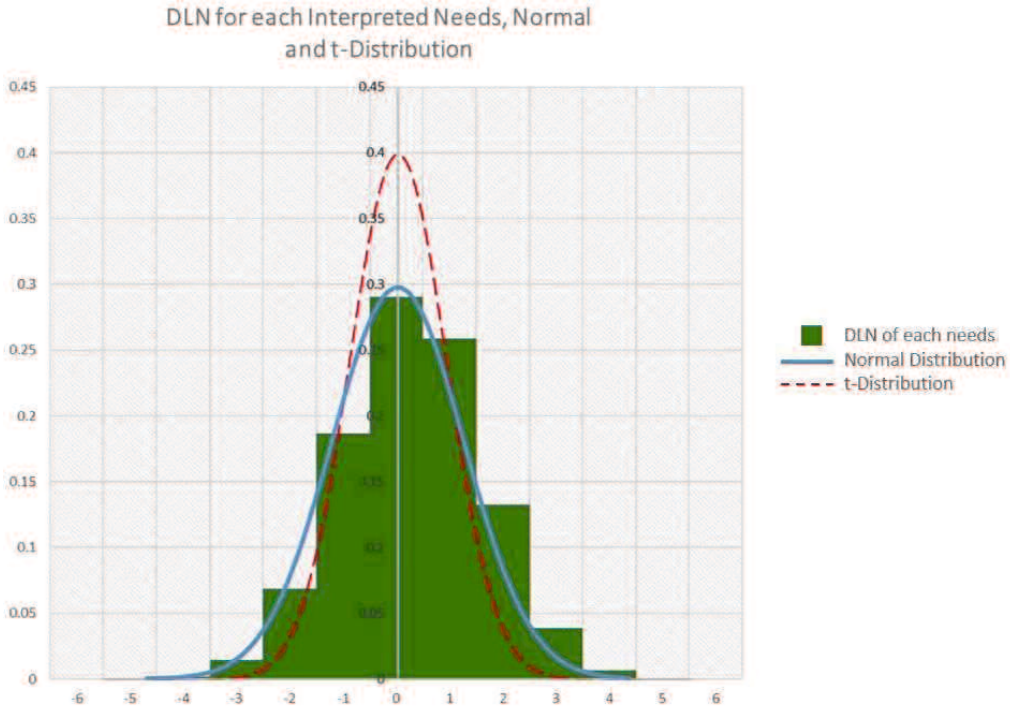

Fig. 5-5 Comparison between DLN values distribution with Normal and t-Distribution (combined graph)

5.4.3 Discussion on DLN rankings

From the results of the 20 highest DLN in Table 5.5, it indicates that the product functions with the highest DLN on average are indeed attractive features in terms of design and can be assumed to be important latent needs. This suggests that the basis of rating in DLN is effective to assist on discovering essential latent needs. On the other hand, the results of the 20 lowest DLN in the same Table 5.5 indicate that the functions with lowest DLN on average are certainly unattractive as a design feature, and there are many functions that cannot be considered as latent needs.

5.4.4 The Average and Variance of Each Interpreted Need (Product Function)

As we can consider the DLN values (V^{DLN}) of interpreted needs as normal distribution based on Fig 5.2-5-4, we are able to compare the average and variance of each interpreted needs. If the average (A^{DLN}) of each interpreted need is high and the standard deviation is low, it indicates that the interpreted needs (product functions) received consistently high rates from all the evaluators. The interpreted needs were highly recognized, still among the attractive features they may be needs that should not be considered important in design. Therefore, designers should select the product function carefully upon designing. If both the average (A^{DLN}) and the standard deviation is high, and the minority opinion is genuine, it might mean that “many evaluators think it is important, but in fact, a few evaluators know specific reasons why it should not be considered so important”. This can be interpreted as a dangerous trap to be caught in design. If the average (A^{DLN}) is low but the standard deviation is high, and the minority opinion is genuine, it might mean that "only a few evaluators are aware of what is actually important, while many are not”. This can be interpreted as a great opportunity in design.

Based on the results of the average (A^{DLN}) and the standard deviation (σ^{DLN}) of the Degree of Latent Needs (DLN) in a product function, the rating points where the evaluation is largely divided can be identified. The low average of the degree of latent needs in a product function (A^{DLN}) scores also revealed some ideas that should not be overlooked. The A^{DLN} values for some interpreted needs are around the average of A^{DLN}, but the variance and the standard deviation for each function are large, which means that a small number of evaluators gave high rates to these product functions. For example, as shown in Table 5.15, the A^{DLN} values for the interpreted needs “The device is able to prevent a child from choking”, “The device is able to judge the level of sickness and notify parents or authorities (hospital, etc.)”, and “The device is able to recognize items (food or not) that a child wants to put in the mouth” are below the average but the standard deviation values are high. A large variance and standard deviation mean that the idea has pushback, indicating that there are opposing opinions to the idea. The interpreted need supported by a small number of evaluators is likely to be important, even if there are objections. It is possible that there are truly attractive needs hidden in the high rates of a minority of evaluators. These may lead to the discovery of further needs through individual pinpoint interviews.

Therefore, we conducted interviews with a minority of evaluators who gave different rates to certain needs. Most of the interview answers indicate that they admit there were mistakes in understanding the interpreted needs (product functions) and giving the rates. However, some of the interview answers show a clear reason of the pushback. For example, the evaluator that rated the need “The device is able to recognize items (food or not) that a child wants to put in the mouth” higher than others explained that the function is essential in a childcare device as there are a lot of death cases of children mistakenly swallowed button battery (US National Capital Poison Center). After explaining to others evaluators, they also agreed that the function is important for a childcare device. Another example is the need “The device is able to monitor children and notify the parent in case of emergency” which was rated high by one evaluator compared to others. The reason given was that there is a possibility of emergency incidents such as bathtub drownings (Dworkin, 2018) occurring the moment the parents take their eyes off their children, therefore the function is important for a childcare device. The need “The device is able to provide human touch and warmth while changing the diaper” was also rated high by two evaluators. One evaluator explained that changing the diaper process is a delicate process and it is essential to keep the baby comfortable along the process while the other evaluator clarify that the technology for imitating human touch and warmth is possible to implement. After explaining to others evaluators, they understood the importance of the needs above for a childcare device. There are also needs that are evaluated highly by the majority but low by one or two evaluators. For example, the need “The device’s part can be used and operated separately” was rated low by an evaluator. The reason given was it might be efficient if can separate the parts of the device but the device might not function according to the needs at the time of the incident if the parts are incomplete. After explaining to others evaluators, they also agreed that the function is less important for a childcare device. Based on the interview results, it is indicated that by interview, although the needs were rated low by the majority of evaluators, the importance of those needs was able to be discovered.

5.4.5 Eight Patterns of DLN

The maximum evaluation of DLN is based on the combination/compilation of technological feasibility, latent-ness, and importance to an interpreted need. However, among all the interpreted needs obtained from customers, there are cases of a need with high latent-ness but not high importance, or an important need but still no feasible technology. Therefore, we are suggesting that evaluation of the need according to these three metrics from the viewpoint of practicality is also possible.

The evaluation points for each indicator were then divided into two levels which are high and low, and classified into eight patterns based on the combination of these two levels. By dividing the needs into these eight patterns as shown in Table 5.7, it is possible to determine the ranking of the interpreted needs according to each metrics in the future work.

Table 5.7 Eight pattern of DLN

No	Criteria	Level	Pattern Name & Description
1	Importance	High	**First-come-first-served**
	Latent-ness	High	Most likely to be a valuable latent need, highest priority
	Feasibility	High	
2	Importance	High	**Dream**
	Latent-ness	Low	Important but technically difficult as no feasible technology
	Feasibility	Low	Customers are able to recognize the need
3	Importance	High	**Delight**
	Latent-ness	High	Customers are unable to describe and recognize
	Feasibility	Low	Technically difficult but important
4	Importance	High	**Void**
	Latent-ness	Low	A rare chance of an important and technologically feasible need.
	Feasibility	High	Low latent-ness indicate that the chance is low too which suggest an evaluation mistake.
5	Importance	Low	**Magic Show**
	Latent-ness	High	Customers are unable to describe and recognize the need
	Feasibility	High	Feasible technology but not a necessary function in design
6	Importance	Low	**Fantasy**
	Latent-ness	High	Customers are unable to describe and recognize the need
	Feasibility	Low	Technically difficult and not a necessary function in design
7	Importance	Low	**Needless Care**
	Latent-ness	Low	Feasible technology but not a necessary function in design
	Feasibility	High	Customers are able to recognize the need
8	Importance	Low	**Noise**
	Latent-ness	Low	It is not a necessary function for the design target
	Feasibility	Low	No feasible technology but customers recognize the need

5.5 Conclusion

The purpose of this research is to verify a quantitative evaluation method for identifying latent needs. This research was conducted by rating the interpreted needs of consumers' interview responses based on three perspectives of importance, latent-ness, and technological feasibility. The Degree of Latent Needs (DLN) was calculated by multiplying these three metrics. Based on the result for the mean and variance of the average of the degree of latent needs in a design (E^{DLN}) for each evaluator which is sufficiently small, it indicates that the basis of rating for importance, latent-ness, and technological feasibility in the DLN is effective. The results for the DLN ranking also indicate that the 20 highest DLN points of the interpreted needs contain attractive features in terms of design. On the other hand, we had gotten some pushback on the average of each interpreted need (A^{DLN}) and its variance which indicates opposing opinions among evaluators. As it is possible that attractive

needs are hidden and may lead to the discovery of latent needs through individual pinpoint interviews, the interviews with the minority evaluators were conducted. The interview results indicate that the important latent needs with low DLN rates might be able to be discovered by conducting follow-up interviews such as “The device is able to recognize items (food or not) that a child wants to put in the mouth” and “The device is able to provide human touch and warmth while changing the diaper”.

Chapter 6 - A decision-making method based on patent analysis at stages between conceptual design, prototyping, and production ramp-up

6.1 Introduction

6.1.1 Patent Strategy

Many innovations are inspired by the eagerness to solve problems to make life easier or to create good value for the communities. The success of innovation depends on how far the product or service can satisfy customer needs. The process of identifying and understanding consumers' needs is one of the steps outlined by Ulrich et al (2012) in their book, "Product Design and Development" to guide designers and engineers in creating solutions for problems in communities. Other steps introduced in the book were conceptual design, prototyping, design for manufacturing, and survey for competitors. A careful and thorough survey of competitors is an essential decision-making step between conceptual design and prototyping stage in product development as large capital investments are required. Therefore, in this paper, we proposed and verified a supporting method of concept design evaluation and decision-making before the mass production stage by conducting competitor analysis using patent search.

A patent strategy is a series of steps that companies take in order to secure their inventions/products and their position within the technological sector in which they operate. Patent strategy is established before product development for understanding market trends and grasping technological evolution, protecting own product intellectual property, and identifying competing firms by competitor analysis. As it is difficult to select of concept design, conducting patent strategy was assumed to support on how to select the right concept precisely. In concept design stage of Ulrich & Eppinger's (2015) product development process, Pahl & Beitz's (1996) functional diagram was applied to outline all the functions of the product design. In this research, by conducting a patent search in this stage by the designer who understood best about the product functions and working principles, we introduce a supporting method to assist designer for their decision making process and we assume that it will be able to assist in reducing the possibility of design failure in the future.

6.1.2 Conceptual Design Stage in Product Development

Fig. 6-1 indicate the product development process by Ulrich (2015). In the concept development step in this product development process, there is a product concept generating or designing stage. A supporting method for decision-making was applied at this concept designing stage gate. Several concept designs are considered as input. Then at the stage gate, the input will be evaluated and validated to determine whether the concept design should be continued to develop or not.

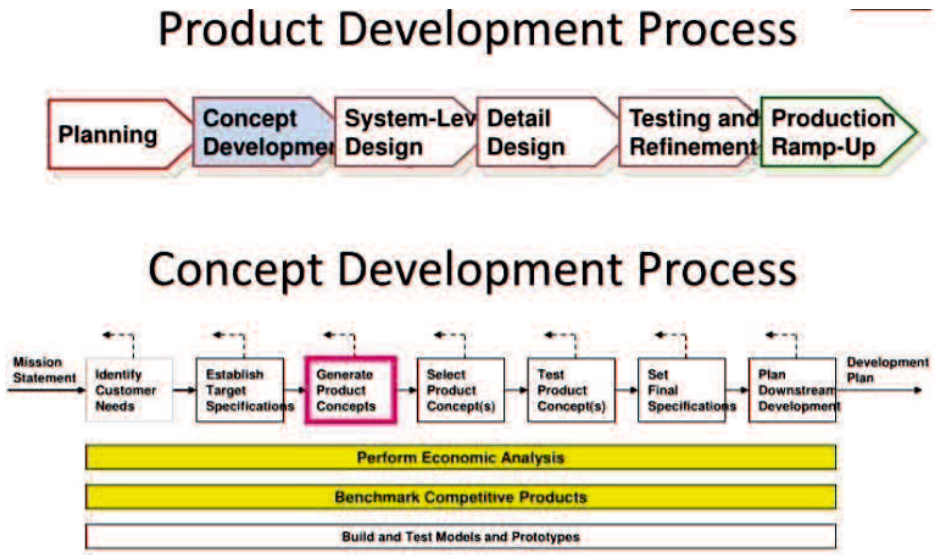

Fig. 6-1 Product Development Process by Ulrich (2015)

6.2 Method

6.2.1 Story and Functional Diagram

A story is illustrated to assist designer in explaining the function of the product that they design. A functional diagram in mechanical engineering is a tool to describe the functions and their interrelationship in a system. It consisted of block diagrams connected by lines that indicate the relationships. In this diagram, the input and output of the function which consisted of signal, material, and energy are also explained. In this paper, we illustrate a few stories that describe the problem that probably occurs during balancing work-at-home and childcare and possible solution ideas. Then, the functions that were illustrated in the stories were described in the functional diagrams and were specified in the sub-functional diagrams.

6.2.2 Concept Designing Process

The concept generating process is a classification and refinement process after stories illustration and process of function outlining in a functional diagram. By combining options of functions and generating several concepts, the design will be more distinct. In this research, we generated a few concept designs to solve the problems of balancing work-at-home and childcare for parents/guardians.

6.2.3 Patent Analysis Process

Patent analysis provides researchers and inventors with valuable technological information needed to find innovative solutions to technical problems. It is also being utilized to determine whether a designed concept can be realized and proceeded within our own organization or whether we should be licensing in the patented technologies. In this paper, the patent analysis was used to investigate our competitors and the technologies monopolized by them. The decision on whether to continue with the functions or designed concepts is by calculating the level of dominance. It was justified by the percentage or ratio of dominating or monopolizing a function by one company. First, the important level among the sub-functions was decided and multiplied by the company coverage level, and then those values were totaled to obtain the percentage or ratio.

6.3 Results

6.3.1 Function 1 – Sleep Support and Sudden Infant Death Syndrome (SIDS) Prevention

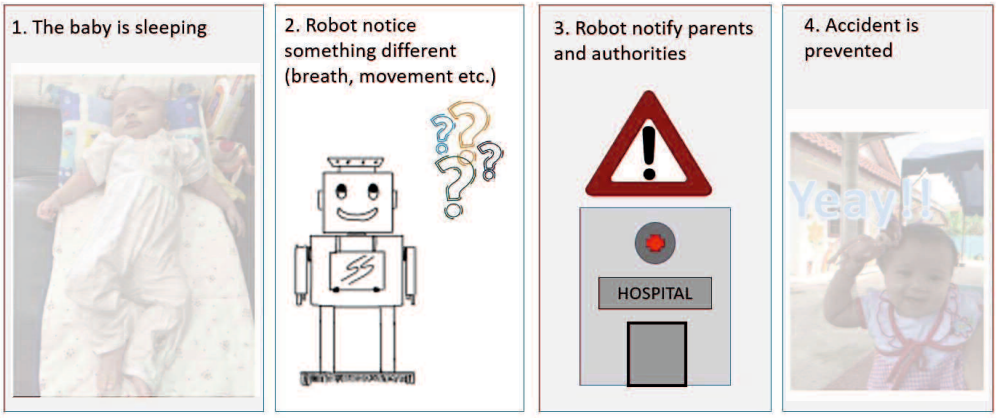

Fig. 6-2 Story- Sleep Support and SIDS Prevention

Several stories were outlined based on several functions that we assumed as solutions ideas for balancing work-at-home and childcare. For example, Fig 6-2 illustrates a story about a 'Sleep Support' function on how a robot notices small changes in a sleeping baby by monitoring the baby's movement and breath. The robot then will notify parents and authorities if the baby is in a dangerous situation and such an accident or incident such as sudden infant death syndrome (SIDS) might be prevented.

Functional diagrams and sub-functional diagrams of the illustrated stories were outlined in this research. Fig 6-3 indicates the functional diagram for the 'Sleep Support' function and Fig 6-4 shows the sub-functional diagrams of the 'Sleep Support' function, which decomposed the function in Fig 6-3. The sub-functions that we considered important in these

functional diagrams were 'monitor sleep posture & movement', 'detect small changes compare to other days', 'correct sleeping posture' and 'notify parents/guardian if in danger'. Then, in the concept design diagram in Fig 6-5, the possible structure and mechanism for each function were outlined before conducting the concept selection. Based on the structures and mechanisms in the concept design diagram, patent searches were conducted for each sub-function.

In patent analysis process, patents' abstract-based text mining was conducted in a global patent database that cover full patent documents from 75 countries. Competitive companies were investigated by arranging number of patent publication based on assignee or applicant in the patent matrix in Fig 6-6. The number in the matrix represent the patent volume own by the companies. 5 represent more than 100 patents while 3 represent 30 and below while 1 represent 10 and below. The last column referred to the importance of the function to our design. From the patent matrix, it is able to observed that different companies focused on different functions and there are functions that are still not monopolized by any company and the sleep support and SIDS prevention function is possible to be considered in our concept design.

Fig. 6-3 Functional Diagram- Sleep Support and SIDS Prevention

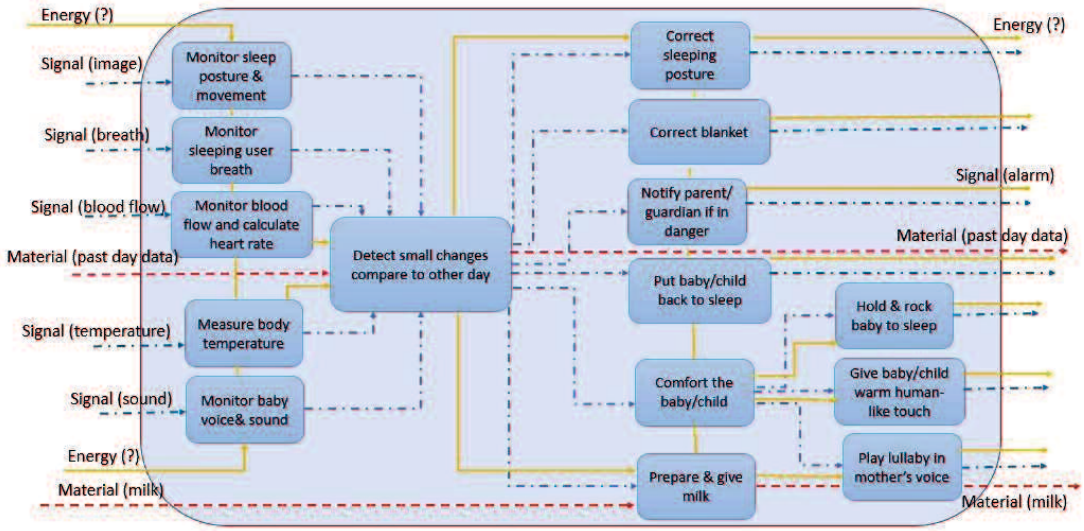

Fig. 6-4 Sub-Functional Diagram- Sleep Support and SIDS Prevention

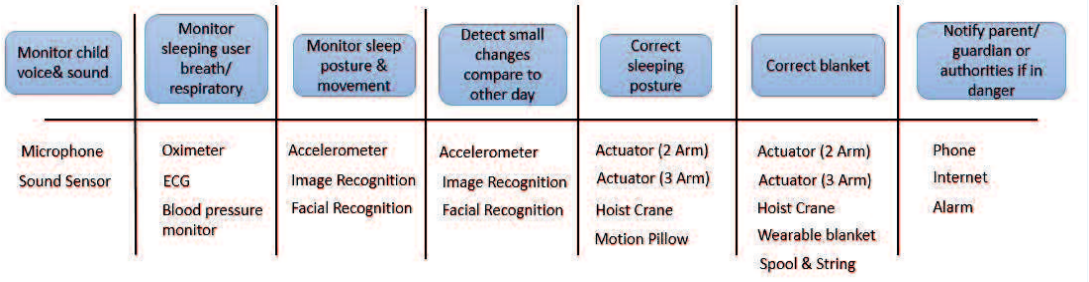

Fig. 6-5 Concept Design Diagram- Sleep Support and SIDS Prevention

	HITACHI	KONINKL PHILIPS	IBM	ZTE CORP	TOYOTA	XEROX CORP	Importance
Monitor sleep posture & movement	5		5	1			3
Monitor sleeping user breath/ respiratory		3				1	5
Monitor child voice& sound	3		5		3		5
Correct sleeping posture				1			3
Correct blanket				1			1
Notify parent/ guardian or authorities if in danger	3	3	1		3		3
Prevent Sudden Infant Death Syndrome (SIDS)						3	5

Fig. 6-6 Patent Matrix- Sleep Support and SIDS Prevention

6.3.2 Function 2 – Playing and Education

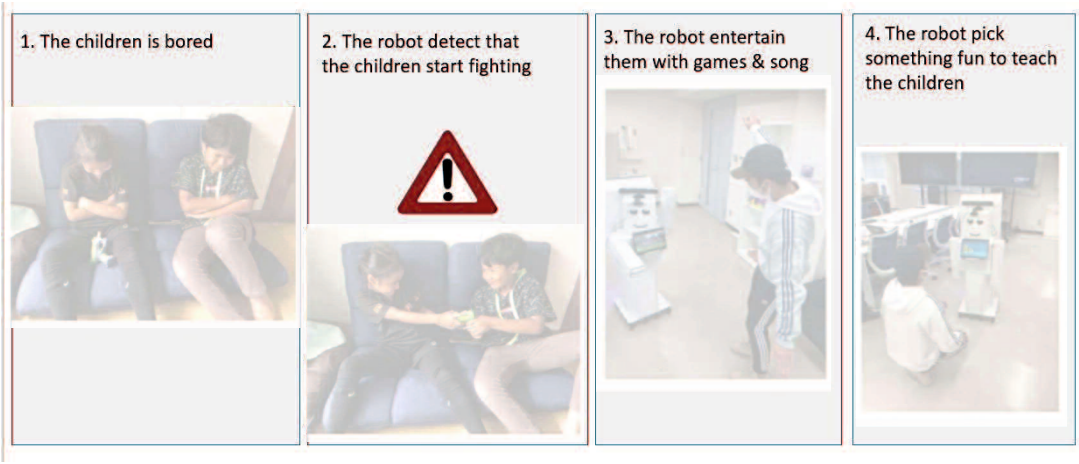

Fig. 6-7 Story- Playing and Education

Fig. 6-7 illustrates a story about a 'Playing and Education' function on how a robot notices that the children are bored and start to fight. The robot will then entertain them with games and songs or pick up something fun to teach them.

Fig 6-8 indicates the functional diagram for the 'Playing and Education' function and Fig 6-9 shows the sub-functional diagrams of the 'Playing and Education' function, which decomposed the function in Fig. 6-8. The sub-functions that we considered important in these functional diagrams were 'monitor children focus' 'warn children of they lost focus', and 'give treat after lesson'. Then, in the concept design diagram in Fig 6-10, the possible structure

and mechanism for each function were outlined before conducting the concept selection. From the patent matrix in Fig 6-11, it is able to observed that different companies focused on different functions and there are functions that are still not monopolized by any company and the playing and education function is possible to be considered in our concept design.

Fig. 6-8 Functional Diagram- Playing and Education

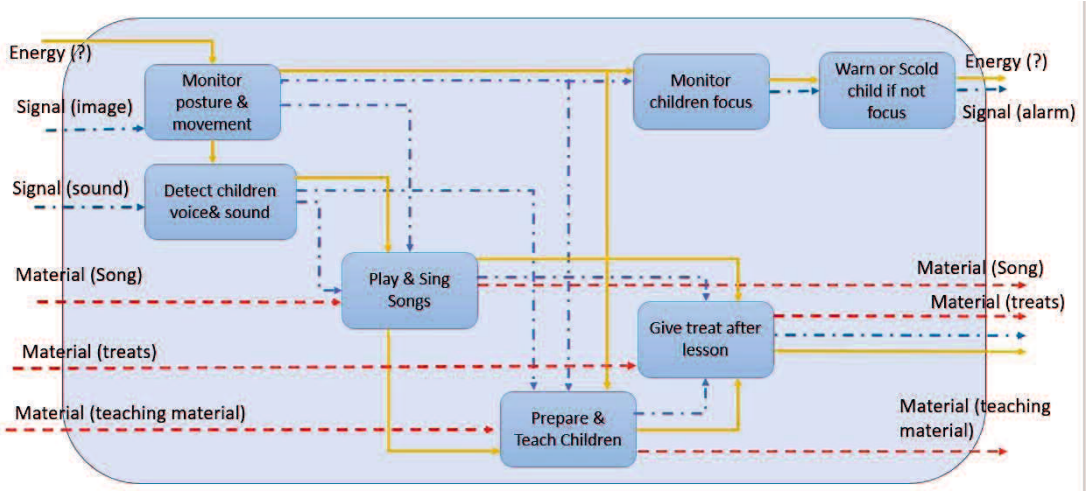

Fig. 6-9 Functional Diagram- Playing and Education

Detect children voice& sound	Monitor posture & movement	Play songs, Sing & Dance	Prepare & Teach Children	Give treat after lesson	Monitor children focus	Warn or Scold child if not focus
Microphone	Accelerometer	Actuator (2 Arm)	Actuator (2 Arm)	Actuator (2 Arm)	Accelerometer	Voice
Sound Sensor	Image Recognition	Actuator (3 Arm)	Actuator (3 Arm)	Actuator (3 Arm)	Image Recognition	Internet
	Facial Recognition	Voice	Voice		Facial Recognition	Display
		Internet	Internet			
		Display	Display			

Fig. 6-10 Concept Design Diagram - Playing and Education

	IBM	STATE GRID CORP	TOYOTA	SHENZEN DIANMAO	TENCENT TECH	Importance
Detect children voice& sound	5				3	5
Monitor posture & movement				1	5	5
Play songs, Sing & Dance	3		3			3
Prepare & Teach Children		3				5
Give treat after lesson	5	3	1			1
Monitor children focus				1	3	5
Warn or Scold child if not focus		1		3		3

Fig. 6-11 Patent Matrix- Playing and Education

6.3.3 Function 3 – Prevention from Entering Dangerous Area

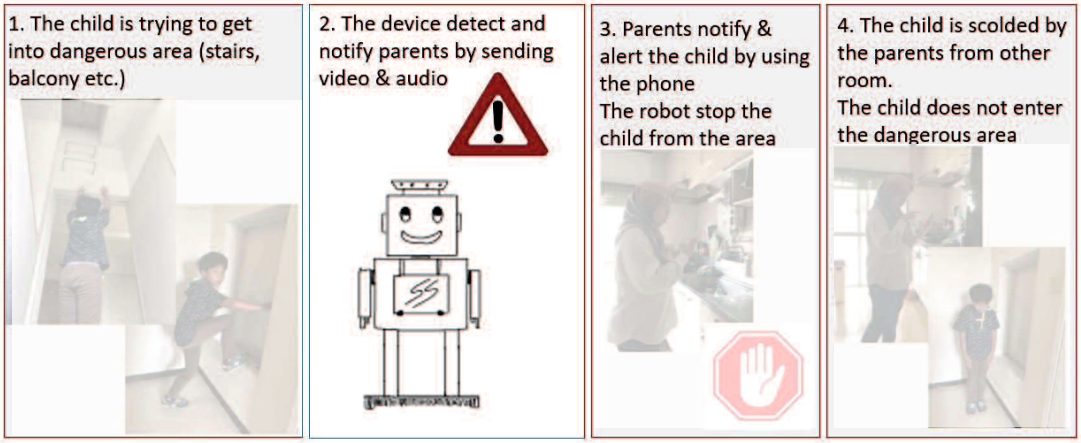

Fig. 6-12 Story- Prevention from Entering Dangerous Area

Fig 6-12 illustrates a story about a 'Prevention from Entering Dangerous Area' function on how a robot notices that the child is trying to get into dangerous area such as stairs, bathroom or balcony, and the robot will notify parents by sending video while stopping the child at the same time. Parents will alert the child via their devices and such a dangerous incident can be prevented.

Fig 6-13 indicates the functional diagram for the 'Prevention from Entering Dangerous Area' function and Fig 6-14 shows the sub-functional diagrams of the 'Prevention from Entering Dangerous Area' function, which decomposed the function in Fig 6-13. The sub-functions that we considered important in these functional diagrams were 'monitor and stop the child movement to dangerous area' and 'connect parents with the child to warn them'. Then, in the concept design diagram in Fig 6-15, the possible structure and mechanism for each function were outlined before conducting the concept selection. From the patent matrix in Fig 6-16, it is able to observed that one company dominated most of the functions and the failure risk become higher if we considered this function in our concept design.

Fig. 6-13 Functional Diagram- Prevention from Entering Dangerous Area

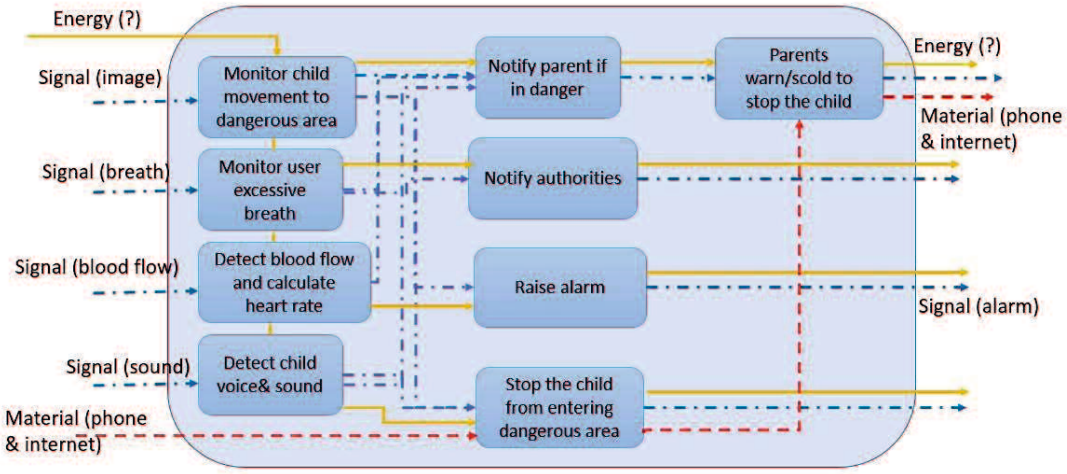

Fig. 6-14 Sub-Functional Diagram- Prevention from Entering Dangerous Area

Detect child voice& sound	Monitor child movement to dangerous area	Monitor user excessive breath/respiratory	Notify parent/guardian if in danger	Raise Alarm	Parents warn/scold to stop the child
Microphone	Image Recognition	Oximeter	Phone	Alarm	Phone
Sound Sensor	Facial Recognition	ECG	Internet		Internet
	Accelerometer	Blood pressure monitor			

Fig. 6-15 Concept Design Diagram- Prevention from Entering Dangerous Area

	APPLE INC	CARDIAC PACEMAKERS	SAMSUNG ELECTRONICS	HUAWEI TECH	AVVERY DENNISON	Importance
Detect child voice& sound	5		1			3
Monitor child movement to dangerous area	5			3	3	5
Monitor user excessive breath/respiratory		5				5
Notify parent/guardian if in danger	5		3	3	3	5
Raise Alarm	5		3			3
Parents warn/scold to stop the child	3				1	3

Fig. 6-16 Patent Matrix- Prevention from Entering Dangerous Area

6.3.4 Function 4 – Sanitizing and Cleaning

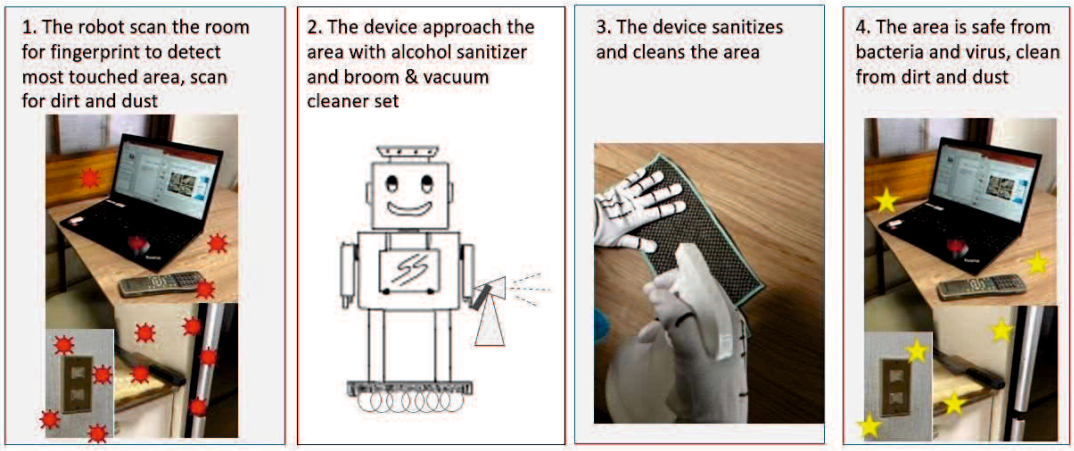

Fig. 6-17 Story – Sanitizing and Cleaning

Fig 6-17 illustrates a story about a 'Sanitizing and Cleaning' function on how a robot scans the room for fingerprint to detect most touched area and also scan for dirt and dust. The robot then approaches the area with sanitizer and cleaning device to sanitize and clean the area. The area will be safe from bacteria and viruses.

Fig 6-18 indicates the functional diagram for the 'Sanitizing and Cleaning' function and Fig 6-19 shows the sub-functional diagrams of the 'Sanitizing and Cleaning' function, which decomposed the function in Fig 6-18. The sub-functions that we considered important in these functional diagrams were 'monitor children focus' 'warn children of they lost focus', and 'give treat after lesson'. Then, in the concept design diagram in Fig 6-20, the possible structure and mechanism for each function were outlined before conducting the concept selection. From the patent matrix in Fig 6-21, it is able to observed that different companies focused on different functions and there are functions that are still not monopolized by any company and the sanitizing and cleaning function is possible to be considered in our concept design.

Fig. 6-18 Functional Diagram – Sanitizing and Cleaning

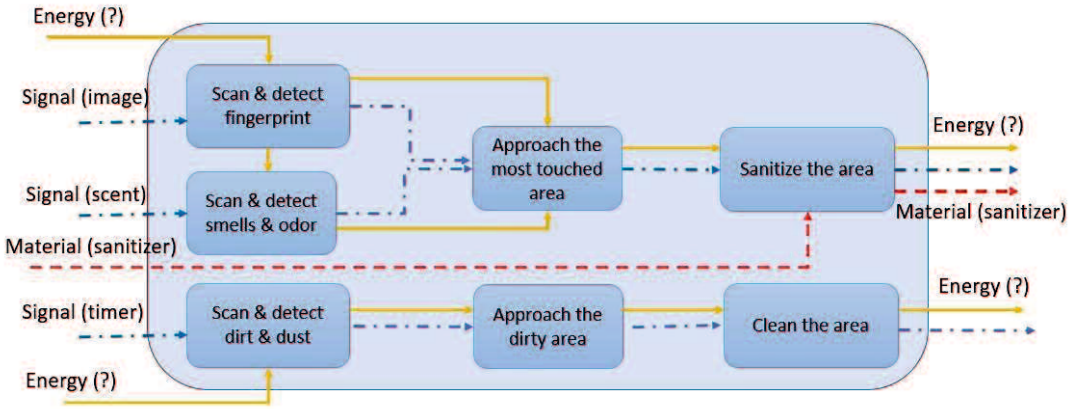

Fig. 6-19 Sub-Functional Diagram – Sanitizing and Cleaning

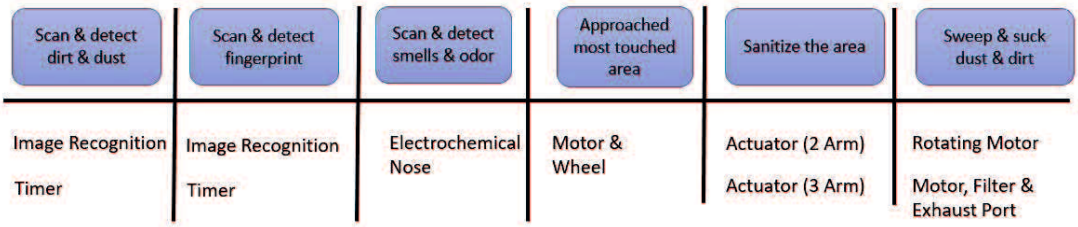

Fig. 6-20 Concept Design Diagram – Sanitizing and Cleaning

	iROBOT	JINLING	LG ELECTRONICS	SAMSUNG ELECTRONICS	GOJO IND	Importance
Scan & detect dirt & dust	5		3	3		5
Scan & detect fingerprint					5	5
Scan & detect smells & odor		3				3
Approached most touched area	5		3	1		5
Sanitize the area		1			5	5
Sweep & suck dust & dirt	5		3	3		5

Fig. 6-21 Patent Matrix – Sanitizing and Cleaning

6.4 Discussion and Conclusion

6.4.1 The Ratio of Average by the Importance

In order to evaluate quantitatively the dominating companies in the patent matrix, the ratio of the average by the importance were calculated for each function. The equation for the ratio of average were calculated as follow. The standard deviation for the ratio was also calculated.

$$\text{Ratio of average} = \frac{(\text{Sum of Company A}) + \ldots\ldots + (\text{Sum of Company N})}{(\text{Sum of importance})} \times \frac{1}{N}$$

The value for both the ratio of the average by importance and the standard deviation for each function were indicated below in Table 6-1

Table 6-1 The Ratio of the Average by the Importance and the Standard Deviation

	The Ratio of the Average	Standard Deviation
Function 1 (Sleep Support & SIDS Prevention)	0.26	0.25
Function 2 (Playing & Education	0.30	0.23
Function 3 (Prevention from Dangerous Area)	0.61	0.53
Function 4 (Sanitizing & Cleaning	0.32	0.23

Based on the results, we are able to observe that the value of average ratio and standard deviation for the Function 3 (Prevention from Dangerous Area) is the highest among the other concepts. As shown in patent matrix for this function in Fig 6-16, compare to other functions, in Function 3 we are able to observe that there is one company that is dominating almost all of the technologies for the sub-functions in this Prevention from Entering Dangerous Area function. On the other hand, as shown in Fig 6-6 in Function 1 (Sleep Support & SIDS Prevention), we are able to observe that there were no companies that dominate the technology for the sub-functions.

By applying this method at the stage gate of concept design process, we are able to observe whether there are dominating companies or not for our concept design. If there is a dominating company, a possibility of not being able to produce our concept become bigger (as it might involve technology infringement, or the dominating company already dominate the market). This method may be applied as an indicator to support decision making in concept design stage, whether to proceed with the concept design or not, and to reduce the possibility of product failure in the future.

Chapter 7 – Conclusion

7.1 Conclusion

Ulrich et al. (2012) stated that latent needs are those that many consumers recognize as important in a final product but do not or cannot articulate in advance. The latent needs addressed in this study was focusing on the consumer requirements in product development. The challenge in identifying latent needs is finding the method to elicit from consumers the needs which are not addressed by any player in the present market but would delight them if delivered tomorrow. The success of a product or a service is largely dependent on how far the product or the service satisfies consumer needs and demands. Therefore, latent needs are particularly critical to product innovation and success.

The purpose of the research in Chapter 3 was to verify the method in the elicitation of latent needs from consumer needs by conducting the working prototype-based interview and collecting raw data which is responses from the consumer. The results indicated that interpreted needs from interviewees' responses and the categories of the needs obtained from the Prototype-based interviews are more than from the Problem-based interview. The latent needs that we were able to obtain from this research were for example, "The device is able to detect small changes in a child while changing a diaper" and "The device is able to detect small changes in a child while watching he/she sleeping" which could lead into the prevention of unwanted incident such as sudden infant death syndrome (SIDS). This supports our assumption that showing working prototype based materials with story descriptions can be effective in uncovering potential latent needs. We were able to observe that empathizing and exchanging ideas among interviewees with a child of the same age during the discussion sessions leads into discovering a number of latent needs such as "The device can block children`s path and keep them away from dangerous things", "The device is able to recognize items (food or not) before a child put in his/her mouth" and "The device turns off the electricity if a child was electrocuted". However, due to the COVID-19 pandemic, we were unable to give the interviewees chances to touch and look closely at the working prototype therefore latent needs possibly gained from this experience are still uncovered. Although there are still limitations in our findings, the method that we proposed is able to support discovering latent needs in the future.

In the research in Chapter 4, we were able to interpreted raw data of consumers' interviews to the consumer needs. We were able to conclude that the number of interpreted needs increase when we additionally applied the new proposed guideline. Although the number of increased needs are small, the needs might not be interpreted if these 3 new guidelines were not considered. We were also able to obtain a few important latent needs when we applied these new guidelines. We could conclude that by including these guidelines upon interpreting raw data of consumers interviews might lead into discovering important and critical latent needs of the consumers.

This prototype based experimental approach also recorded a customer-device relationships including movement, voice, and interactions as some movies and voice data.

In the future, by observing the raw data on relationships and utilizing this new proposed guidelines, more latent needs that could not even figured by customers could be discovered.

The purpose of the research in Chapter 5 was to verify a quantitative evaluation method for identifying latent needs. This research was conducted by rating the interpreted needs of consumers' interview responses based on three perspectives of importance, latent-ness, and technological feasibility. The Degree of Latent Needs (DLN) was calculated by multiplying these three metrics. Based on the result for the mean and variance of the average of the degree of latent needs in a design (E^{DLN}) for each evaluator which is sufficiently small, it indicates that the basis of rating for importance, latent-ness, and technological feasibility in the DLN is effective. The results for the DLN ranking also indicate that the 20 highest DLN points of the interpreted needs contain attractive features in terms of design. On the other hand, we had gotten some pushback on the average of each interpreted need (A^{DLN}) and its variance which indicates opposing opinions among evaluators. As it is possible that attractive needs are hidden and may lead to the discovery of latent needs through individual pinpoint interviews, the interviews with the minority evaluators were conducted. The interview results indicate that the important latent needs with low DLN rates might be able to be discovered by conducting follow-up interviews such as "The device is able to recognize items (food or not) that a child wants to put in the mouth" and "The device is able to provide human touch and warmth while changing the diaper".

As it is difficult to select of concept design, conducting patent strategy was assumed to support on how to select the right concept precisely. In the research in Chapter 6, by conducting a patent search in this stage by the designer who understood best about the product functions and working principles, we introduce a supporting method to assist designer for their decision making process and we assume that it will be able to assist in reducing the possibility of design failure in the future. By applying this method at the stage gate of concept design process, we are able to observe whether there are dominating companies or not for our concept design. If there is a dominating company, a possibility of not being able to produce our concept become bigger (as it might involve technology infringement, or the dominating company already dominate the market). This method may be applied as an indicator to support decision making in concept design stage, whether to proceed with the concept design or not, and to reduce the possibility of product failure in the future.

From the results of all the studies, we could conclude that these above methods may be applied as assistive tools to support designers' understanding of consumers' requirements and selecting the right concept design.

7.2 Future Work

This research was conducted from early 2020 just when the COVID-19 pandemic started. The interviews were conducted with heavy precaution, therefore we were unable to bring and let the interviewees experience the movemnet and fucntions of the prototype. In the future, we hope to be able to introduce prototype directly to potential consumers and to observe consumers' reaction and responses to elicit more latent needs from empathizing and interpreting consumers' voices and actions.

In this research, the childcare and housework in COVID-19 was selected as the sample application because the working-at-home parents needed support for housework, childcare and virus prevention during the pandemic. However, there were questions from potential users that the prototype and its functions might be able to be used and applied to other needs such as for elders or disabled people. As a working prototype is possible to be built according to the user needs, therefore in the future we might build a new working prototype with different usage and functions to elicit other potential user needs and solving their problems.

Last but not least, we conducted a patent search in the concept designing stage and introduce a supporting method to assist designer for their decision making process and we assume that it will be able to assist in reducing the possibility of design failure in the future. In addition to this, we plan to conduct more details patent analysis that include link between product function and link between competitive companies in order to assist more in decision making.

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Research Achievement

Research Achievement

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Appendix

Interview Responses

Group 1
Interviewee details:
A – (Female, 36 years old, Japanese)
B – (Female, 37 years old, Japanese)
C – (Female, 40 years old, Japanese)
Interview Language: Japanese

Problem-based Interview

Question 1: What kind of life are you currently living?
(質問 1：あなたは現在、どのような生活を送っていますか？)
A:仕事は現場．家庭では外出を控える．スーパーに子供を連れて行かないようにする．
B: 現場仕事．休みはなく今まで通り仕事をして家に帰る．手洗いは以前からしていたので変わらない．買い物を週末にまとめてやる．流行ってるところ・地域にはいかない．
C: 生活はあまり変わっていない．学校が休み．上の子は一人で留守番・勉強しているがその時の家の様子がちょっとわからない．下の子は学校を休むときはデイサービスに預ける．

Question 2: Good points in Covid-19 pandemic daily life
(質問 2：Covid-19 パンデミックデイリーライフの良いところ)
A: 在宅時間が長いので家がきれい．掃除する時間がたっぷりある．
B: 嘔吐下痢症（ノロウイルス，風邪のウイルス）が流行っていない．インフルエンザもない・皆が消毒をしているから？
C: マスク，手洗いでインフルエンザとかが流行らない．お金がたまる（ガソリン減らないし），かかるのは食費．

Question 3: Bad points in Covid-19 pandemic daily life
(質問 3：Covid-19 パンデミック日常生活の悪い点)
A: 子供には外で遊んでほしいし友達と関わってほしいが難しい．ストレスがたまるだろうし楽しいことをもっといっぱいさせてあげたい．
B: 遠方の実家に帰れない
C: 行事が開けないのが残念．県外に出れないし人ごみ避けるので行動範囲が狭まった．

Question 4: Free talk (Covid-19 pandemic related matters and device-related requests)
(質問 4：フリートーク（Covid-19 パンデミックに関すること、デバイスに関する要望など）)
A: 家中掃除（壁天井も）．ウイルスが上まで上がってしまう．菌が付着している部分を見える．感知してくれる（特殊な液をかけてＵＶで見えるようなものがあるが，家では難しい）．手ごろに手に入るもの．食事の準備，片付け．親として主婦として，家事やってくれると助かる．
B: 子供がまだ 2 歳なので何しだすかわからない，ちょっと目を離したら階段上ろうとする．興味が広がってきて，でもいけないことといいことがまだはっきりわかっていない年齢の子から目を離すのが怖いので，子供を見ていたいので他の事をやってくれるとうれしい．
C: 手術室入る前みたいに，通ったら完全に除菌されるミストとかじゃなくて，通ったら殺菌．保育園あったら助かる
B: 一回外出たときとかいいかも，という発言），服も傷めず，肌も傷めず，消毒の手間いらず通ると消毒される機器，立ち止まるぐらいで
A & B: やっぱり手が荒れる，しみる，刺激がない殺菌消毒が良い．
C: ＰＣＲみたいな今かかってるかかかってないかがわかる簡単なもの

A: 妊娠した時にすぐわかるような，唾液付けたらわかるようなキット
B: 無症状の人が検査したらかかってたというのが怖い
A: 室温調整，湿度調整も，除菌もできるもの
C: 加湿器つけなきゃいけない
A: プラズマクラスターとかつけてとか大変

Prototype and Story-based Interview

Question 1: How do you will/want to use the device?
(質問 1：デバイスをどのように使う予定/希望ですか？)
A: 保育園で使える．体温図る機能，チップ付けて心拍数とかは導入したいという話が保育園であった．
B: 消毒が良い．おもちゃの数がすごい，液体入れて漬けて干してが大変，入れておけば消毒できるというのが便利，絵本も多い，体温が図れるのが良い，生まれたばかりの頃はとても心配だった．
C: 窓開け閉め良い．子供が怪我した時に通報は良い，保育士はケガした子供から離れられないなので，ロボに，電話や保護者への連絡や誰かを呼んだり，あれ持ってきてとかあったら便利．

Question 2: Please tell us what you think is good about the device
(質問 2：デバイスの良いと思うところを教えてください。)
（1 と同じ）

Question 3: Please tell us what you think is bad about the device
(質問 3：デバイスの悪いと思うところを教えてください。)
A: 保育は人間と人間，人と人とのかかわり，熱図るにしても抱っこして大きい子で嫌がる子もおでこに手を当ててやる，触れ合いが大切．ロボットはロボットの役割をしてもらって，絶対にロボットにできない部分（おむつを替えるのも，人間の目視，肌荒れとかをみる．ロボットに小さな変化は見れないと信じている．人間にしかできないと信じている）子供にもっと目を向けられる体制のためのロボット．もっと子供と触れ合える時間を増やせる．人間がしなくてもよくないという時間があると思う．
B: おむつ交換とか，触りたい，ぬくもりは大切と思う．顔の表情で赤ちゃんの表情が増える．赤ちゃんと触れ合える時間を減らしてほしくない．母親にとってはラッキーかもしれないが，赤ちゃんにとっては良くないのかなあと思う．
C: 雰囲気，いつもと違うなあっていうのがあるのに気づくのが仕事
B: センサーがあっても 2 重チェックする
C: そういった細かいところまでロボットが気付けるようになったら保育士はいらない
A: 保育士も看護師もいらない補助的ならほしいロボが出来るようになったら保育士としても親としても立場を失う．
B: 保育士としての立場だからこう考えると思う．スマホを見ながら育児する時代だから．

Question 4: Free talk (Improvement and request regarding the device)
(質問 4：フリートーク（デバイスに関する改善点・要望など）)
C: マスク消毒　洗うと臭くなる　マスク保管庫的な．
B: フォルムが丸いといい
A: 表情が変わったらいい　赤ちゃんが怖がる
B: 丸いとあったかいイメージ，カクカクしてると冷たいイメージ
C: ロボットあったかいといい，人肌
A: 体温ってすごく大事
B: たしかに

C: さわったらつめたい，体温ぐらいあったらいい，握ったら眠れるようなもの
A: シリコン製のものにする，人肌に近いもの
C: 何か握ってないと寝れない子が保育士さんがちょっと離れたいときに
A: トントンしてくれる機能，プラスチックじゃなくて人間の手みたいな
C: 人間の体温ぐらいの，
A: トントンのリズムもどんどんゆっくりなっていくような，最後に布団欠けてくれる
C: 布団かけ機能良い
B: ふとんかけたらねる
C: 布団蹴っ飛ばしてたら直す　家で
A & B: 俯せだったら仰向けに直す，起こしてくれる機能は良い，小学校とかのこどもにつかいたい
C: 中学生ぐらいの子供に使いたい，親が出かけた後とか
A: ロボがやるのが効果的かはわからない，親が怒った方が効果的かも
ALL: （起こしかたで盛り上がる）
A: ミルクあげるにしても人間が
C: ロボはしゃべるか？ロボの声が変わると面白い，抑揚　起こるとき，優しいとき
A: 代わりに怒ってくれる，イラっとした時に代わりに怒ってくれる機能.

Group 2

Interviewee details:
D – (Female, 27 years old, Malaysian)
E – (Female, 32 years old, Indonesian)
F – (Female, 41 years old, Indonesian)
Interview Language: English

Problem-based Interview

Question 1: What kind of life are you currently living?
D: I ask husband to shower after returning from work. I disinfect all clothing from the outside. I always wash hands after returning from outside. I wash baby's hands after returning from daycare.
E: I separate the clothes you wear outside from the clothes you wear only inside the house. I do laundry every day (sometimes twice a day).
F: I limit the number of time children can play outside, and only play in areas with few people. I separate clothes after going outside and showered after each return. I have a special place for everything that comes in from the outside (e.g., parcels from the mailman). We don't have to ask the children to take showers (they are afraid of viruses and know when to shower). Children are more obedient when it comes to cleaning.

Question 2: Good points in Covid-19 pandemic daily life
D: I can work from home (no need to go to college)
E: Online classes help me make more time at home while taking care of my children.
F: Cleanliness improved at home (children wash their hands all the time)

Question 3: Bad points in Covid-19 pandemic daily life
D: We cannot go anywhere for fear of the virus. I become paranoid (feel like the virus is everywhere). It is difficult to disinfect hands each time. Skin on my hands becomes dry (I need to bring skin moisturizer). I need to wipe chairs and tables when eating in restaurants.
E: The children were bored at home because I can't go anywhere.

F: Children are bored in the house. Children are always looking for new toys. I need to buy lots of toys (so I do not need to go out often to buy new toys).

Question 4: Free talk (Covid-19 pandemic related matters and device-related requests)
D: I want a hand sanitizer that does not dry out my skin. I want a device that can see the virus (visually).
E: I want an air humidifier disinfectant
F: I need a machine that can disinfect the entire room (like an air conditioner, but be careful not to make it difficult to breathe).

Prototype and Story-based Interview

Question 1: How do you will/want to use the device?
D: I want to take it everywhere as a helper. I can make it as a maid/nurse
E: I can use the robot to calm or put your baby to sleep. It can give a pat action or put baby to sleep. It can sing a lullaby to put baby to sleep
F: I can instruct my children about time using the robot (e.g., time to shower, time to pray, time to study).

Question 2: Please tell us what you think is good about the device
D: The disinfection part is perfect.
E: I like all the function of the robot
F: It is suitable for children's scheduling

Question 3: Please tell us what you think is bad about the device
D: The device has no first action (and the child has already been in an incident).
E: If a child is involved in an incident, it does nothing (e.g., -broken glass). Notifying parents is not sufficient because the child may come into contact with the broken glass
F: It cannot detect people from outside the house. Too large (difficult to move)

Question 4: Free talk (Improvement and request regarding the device)
D: I prefer a smaller size (easy to carry anywhere in the house)
Not require a cleaning section
E: Can the robot make the first move to save the children? (e.g., collect broken glass). Robot needs to be more active to track children's paces (children get bored easily). Can it collect and put away toys (separate toys)? I want touch screen for children to write on. I want the device to carry the baby like a mother.
F: I want the robot to detect people outside the door (no point if the robot only scans people who have already entered the house)

Group 3
Interviewee details:
G – (Female, 31 years old, Indonesian)
H – (Female, 32 years old, Malaysian)

Interview Language: Malay and Indonesia

Problem-based Interview

Question 1: What kind of life are you currently living?

(Pertanyaan 1: Kehidupan seperti apa yang sedang Anda jalani saat ini?)

G: Pandemi covid-19 dimulai Januari lalu di Jepang. Saya mulai panik, tetapi kabar baiknya adalah saya tinggal di Ube. Itu tidak mempengaruhi pekerjaan saya. (Itu mempengaruhi orang-orang di Tokyo.) Saya tidak keberatan karena saya memiliki kebiasaan memakai masker di tempat kerja. Saya tidak terganggu oleh hal itu dibandingkan dengan orang asing lainnya karena saya memiliki kebiasaan memakai masker tergantung pada pekerjaan saya. Saya memakai masker dengan sarung tangan. Tapi itu sulit karena saya harus memakai masker tidak hanya di tempat kerja tetapi juga di tempat lain. Saya mulai menahan diri untuk tidak membawa anak-anak saya ke mal. Saya mengeluarkan anak saya dari tempat penitipan anak selama sebulan. Saya takut anak saya lebih lemah dan lebih rentan terhadap penyakit. Saya takut menyentuh ini dan itu. Saya bekerja pada saat itu, tetapi suami saya mengambil kelas online. Saya paling terpengaruh ketika saya melahirkan anak kedua saya (anak perempuan). Suami saya ingin hadir saat kelahiran anak kedua saya karena saya tidak dapat hadir saat kelahiran anak pertama saya, tetapi saya kecewa karena saya tidak dapat melakukannya karena covid-19.

Question 2: Good points in Covid-19 pandemic daily life
(Pertanyaan 2: Poin-poin bagus dalam kehidupan sehari-hari pandemi Covid-19)

G: Saya memiliki alergi dan demam selama tiga tahun terakhir, tetapi saya tidak memiliki alergi atau demam sejak covid-19 tiba. Saya pikir itu karena saya dan orang lain bersih.
Anak saya mengunjungi dokter anak hanya sekali tahun lalu, dan dia lebih baik dari sebelumnya. Karena semua orang bekerja sama untuk menjaga kebersihan. Manfaat pemerintah juga bagus.
H: Saya bisa menghabiskan lebih banyak waktu dengan keluarga saya.

Question 3: Bad points in Covid-19 pandemic daily life
(Pertanyaan 3: Hal-hal buruk dalam kehidupan sehari-hari pandemi Covid-19)

G: Saya tidak bisa kembali ke negara saya. Saya dijadwalkan untuk kembali. Saya tidak bisa pulang ke rumah karena penerbangan saya dibatalkan dan saya tidak bisa keluar masuk Jepang. Berbelanja menjadi merepotkan. Saya menunggu di mobil bersama anak-anak saya sementara suami saya berbelanja. Dan kemudian kami bertukar. Tetapi ada keuntungannya juga: suami saya telah menjadi pembelanja yang lebih baik. Dulu dia lupa untuk membeli beberapa barang dalam daftar saya.
H: Ketidakmampuan untuk melakukan penelitian. Harus membatalkan eksperimen dan konferensi. Tetapi ada keuntungannya, saya menemukan bahwa saya dapat melakukan hal-hal tanpa tatap muka

Question 4: Free talk (Covid-19 pandemic related matters and device-related requests)
(Pertanyaan 4: Pembicaraan bebas (hal-hal terkait pandemi Covid-19 dan permintaan terkait perangkat)

G: Sebelum pembatalan Olimpiade, pemerintah Jepang tampaknya telah melakukan lebih sedikit tes PCR untuk membuat jumlah infeksi tampak lebih rendah. Setelah pembatalan, jumlah kasus naik. Dan kemudian mereka melakukan GoToTravel, dll.... Saya tidak mempercayai pemerintah Jepang karena saya khawatir. Saya khawatir tentang suami saya yang pergi bekerja setiap hari. Khawatir tentang mengirim anak saya ke tempat penitipan anak.

H: Saya mengkhawatirkan anak saya, dan saya ingin membantunya pergi ke sekolah dengan tenang. Saya ingin perangkat yang dapat mendeteksi virus. Saya tidak merasa banyak bahwa saya menginginkan dukungan untuk anak-anak saya di rumah karena mereka siap untuk sekolah. Saya ingin perangkat yang dapat memastikan bahwa anak saya sehat dan tidak terinfeksi ketika dia pulang dari sekolah.

Prototype and Story-based Interview

Question 1: How do you will/want to use the device?
(Pertanyaan 1: Bagaimana Anda akan/ingin menggunakan perangkat ini?)

G: Apakah untuk rumah? Apakah untuk sekolah pembibitan? Jangka panjang? Jika perangkat ini benar-benar ada, saya ingin menggunakannya. Apakah saya mampu membelinya atau tidak, tergantung pada harganya. Menurut saya, ini adalah ide yang bagus...karena anak-anak sangat pandai mengalihkan perhatian mereka dari pekerjaan saya. Saya khawatir jika saya tidak mengawasi mereka sepanjang waktu, yang lebih tua akan mendorong yang lebih muda. Saya suka konsepnya. Sangat menyenangkan untuk bisa berpindah dari satu tempat ke tempat lain, tetapi terkadang menyenangkan untuk bisa duduk diam.
H: Saya rasa tidak perlu memiliki fungsi untuk mengganti popok, tetapi saya ingin memiliki fungsi untuk memberi tahu saya kapan saatnya mengganti popok. Menurut saya CCTV itu normal, tetapi menurut saya alat ini lebih efektif karena bisa melihat wajah ibu. Menurut saya, kontak kulit-ke-kulit itu penting dan perangkat ini dapat mendukungnya dari waktu ke waktu. Satu set mata lain di rumah. Alat ini bisa mengawasi anak-anak saya. Kemampuan untuk mengukur suhu tubuh juga bagus, karena terkadang saya lupa melakukannya.

Question 2: Please tell us what you think is good about the device
(Pertanyaan 2: Tolong beritahu kami apa yang menurut Anda bagus tentang perangkat ini)

G: Saya menyukai fakta bahwa perangkat akan membunyikan alarm jika Anda mencoba melakukan sesuatu yang berbahaya
H: Saya lebih memilih perangkat ini daripada mempekerjakan orang lain (misalnya, pembantu rumah tangga) yang mungkin melanggar privasi keluarga saya.

Question 3: Please tell us what you think is bad about the device
(Pertanyaan 3: Tolong beritahu kami apa yang menurut Anda buruk tentang perangkat ini)

G: Ukurannya terlalu besar, tetapi saya merasa sulit untuk mendisinfeksi jika tidak cukup tinggi. Anak-anak tergoda untuk terus melihat layar perangkat, tetapi menurut saya itu bukan ide yang bagus. Saya membelikan tablet untuk anak saya sekarang, tetapi saya tidak banyak menunjukkannya kepadanya.
H: Saya pikir ukurannya terlalu besar. Saya pikir itu terlalu besar untuk rumah Jepang. Tetapi jika ukurannya diperlukan untuk fungsi untuk menunjukkan wajah ibu, dll., itu tidak bisa dihindari. Saya pikir itu memiliki terlalu banyak fungsi. Ada hal-hal yang harus kita lakukan sebagai orang tua. Saya tidak ingin bergantung pada perangkat sepanjang waktu. Saya bukan ibu yang bekerja di rumah, jadi saya merasa tidak terlalu membutuhkannya.

Question 4: Free talk (Improvement and request regarding the device)
(Pertanyaan 4: Pembicaraan bebas (Perbaikan dan permintaan mengenai perangkat))

G: Alangkah baiknya jika memiliki fungsi pembersih udara.
H: Menurut saya, perangkat ini dibutuhkan oleh seorang ibu yang bekerja dari rumah di Malaysia.

Group 4
Interviewee details:
I– (Female, 36 years old, Malaysian)
J – (Female, 27 years old, Malaysian)

Interview Language: Malay

Problem-based Interview

Question 1: What kind of life are you currently living?
(Soalan 1: Apakah jenis kehidupan yang anda jalani sekarang?)

I: Saya bekerja kadang-kadang di rumah, kadang-kadang di pejabat, kadang-kadang di lokasi perniagaan. Kelas anak-anak saya dalam talian sahaja (kelas 3 dan 1).
J: Pada masa ini, kelas dalam talian dan saya pergi ke sekolah sekali-sekala untuk mesyuarat. Suami saya juga bekerja dari rumah, jadi dia menjaga anak-anak semasa kelas dalam talian.

Question 2: Good points in Covid-19 pandemic daily life
(Soalan 2: Perkara yang baik dalam kehidupan seharian pandemik Covid-19)

I: Lebih banyak masa bersama keluarga. Keupayaan untuk mengalami persekolahan di rumah. Memilih dan memilih bahan pengajaran sebagai tambahan kepada kelas yang ditetapkan oleh sekolah rendah.
J: Saya boleh melihat pertumbuhan anak saya di rumah. Aktiviti boleh dilakukan dengan mereka semasa mereka berkembang. Tidak terperangkap dalam kesesakan lalu lintas. Selalunya saya mengambil masa sejam untuk sampai ke sekolah setiap perjalanan.

Question 3: Bad points in Covid-19 pandemic daily life
(Soalan 3: Perkara yang buruk dalam kehidupan seharian pandemik Covid-19)

I: Kewangan adalah sukar. Saya bimbang anak-anak saya tidak dapat mengejar pelajaran mereka, jadi saya menghantar mereka ke sekolah cram juga (dalam talian). Saya juga bekerja, jadi saya letih apabila pulang ke rumah dan kadangkala tidak dapat menampung pelajaran anak-anak. Saya bukan seorang guru dan tidak mempunyai pengalaman mengajar, jadi saya tidak tahu bagaimana untuk mengajar dan menyokong kanak-kanak.
J: Saya tiada masa untuk diri sendiri. Stress bertambah dengan tidak boleh keluar rumah. Tempat terhad untuk pergi walaupun saya boleh keluar dari rumah (parkir di bawah rumah). Pergi ke mesyuarat di sekolah telah menjadi sesuatu yang ditunggu-tunggu. Saya tidak boleh berfikir dengan betul?
I: Nah, perasaan yang sama saya rasakan semasa saya cuti bersalin.
J: Jika saya akan membuat peranti, saya mahu peranti yang boleh memasak. Saya mahu peranti yang boleh memasak sebaik sahaja saya memasukkan bahan-bahan. Produk semasa (periuk tekanan, dll.) masih menyusahkan kerana anda perlu memasak pada tahap

tertentu. Saya boleh mengemas rumah sendiri, tetapi saya perlukan bantuan untuk memasak.

Question 4: Free talk (Covid-19 pandemic related matters and device-related requests)
(Soalan 4: Perbualan bebas (perkara berkaitan pandemik Covid-19 dan permintaan berkaitan peranti))
(No answer)

Prototype and Story-based Interview

Question 1: How do you will/want to use the device?
(Soalan 1: Bagaimanakah anda akan/ingin menggunakan peranti tersebut?)

I: Saya rasa fungsi ganjaran adalah sangat baik.
J: Saya rasa ciri bantuan penjagaan kanak-kanak adalah bagus. Jika robot boleh menjaga anak, ibu bapa boleh melakukan perkara yang berbeza.

Question 2: Please tell us what you think is good about the device
(Soalan 2: Sila beritahu kami perkara yang anda fikir bagus tentang peranti itu)

I: Saya rasa robot itu akan sangat berguna jika anak-anak saya terpaksa pergi ke sekolah semula. Fungsi membasmi kuman barang-barang kecil dengan sinaran ultraungu akan sangat berguna sekiranya anak-anak saya terpaksa pergi ke sekolah semula.
J: Kanak-kanak juga boleh bermain dengan robot dan ibu bapa boleh menjauhkan diri dari anak-anak untuk seketika. Saya suka fungsi permainan dan pendidikan, kerana sekarang saya melakukannya sendiri. Terdapat banyak mainan, jadi lebih baik untuk mempunyai pembasmi kuman untuk barangan kecil.

Question 3: Please tell us what you think is bad about the device
(Soalan 3: Sila beritahu kami perkara yang anda fikir buruk tentang peranti itu)

I: Pembasmian kuman dilakukan lebih kerap dengan membasuh tangan dengan sabun dan air, kerana saya dan anak-anak saya tidak keluar rumah pada masa ini. Saya menggunakan detergen komersial untuk lantai dan atas meja. Saya juga menggunakan tisu basah. Saya tidak mempunyai anak kecil pada masa ini, jadi saya tidak memerlukan fungsi pemantauan degupan jantung dan pernafasan.
J: Saya mempunyai anak kecil jadi saya memerlukan fungsi pemantauan degupan jantung dan pernafasan.

Question 4: Free talk (Improvement and request regarding the device)
(Soalan 4: Perbualan bebas (Penambahbaikan dan permintaan mengenai peranti))

I: Saya ingin mempunyai fungsi untuk memantau kelas dalam talian, bukan fungsi untuk membuat robot marah. Saya mahu robot itu membuatkan kanak-kanak fokus pada pelajaran. Ibu bapa tidak perlu marah atau meminta anak-anak memberi perhatian. Saya mahukan robot yang boleh mengingatkan mereka tentang masa untuk kelas seterusnya, beritahu mereka buku apa yang perlu mereka sediakan, dsb. (Ibu bapa kadangkala marah apabila mereka tidak memberi perhatian kepada kelas) Saya pernah mengalami bahawa saya tidak marah pada satu hari, tetapi saya marah pada hari berikutnya. Saya mahukan peringatan masa, peringatan tentang apa yang perlu disediakan dan peringatan tentang masa untuk

bersiap. Saya perlu berpakaian kemas sebelum kelas kerana saya perlu menghidupkan kamera semasa kelas dalam talian. Saya ingin mempunyai fungsi pengesanan ekspresi muka supaya saya dapat melihat sama ada anak saya menumpukan perhatian semasa kelas. Berfungsi untuk mengesan pergerakan mata dan kecondongan kepala.
J: (no answer)

Group 5
Interviewee details:
K – (Male, 29 years old, Malaysian)
L – (Male, 36 years old, Malaysian)
M – (Male, 33 years old, Malaysian)

Interview Language: Malay

Problem-based Interview

Question 1: What kind of life are you currently living?
(Soalan 1: Apakah jenis kehidupan yang anda jalani sekarang?)

K: Sentiasa di rumah kecuali untuk kerja. Tidak boleh ke mana-mana (makan di luar, membeli-belah, dll.)
L: Saya bekerja dari rumah, tetapi masih perlu ke pejabat sekali atau dua kali seminggu. Saya menghabiskan banyak masa di rumah.
M: Saya tidak suka topeng muka (ia membuatkan saya berasa tidak selesa). Saya perlu melakukan lebih banyak pakaian. Selalunya, saya tidak boleh melancong dan tinggal di rumah.

Question 2: Good points in Covid-19 pandemic daily life
(Soalan 2: Perkara yang baik dalam kehidupan seharian pandemik Covid-19)

K: Saya menjimatkan wang kerana saya menghabiskan banyak masa di rumah. Saya menyukainya kerana saya seorang yang "duduk di rumah". Merancang kerja saya adalah mudah (berniaga dari rumah)
L: Penjimatan yang ketara untuk pengangkutan (tiada perbelanjaan perjalanan)
M: Saya banyak menghabiskan masa untuk anak-anak dan kerja rumah, jadi saya sedar betapa sukarnya menjadi seorang ibu. Menjadi tabiat saya sekarang membantu isteri saya melakukan kerja rumah.

Question 3: Bad points in Covid-19 pandemic daily life
(Soalan 3: Perkara yang buruk dalam kehidupan seharian pandemik Covid-19)

K: Saya tidak boleh pergi ke mana-mana (kerana takut virus). Sukar untuk membasmi kuman setiap masa.
L: Saya terlalu memikirkan tentang diri saya dan keluarga saya sehingga saya lupa orang di sekeliling saya. Saya utamakan keluarga dan diri saya. Saya tidak dapat menjaga rakan saya yang memerlukan bantuan lebih daripada saya.
M: Mesti hadkan aktiviti harian. Tidak boleh keluar untuk bekerja walaupun batuk biasa (orang di sekeliling anda akan kelihatan tidak selesa)

Question 4: Free talk (Covid-19 pandemic related matters and device-related requests)

(Soalan 4: Perbualan bebas (perkara berkaitan pandemik Covid-19 dan permintaan berkaitan peranti))

K: Perlukan peranti yang boleh mengesan virus. Memerlukan peranti yang boleh memberi amaran jika lokasi selamat
L: Peranti untuk membantu mengesan virus luaran pada pakaian atau badan apabila memasuki rumah (letak peranti di pintu).
M: Saya memerlukan peranti yang boleh berinteraksi dengan anak saya semasa melakukan kerja rumah. Saya memerlukan robot pembersih yang boleh digunakan oleh anak saya sebagai mainan.

Prototype and Story-based Interview

Question 1: How do you will/want to use the device?
(Soalan 1: Bagaimanakah anda akan/ingin menggunakan peranti tersebut?)

K: Pantau orang yang datang ke rumah. Membersihkan rumah. Mengawasi anak-anak yang sedang tidur jika isteri terpaksa keluar (atau di bilik lain)
L: Pantau kanak-kanak di bilik lain, terutamanya semasa mesyuarat dalam talian. Harus membantu membangunkan kanak-kanak pada waktu pagi
M: Pantau bayi tidur di bilik lain (ibu bapa mungkin tidak menyedari anak mereka menangis). Membersihkan rumah

Question 2: Please tell us what you think is good about the device
(Soalan 2: Sila beritahu kami perkara yang anda fikir bagus tentang peranti itu)

K: Mengurangkan beban kerja rumah. Jimat masa anda sendiri.
L: Boleh berinteraksi dengan anak-anak bagi menggantikan ibu bapa.
M: Bermain dengan anak-anak (ibu bapa mungkin tidak tahu apa yang perlu dilakukan dengan anak-anak mereka)

Question 3: Please tell us what you think is bad about the device
(Soalan 3: Sila beritahu kami perkara yang anda fikir buruk tentang peranti itu)

K: Elektrik (perlu menggunakan banyak elektrik untuk mengecas peranti). Saiz peranti agak besar (robot mungkin jatuh ke atas kanak-kanak / sukar untuk berjalan di sekitar rumah) Takut bahawa peranti akan memberikan doktor maklumat yang salah tentang kanak-kanak itu.
L: Ibu bapa takut jika robot melakukan semua kerja dengan kanak-kanak, ia akan menjadi tidak bernilai. Kanak-kanak akan lebih menyayangi robot berbanding ibu bapa mereka. Elektrik.
M: Jika robot hanya mempunyai skrin untuk bermain dengan kanak-kanak, ia tidak mencukupi (kanak-kanak mudah bosan). Robot kelihatan rapuh dan mudah pecah (kanak-kanak takut memecahkan robot). Saiz terlalu besar (kanak-kanak akan takut).

Question 4: Free talk (Improvement and request regarding the device)
(Soalan 4: Perbualan bebas (Penambahbaikan dan permintaan mengenai peranti))

K: Buat dalam saiz kecil (mudah berjalan di sekitar rumah). Pastikan peranti boleh memberikan maklumat yang betul.

L: Optimumkan tenaga sumber robot (untuk menjimatkan kuasa). Kesan hanya di mana virus terdapat dan bersihkan kawasan tertentu sahaja, bukannya membersihkan semua kawasan. Jangan bersihkan semua kawasan (kerana takut robot akan membersihkan kawasan yang tidak sepatutnya).
M: Tidak suka bahagian "boleh berinteraksi dengan kanak-kanak" (takut kanak-kanak akan mengikut cara robot bercakap). Akan menjadi saiz yang kecil dan comel (selamat untuk kanak-kanak). Alangkah baiknya jika ia boleh dibuat pada harga yang berpatutan (nampak sangat mahal).

Rating of Importance, Latentness and Technological Feasibility

Table A-1 Rating value of importance, latent-ness, and technological feasibility, and DLN value (V^{DLN}) for evaluator A

No	Interpreted Needs	Importance	Latent-ness	Technological Feasibility	V^{DLN}
1	The device is able to sanitize small item in UV box	3	1	5	15
2	The device will send/update the information of people entering/exiting the house to parents	2	3	4	24
3	The device is able to give right/ precise information to authorities (police, hospital etc.)	3	2	4	24
4	The device is able to contact parents in case of emergency	5	2	4	40
5	The device is able to detect small changes of a child while measuring temperature	5	3	4	60
6	The device is able to change the voice tone.	1	3	5	15
7	The device's power last long	5	1	5	25
8	The device is able to sing lullaby to put child to sleep	4	3	5	60
9	The device is able to play lullaby song from mother's voice	3	3	5	45
10	The device is able to monitor children and notify parent in case of emergency	5	3	5	75
11	The device is able to cut electricity in case of danger	5	2	5	50
12	The device is able to stop water in case of danger	4	4	3	48
13	The device is able to conduct CPR	5	3	3	45
14	The device can be set to use when needed only	3	1	5	15
15	The device can be turn on and off by the user	3	1	5	15
16	The device is able to detect eye contact and head's tilting and turning angle	4	4	3	48
17	The device is able to interact with children with voice and facial expression	5	3	4	60
18	The device is able to play with children with voice and facial expression	4	3	3	36
19	The device will only clean the part of the house set by user	4	1	5	20

20	The device's function to interact with children can be turned off	5	1	5	25
21	The device' function to alert and scold children can be set off	5	1	5	25
22	The device is able to recognize items (food or not) that a child wants to put in mouth	5	4	4	80
23	The device is able to monitor baby sleeping	5	4	5	100
24	The device is able to interact with children with display	3	1	5	15
25	The device's functioning time is able to be set by user	4	1	5	20
26	The device's function can be set to take care other things than a baby	3	3	3	27
27	The device is able to correct the position of blanket	5	4	4	80
28	The device will notify authorities (police etc.) if the person in/around the house is suspicious	5	2	5	50
29	The device is able to clean up and arrange toys according to type	3	3	4	36
30	The device is able to teach with voice and facial expression	3	4	4	48
31	The device is able to suggest new/suitable game for parents and children	3	4	3	36
32	The device's functions are able to be set up only for house chores	3	2	5	30
33	The device's functions are able to be set up not to connect with children	4	2	5	40
34	The device is able to give human-like touch	5	3	5	75
35	The device is able to give a human-like warm hug	5	4	4	80
36	The device is able to give facial expression	4	3	4	48
37	The device's hand is able to hold child's hand until he/she falls asleep	5	4	4	80
38	The device is able to pat child while slowing the pace until he/she falls asleep	5	4	3	60
39	The device is able to correct a child sleeping posture	5	5	4	100
40	The device is able to sanitize a lot of toys at the same time	4	1	5	20
41	The device is able to measure temperature (room and body)	4	1	5	20

42	The device is able to contact authorities (police/hospital) in case of emergency or accident	5	2	5	50
43	The device is able to detect small changes in child compare to other day	5	4	4	80
44	The device is able to sanitize and keep mask	2	1	5	10
45	The device's temperature is same as human	3	3	5	45
46	The device's texture is soft like silicon	5	3	5	75
47	The device is able to be used indoor/outdoor	3	4	4	48
48	The device is able to calm the child	5	5	3	75
49	The device is able to wake the child up	5	5	4	100
50	The device is able to react fast in case of emergency	5	2	4	40
51	The device is able to react fast in case of danger	5	2	4	40
52	The device is able to clean up broken glass, spilled water etc.	5	1	5	25
53	The device is able to prevent child from choking	5	4	4	80
54	The device will remind the schedule for next class	3	1	5	15
55	The device will remind to finish homework before next class	4	3	5	60
56	The device will remind to prepare for next class	3	2	5	30
57	The device is able to alert parents when the baby wake up	5	4	4	80
58	The device is able to operate with small power	2	1	3	6
59	The device has a power saving mode	1	1	5	5
60	The device is able to sanitize the house using alcohol sanitizer or UV light	3	2	5	30
61	The device is able to scan and recognize user/stranger	4	3	5	60
62	The device can clean the house while moving around the house	4	1	5	20
63	The device will alert user with alarm in case of danger	5	3	5	75
64	The usage time of the display by the children can be set	4	3	5	60
65	The device is able to sanitize bag & books before and after school	5	2	5	50
66	The device is able to scan and detect most touch part of the house and sanitize	5	2	4	40

67	The device will do other house chores while parents take care of children	4	4	3	48
68	The device will take care of other house chores while parents with the baby	4	4	3	48
69	The device's texture feels like human skin	4	4	4	64
70	The device able to put blanket on a sleeping child	3	4	4	48
71	The device is able to give milk to children only when needed	5	4	2	40
72	The device is able to judge the level of sickness and notify parents or authorities (hospital etc.)	5	5	3	75
73	The device is able to put child to sleep	4	5	3	60
74	The device is able to manage the schedule for children	3	1	5	15
75	The device's size is able to be customized according to child age or user preference	4	3	3	36
76	The device is able to take care other child while parents taking care the other	4	4	3	48
77	The device's part can be use and operate separately	3	3	4	36
78	The device is able to give children a treat once they finished homework/ quizzes	4	3	5	60
79	The device is able to give children refreshment after finished class/lesson	4	3	5	60
80	The device is able to teach and play with children	5	4	4	80
81	The device is able to alert children for their schedule	3	1	5	15
82	The device will monitor children movement in the house	5	3	5	75
83	The device is equipped with camera with make-up filter	2	1	5	10
84	The device's is able to remind parents and children to communicate to each other	5	4	4	80
85	The device puts out soap for hand washing	3	1	5	15
86	The device is able to measure body temperature	3	1	5	15
87	The device is able to measure heart beat	4	3	4	48
88	The device measure heart beat by connecting to heartbeat sensor placed near the body	4	2	5	40

89	The device is able to sanitize a lot of books at the same time	3	1	5	15
90	The device is able to decide who to notify first (parents or authorities)	5	4	3	60
91	The device is able to monitor people/ stranger inside/ outside/ around the house	4	1	4	16
92	The device's display is interactive	5	1	5	25
93	The device is able to scan and recognize people outside /around the house	4	1	4	16
94	The device will tell parents when to change the diaper	3	4	5	60
95	The device is able to connect parents and child using the display	5	1	5	25
96	The device is able to teach from display	5	1	5	25
97	The device will remind user to wash hand with soap	3	2	5	30
98	The device is made from strong material	4	1	5	20
99	The device is able to follow order from user (to call someone or to bring something etc.)	4	3	3	36
100	The device will suggest activities for parents and children to do together	3	4	4	48
101	The device's function can be selected by user	5	1	5	25
102	The device is able to scold or warn children	5	4	4	80
103	The device is able to teach user	4	5	4	80
104	The device is able to play, dance, sing and karaoke with user	5	4	4	80
105	The device is able to move slow or fast according to the task/activity	4	1	5	20
106	The device is able to be used in any situation (post-covid19)	4	1	5	20
107	The device is able to set to freely move and set to still	5	1	5	25
108	The device is suitable to support working mother or housewife	4	5	2	40
109	The device is able to make children focus during online class	5	4	3	60
110	The device will remind to dress properly before class	2	3	3	18
111	The device is able to give simple guide to get dress before class	3	3	3	27
112	The device is able to play games with children	3	4	4	48
113	The device is able to sanitize house	5	1	5	25

114	The device is able to make children to study and monitor them	5	5	4	100
115	The device will alert children if they lost focus during classes/lessons	4	5	4	80
116	The device will alert children to look at the screen or open the book or listen to the teacher	3	5	3	45
117	The device is able to advice/suggest how to spend free time	3	5	3	45
118	The device is able to ventilate room	3	1	5	15
119	The device will stop child from touching dangerous thing (broken glass, open wire, fire etc.)	4	2	4	32
120	The device will remind to measure temperature	2	1	5	10
121	The device is able to purify the air	2	1	5	10
122	The device is able to wipe, clean and sanitize table and floor	4	2	5	40
123	The device's weight is suitable to be carried by user around the house	5	1	5	25
124	The device is able to detect small changes of a child while changing diaper	5	5	3	75
125	The device's function is only to support parents or nursery/kindergarten teacher	5	5	3	75
126	The device is able to do the task for maid or nurse	5	5	2	50
127	The device is able to greet user or stranger at the front door	4	4	4	64
128	The cleaning part of the device is able to be detached.	3	1	5	15
129	The device is able to hold a baby like a mother.	5	5	3	75
130	The device function is able to be customized according to customer preference or budget	4	1	5	20
131	The device is able to scan and detect user's focus in class	5	4	3	60
132	The device is able to have conversation with children	5	2	4	40
133	The device is able to be used in kindergarten or nursery	4	5	2	40
134	The device is able to open and close window and curtain	3	1	5	15
135	The device's shape is round	3	3	5	45
136	The device is able to give milk and bath, and change diaper	5	5	2	50
137	The device price is affordable	5	1	4	20

138	The device relaxes the baby	5	5	2	50
139	The device is able to provide human touch and warmth while changing the diaper	5	5	4	100
140	The device will remind parents if they did not look after the children (ex. Looking at the phone)	5	5	3	75
141	The device is able to sweep and vacuum the floor.	4	1	5	20

Table A-2 Rating value of importance, latent-ness, and technological feasibility, and DLN value (V^{DLN}) for evaluator B

No	Interpreted Needs	Importance	Latent-ness	Technological Feasibility	V^{DLN}
1	The device is able to sanitize small item in UV box	2	1	5	10
2	The device will send/update the information of people entering/exiting the house to parents	2	3	4	24
3	The device is able to give right/ precise information to authorities (police, hospital etc.)	2	2	4	16
4	The device is able to contact parents in case of emergency	5	2	4	40
5	The device is able to detect small changes of a child while measuring temperature	5	3	4	60
6	The device is able to change the voice tone.	2	3	5	30
7	The device's power last long	5	1	5	25
8	The device is able to sing lullaby to put child to sleep	4	3	5	60
9	The device is able to play lullaby song from mother's voice	4	3	5	60
10	The device is able to monitor children and notify parent in case of emergency	5	3	5	75
11	The device is able to cut electricity in case of danger	5	2	5	50
12	The device is able to stop water in case of danger	3	4	4	48
13	The device is able to conduct CPR	5	4	3	60
14	The device can be set to use when needed only	3	1	5	15
15	The device can be turn on and off by the user	3	1	5	15
16	The device is able to detect eye contact and head's tilting and turning angle	4	4	4	64

17	The device is able to interact with children with voice and facial expression	5	3	4	60
18	The device is able to play with children with voice and facial expression	5	4	3	60
19	The device will only clean the part of the house set by user	4	1	5	20
20	The device's function to interact with children can be turned off	5	1	5	25
21	The device' function to alert and scold children can be set off	5	1	5	25
22	The device is able to recognize items (food or not) that a child wants to put in mouth	5	3	4	60
23	The device is able to monitor baby sleeping	5	4	4	80
24	The device is able to interact with children with display	5	1	5	25
25	The device's functioning time is able to be set by user	5	1	5	25
26	The device's function can be set to take care other things than a baby	3	3	4	36
27	The device is able to correct the position of blanket	4	4	4	64
28	The device will notify authorities (police etc.) if the person in/around the house is suspicious	4	2	4	32
29	The device is able to clean up and arrange toys according to type	3	3	4	36
30	The device is able to teach with voice and facial expression	4	4	4	64
31	The device is able to suggest new/suitable game for parents and children	4	4	3	48
32	The device's functions are able to be set up only for house chores	3	2	5	30
33	The device's functions are able to be set up not to connect with children	3	2	5	30
34	The device is able to give human-like touch	5	3	5	75
35	The device is able to give a human-like warm hug	5	4	4	80
36	The device is able to give facial expression	4	3	4	48
37	The device's hand is able to hold child's hand until he/she falls asleep	5	4	4	80
38	The device is able to pat child while slowing the pace until he/she falls asleep	5	4	4	80

39	The device is able to correct a child sleeping posture	5	5	4	100
40	The device is able to sanitize a lot of toys at the same time	5	1	5	25
41	The device is able to measure temperature (room and body)	5	1	5	25
42	The device is able to contact authorities (police/hospital) in case of emergency or accident	5	2	5	50
43	The device is able to detect small changes in child compare to other day	5	4	4	80
44	The device is able to sanitize and keep mask	3	1	5	15
45	The device's temperature is same as human	5	3	5	75
46	The device's texture is soft like silicon	5	4	5	100
47	The device is able to be used indoor/outdoor	4	4	4	64
48	The device is able to calm the child	5	5	4	100
49	The device is able to wake the child up	5	5	4	100
50	The device is able to react fast in case of emergency	5	2	4	40
51	The device is able to react fast in case of danger	5	2	4	40
52	The device is able to clean up broken glass, spilled water etc.	5	1	5	25
53	The device is able to prevent child from choking	5	4	4	80
54	The device will remind the schedule for next class	3	1	5	15
55	The device will remind to finish homework before next class	4	3	5	60
56	The device will remind to prepare for next class	4	2	5	40
57	The device is able to alert parents when the baby wake up	5	4	4	80
58	The device is able to operate with small power	1	1	4	4
59	The device has a power saving mode	1	1	5	5
60	The device is able to sanitize the house using alcohol sanitizer or UV light	4	2	5	40
61	The device is able to scan and recognize user/stranger	5	3	4	60
62	The device can clean the house while moving around the house	4	1	5	20
63	The device will alert user with alarm in case of danger	4	3	5	60

64	The usage time of the display by the children can be set	3	3	5	45
65	The device is able to sanitize bag & books before and after school	5	2	5	50
66	The device is able to scan and detect most touch part of the house and sanitize	5	2	5	50
67	The device will do other house chores while parents take care of children	5	4	4	80
68	The device will take care of other house chores while parents with the baby	5	4	4	80
69	The device's texture feels like human skin	5	4	4	80
70	The device able to put blanket on a sleeping child	4	4	4	64
71	The device is able to give milk to children only when needed	5	4	2	40
72	The device is able to judge the level of sickness and notify parents or authorities (hospital etc.)	5	5	2	50
73	The device is able to put child to sleep	5	5	3	75
74	The device is able to manage the schedule for children	4	1	5	20
75	The device's size is able to be customized according to child age or user preference	4	3	4	48
76	The device is able to take care other child while parents taking care the other	4	4	4	64
77	The device's part can be use and operate separately	3	3	4	36
78	The device is able to give children a treat once they finished homework/ quizzes	3	3	5	45
79	The device is able to give children refreshment after finished class/lesson	3	3	5	45
80	The device is able to teach and play with children	5	4	4	80
81	The device is able to alert children for their schedule	3	1	5	15
82	The device will monitor children movement in the house	4	3	4	48
83	The device is equipped with camera with make-up filter	3	1	5	15
84	The device's is able to remind parents and children to communicate to each other	5	4	4	80

85	The device puts out soap for hand washing	3	1	5	15
86	The device is able to measure body temperature	3	1	5	15
87	The device is able to measure heart beat	3	3	4	36
88	The device measure heart beat by connecting to heartbeat sensor placed near the body	3	2	5	30
89	The device is able to sanitize a lot of books at the same time	3	1	5	15
90	The device is able to decide who to notify first (parents or authorities)	5	4	3	60
91	The device is able to monitor people/ stranger inside/ outside/ around the house	4	1	4	16
92	The device's display is interactive	5	1	5	25
93	The device is able to scan and recognize people outside /around the house	4	1	4	16
94	The device will tell parents when to change the diaper	4	4	4	64
95	The device is able to connect parents and child using the display	5	1	5	25
96	The device is able to teach from display	5	1	5	25
97	The device will remind user to wash hand with soap	4	2	5	40
98	The device is made from strong material	3	1	5	15
99	The device is able to follow order from user (to call someone or to bring something etc.)	4	3	4	48
100	The device will suggest activities for parents and children to do together	4	4	4	64
101	The device's function can be selected by user	5	1	5	25
102	The device is able to scold or warn children	5	4	4	80
103	The device is able to teach user	5	5	3	75
104	The device is able to play, dance, sing and karaoke with user	5	4	4	80
105	The device is able to move slow or fast according to the task/activity	4	1	5	20
106	The device is able to be used in any situation (post-covid19)	4	1	5	20
107	The device is able to set to freely move and set to still	5	1	5	25

108	The device is suitable to support working mother or housewife	5	5	2	50
109	The device is able to make children focus during online class	5	4	3	60
110	The device will remind to dress properly before class	3	3	3	27
111	The device is able to give simple guide to get dress before class	4	3	3	36
112	The device is able to play games with children	4	4	3	48
113	The device is able to sanitize house	4	1	5	20
114	The device is able to make children to study and monitor them	5	5	4	100
115	The device will alert children if they lost focus during classes/lessons	4	5	4	80
116	The device will alert children to look at the screen or open the book or listen to the teacher	4	5	3	60
117	The device is able to advice/suggest how to spend free time	4	5	3	60
118	The device is able to ventilate room	3	1	5	15
119	The device will stop child from touching dangerous thing (broken glass, open wire, fire etc.)	4	2	4	32
120	The device will remind to measure temperature	3	1	5	15
121	The device is able to purify the air	2	1	5	10
122	The device is able to wipe, clean and sanitize table and floor	4	2	5	40
123	The device's weight is suitable to be carried by user around the house	5	1	5	25
124	The device is able to detect small changes of a child while changing diaper	5	5	3	75
125	The device's function is only to support parents or nursery/kindergarten teacher	5	5	3	75
126	The device is able to do the task for maid or nurse	5	5	2	50
127	The device is able to greet user or stranger at the front door	3	4	4	48
128	The cleaning part of the device is able to be detached.	4	1	5	20
129	The device is able to hold a baby like a mother.	5	5	3	75
130	The device function is able to be customized according to customer preference or budget	3	1	5	15

131	The device is able to scan and detect user's focus in class	5	4	3	60
132	The device is able to have conversation with children	4	2	4	32
133	The device is able to be used in kindergarten or nursery	5	5	2	50
134	The device is able to open and close window and curtain	3	1	5	15
135	The device's shape is round	3	3	5	45
136	The device is able to give milk and bath, and change diaper	5	5	2	50
137	The device price is affordable	5	1	4	20
138	The device relaxes the baby	5	5	2	50
139	The device is able to provide human touch and warmth while changing the diaper	5	5	4	100
140	The device will remind parents if they did not look after the children (ex. Looking at the phone)	4	5	5	100
141	The device is able to sweep and vacuum the floor.	4	1	5	20

Table A-3 Rating value of importance, latent-ness, and technological feasibility, and DLN value (V^{DLN}) for evaluator C

No	Interpreted Needs	Importance	Latent-ness	Technological Feasibility	V^{DLN}
1	The device is able to sanitize small item in UV box	3	2	5	30
2	The device will send/update the information of people entering/exiting the house to parents	3	2	4	24
3	The device is able to give right/ precise information to authorities (police, hospital etc.)	3	2	4	24
4	The device is able to contact parents in case of emergency	5	2	5	50
5	The device is able to detect small changes of a child while measuring temperature	4	2	4	322
6	The device is able to change the voice tone.	2	2	4	16
7	The device's power last long	2	1	5	10
8	The device is able to sing lullaby to put child to sleep	3	2	2	12
9	The device is able to play lullaby song from mother's voice	3	2	5	30
10	The device is able to monitor children and notify parent in case of emergency	5	1	4	20

11	The device is able to cut electricity in case of danger	5	1	5	25
12	The device is able to stop water in case of danger	5	1	5	25
13	The device is able to conduct CPR	5	1	5	25
14	The device can be set to use when needed only	4	1	5	20
15	The device can be turn on and off by the user	5	1	5	25
16	The device is able to detect eye contact and head's tilting and turning angle	3	3	5	45
17	The device is able to interact with children with voice and facial expression	3	2	5	30
18	The device is able to play with children with voice and facial expression	3	2	5	30
19	The device will only clean the part of the house set by user	4	1	5	20
20	The device's function to interact with children can be turned off	3	1	5	15
21	The device' function to alert and scold children can be set off	3	1	5	15
22	The device is able to recognize items (food or not) that a child wants to put in mouth	4	1	4	16
23	The device is able to monitor baby sleeping	5	3	5	75
24	The device is able to interact with children with display	4	2	5	40
25	The device's functioning time is able to be set by user	4	1	5	20
26	The device's function can be set to take care other things than a baby	4	2	5	40
27	The device is able to correct the position of blanket	3	2	5	30
28	The device will notify authorities (police etc.) if the person in/around the house is suspicious	5	1	4	20
29	The device is able to clean up and arrange toys according to type	4	2	4	32
30	The device is able to teach with voice and facial expression	3	3	3	27
31	The device is able to suggest new/suitable game for parents and children	3	3	4	36
32	The device's functions are able to be set up only for house chores	4	2	5	40

33	The device's functions are able to be set up not to connect with children	3	2	5	30
34	The device is able to give human-like touch	3	4	5	60
35	The device is able to give a human-like warm hug	3	4	4	48
36	The device is able to give facial expression	3	4	5	60
37	The device's hand is able to hold child's hand until he/she falls asleep	3	3	5	45
38	The device is able to pat child while slowing the pace until he/she falls asleep	3	3	5	45
39	The device is able to correct a child sleeping posture	3	2	3	18
40	The device is able to sanitize a lot of toys at the same time	3	2	5	30
41	The device is able to measure temperature (room and body)	4	2	5	40
42	The device is able to contact authorities (police/hospital) in case of emergency or accident	5	1	5	25
43	The device is able to detect small changes in child compare to other day	4	3	5	60
44	The device is able to sanitize and keep mask	4	2	5	40
45	The device's temperature is same as human	3	4	5	60
46	The device's texture is soft like silicon	3	4	5	60
47	The device is able to be used indoor/outdoor	4	2	5	40
48	The device is able to calm the child	3	4	3	36
49	The device is able to wake the child up	4	4	3	48
50	The device is able to react fast in case of emergency	5	1	4	20
51	The device is able to react fast in case of danger	5	1	4	20
52	The device is able to clean up broken glass, spilled water etc.	4	2	5	40
53	The device is able to prevent child from choking	4	2	4	32
54	The device will remind the schedule for next class	3	2	5	30
55	The device will remind to finish homework before next class	3	2	5	30
56	The device will remind to prepare for next class	3	2	5	30
57	The device is able to alert parents when the baby wake up	4	3	4	48

58	The device is able to operate with small power	3	1	5	15
59	The device has a power saving mode	3	1	5	15
60	The device is able to sanitize the house using alcohol sanitizer or UV light	3	2	5	30
61	The device is able to scan and recognize user/stranger	4	3	4	48
62	The device can clean the house while moving around the house	3	2	4	24
63	The device will alert user with alarm in case of danger	5	1	4	20
64	The usage time of the display by the children can be set	4	2	5	40
65	The device is able to sanitize bag & books before and after school	3	2	5	30
66	The device is able to scan and detect most touch part of the house and sanitize	4	2	4	32
67	The device will do other house chores while parents take care of children	4	2	3	24
68	The device will take care of other house chores while parents with the baby	4	2	3	24
69	The device's texture feels like human skin	3	4	5	60
70	The device able to put blanket on a sleeping child	3	3	4	36
71	The device is able to give milk to children only when needed	4	3	4	48
72	The device is able to judge the level of sickness and notify parents or authorities (hospital etc.)	5	1	4	20
73	The device is able to put child to sleep	4	4	3	48
74	The device is able to manage the schedule for children	4	3	5	60
75	The device's size is able to be customized according to child age or user preference	3	3	4	36
76	The device is able to take care other child while parents taking care the other	4	3	4	48
77	The device's part can be use and operate separately	5	2	5	50
78	The device is able to give children a treat once they finished homework/ quizzes	3	3	4	36
79	The device is able to give children refreshment after finished class/lesson	3	3	4	36

80	The device is able to teach and play with children	3	3	4	36
81	The device is able to alert children for their schedule	3	2	5	30
82	The device will monitor children movement in the house	4	2	5	40
83	The device is equipped with camera with make-up filter	3	2	5	30
84	The device's is able to remind parents and children to communicate to each other	3	2	5	30
85	The device puts out soap for hand washing	3	1	5	15
86	The device is able to measure body temperature	3	2	5	30
87	The device is able to measure heart beat	3	2	5	30
88	The device measure heart beat by connecting to heartbeat sensor placed near the body	3	2	5	30
89	The device is able to sanitize a lot of books at the same time	3	2	5	30
90	The device is able to decide who to notify first (parents or authorities)	5	1	4	20
91	The device is able to monitor people/ stranger inside/ outside/ around the house	4	2	5	40
92	The device's display is interactive	3	2	4	24
93	The device is able to scan and recognize people outside /around the house	4	2	4	32
94	The device will tell parents when to change the diaper	4	3	5	60
95	The device is able to connect parents and child using the display	4	3	5	60
96	The device is able to teach from display	4	3	4	48
97	The device will remind user to wash hand with soap	4	2	4	32
98	The device is made from strong material	3	3	5	45
99	The device is able to follow order from user (to call someone or to bring something etc.)	4	1	4	16
100	The device will suggest activities for parents and children to do together	3	2	4	24
101	The device's function can be selected by user	3	4	5	60

102	The device is able to scold or warn children	3	3	4	36
103	The device is able to teach user	3	3	4	36
104	The device is able to play, dance, sing and karaoke with user	3	2	5	30
105	The device is able to move slow or fast according to the task/activity	3	2	5	30
106	The device is able to be used in any situation (post-covid19)	3	2	4	24
107	The device is able to set to freely move and set to still	3	1	5	15
108	The device is suitable to support working mother or housewife	4	4	3	48
109	The device is able to make children focus during online class	4	3	3	36
110	The device will remind to dress properly before class	4	3	3	36
111	The device is able to give simple guide to get dress before class	3	2	3	18
112	The device is able to play games with children	3	3	4	36
113	The device is able to sanitize house	3	2	5	30
114	The device is able to make children to study and monitor them	4	3	4	48
115	The device will alert children if they lost focus during classes/lessons	4	3	3	36
116	The device will alert children to look at the screen or open the book or listen to the teacher	4	2	5	40
117	The device is able to advice/suggest how to spend free time	3	3	4	36
118	The device is able to ventilate room	3	2	5	30
119	The device will stop child from touching dangerous thing (broken glass, open wire, fire etc.)	5	2	5	50
120	The device will remind to measure temperature	4	2	5	40
121	The device is able to purify the air	4	2	5	40
122	The device is able to wipe, clean and sanitize table and floor	4	2	5	40
123	The device's weight is suitable to be carried by user around the house	3	2	5	30
124	The device is able to detect small changes of a child while changing diaper	4	2	4	32
125	The device's function is only to support parents or nursery/kindergarten teacher	4	3	3	36

126	The device is able to do the task for maid or nurse	4	3	3	36
127	The device is able to greet user or stranger at the front door	4	3	4	48
128	The cleaning part of the device is able to be detached.	3	2	5	30
129	The device is able to hold a baby like a mother.	4	4	4	64
130	The device function is able to be customized according to customer preference or budget	3	3	4	36
131	The device is able to scan and detect user's focus in class	3	3	4	36
132	The device is able to have conversation with children	3	3	5	45
133	The device is able to be used in kindergarten or nursery	3	4	4	48
134	The device is able to open and close window and curtain	3	2	5	30
135	The device's shape is round	2	4	5	40
136	The device is able to give milk and bath, and change diaper	4	3	3	36
137	The device price is affordable	3	2	4	24
138	The device relaxes the baby	4	4	3	48
139	The device is able to provide human touch and warmth while changing the diaper	3	4	4	48
140	The device will remind parents if they did not look after the children (ex. Looking at the phone)	3	3	4	36
141	The device is able to sweep and vacuum the floor.	3	1	5	15

Table A-4 Rating value of importance, latent-ness, and technological feasibility, and DLN value (V^{DLN}) for evaluator D

No	Interpreted Needs	Importance	Latent-ness	Technological Feasibility	V^{DLN}
1	The device is able to sanitize small item in UV box	3	3	5	45
2	The device will send/update the information of people entering/exiting the house to parents	3	3	4	36
3	The device is able to give right/ precise information to authorities (police, hospital etc.)	3	3	4	36
4	The device is able to contact parents in case of emergency	3	2	5	30

5	The device is able to detect small changes of a child while measuring temperature	3	3	4	36
6	The device is able to change the voice tone.	1	2	5	10
7	The device's power last long	4	5	5	100
8	The device is able to sing lullaby to put child to sleep	3	3	4	36
9	The device is able to play lullaby song from mother's voice	3	2	5	30
10	The device is able to monitor children and notify parent in case of emergency	3	2	4	24
11	The device is able to cut electricity in case of danger	4	3	4	48
12	The device is able to stop water in case of danger	4	3	4	48
13	The device is able to conduct CPR	4	3	4	48
14	The device can be set to use when needed only	5	1	5	25
15	The device can be turn on and off by the user	5	1	5	25
16	The device is able to detect eye contact and head's tilting and turning angle	3	3	5	45
17	The device is able to interact with children with voice and facial expression	4	3	4	48
18	The device is able to play with children with voice and facial expression	4	3	3	36
19	The device will only clean the part of the house set by user	4	3	4	48
20	The device's function to interact with children can be turned off	5	1	5	25
21	The device' function to alert and scold children can be set off	5	1	5	25
22	The device is able to recognize items (food or not) that a child wants to put in mouth	5	1	4	20
23	The device is able to monitor baby sleeping	4	1	4	16
24	The device is able to interact with children with display	4	3	4	48
25	The device's functioning time is able to be set by user	5	1	5	25
26	The device's function can be set to take care other things than a baby	4	3	4	48
27	The device is able to correct the position of blanket	4	3	4	48

28	The device will notify authorities (police etc.) if the person in/around the house is suspicious	4	3	4	48
29	The device is able to clean up and arrange toys according to type	4	4	4	64
30	The device is able to teach with voice and facial expression	4	3	4	48
31	The device is able to suggest new/suitable game for parents and children	4	4	4	64
32	The device's functions are able to be set up only for house chores	4	1	5	20
33	The device's functions are able to be set up not to connect with children	4	2	4	32
34	The device is able to give human-like touch	4	3	4	48
35	The device is able to give a human-like warm hug	3	3	4	36
36	The device is able to give facial expression	3	3	4	36
37	The device's hand is able to hold child's hand until he/she falls asleep	4	3	4	48
38	The device is able to pat child while slowing the pace until he/she falls asleep	4	3	4	48
39	The device is able to correct a child sleeping posture	4	3	4	48
40	The device is able to sanitize a lot of toys at the same time	4	2	5	40
41	The device is able to measure temperature (room and body)	4	1	5	20
42	The device is able to contact authorities (police/hospital) in case of emergency or accident	4	1	5	20
43	The device is able to detect small changes in child compare to other day	4	2	4	32
44	The device is able to sanitize and keep mask	4	2	5	40
45	The device's temperature is same as human	3	2	5	30
46	The device's texture is soft like silicon	4	3	5	60
47	The device is able to be used indoor/outdoor	4	2	5	40
48	The device is able to calm the child	4	2	4	32
49	The device is able to wake the child up	4	2	4	32
50	The device is able to react fast in case of emergency	4	2	4	32
51	The device is able to react fast in case of danger	4	2	4	32

52	The device is able to clean up broken glass, spilled water etc.	4	2	4	32
53	The device is able to prevent child from choking	4	2	4	32
54	The device will remind the schedule for next class	3	2	5	30
55	The device will remind to finish homework before next class	3	2	5	30
56	The device will remind to prepare for next class	3	2	5	30
57	The device is able to alert parents when the baby wake up	3	3	4	36
58	The device is able to operate with small power	4	2	4	32
59	The device has a power saving mode	4	1	5	20
60	The device is able to sanitize the house using alcohol sanitizer or UV light	4	2	5	40
61	The device is able to scan and recognize user/stranger	3	2	5	30
62	The device can clean the house while moving around the house	4	3	4	48
63	The device will alert user with alarm in case of danger	3	2	5	30
64	The usage time of the display by the children can be set	3	2	5	30
65	The device is able to sanitize bag & books before and after school	4	3	4	48
66	The device is able to scan and detect most touch part of the house and sanitize	4	3	4	48
67	The device will do other house chores while parents take care of children	4	2	3	24
68	The device will take care of other house chores while parents with the baby	4	2	3	24
69	The device's texture feels like human skin	3	2	4	24
70	The device able to put blanket on a sleeping child	4	3	4	48
71	The device is able to give milk to children only when needed	4	3	4	48
72	The device is able to judge the level of sickness and notify parents or authorities (hospital etc.)	4	3	4	48
73	The device is able to put child to sleep	3	2	4	24
74	The device is able to manage the schedule for children	3	2	5	30

75	The device's size is able to be customized according to child age or user preference	4	3	4	48
76	The device is able to take care other child while parents taking care the other	4	3	3	36
77	The device's part can be use and operate separately	4	3	4	48
78	The device is able to give children a treat once they finished homework/ quizzes	3	3	4	36
79	The device is able to give children refreshment after finished class/lesson	3	3	4	36
80	The device is able to teach and play with children	4	3	3	36
81	The device is able to alert children for their schedule	3	3	5	45
82	The device will monitor children movement in the house	4	2	4	32
83	The device is equipped with camera with make-up filter	3	3	5	45
84	The device's is able to remind parents and children to communicate to each other	3	3	5	45
85	The device puts out soap for hand washing	3	3	5	45
86	The device is able to measure body temperature	4	1	5	20
87	The device is able to measure heart beat	4	1	5	20
88	The device measure heart beat by connecting to heartbeat sensor placed near the body	4	1	5	20
89	The device is able to sanitize a lot of books at the same time	4	2	5	40
90	The device is able to decide who to notify first (parents or authorities)	4	3	4	48
91	The device is able to monitor people/ stranger inside/ outside/ around the house	4	3	4	48
92	The device's display is interactive	3	3	4	36
93	The device is able to scan and recognize people outside /around the house	4	2	4	32
94	The device will tell parents when to change the diaper	4	3	4	48
95	The device is able to connect parents and child using the display	4	2	5	40

96	The device is able to teach from display	3	2	4	24
97	The device will remind user to wash hand with soap	3	2	4	24
98	The device is made from strong material	4	2	4	32
99	The device is able to follow order from user (to call someone or to bring something etc.)	4	2	5	40
100	The device will suggest activities for parents and children to do together	3	3	4	36
101	The device's function can be selected by user	4	2	5	40
102	The device is able to scold or warn children	4	2	4	32
103	The device is able to teach user	4	2	4	32
104	The device is able to play, dance, sing and karaoke with user	4	2	4	32
105	The device is able to move slow or fast according to the task/activity	4	2	4	32
106	The device is able to be used in any situation (post-covid19)	4	3	4	48
107	The device is able to set to freely move and set to still	4	3	4	48
108	The device is suitable to support working mother or housewife	3	3	4	36
109	The device is able to make children focus during online class	3	3	4	36
110	The device will remind to dress properly before class	3	3	4	36
111	The device is able to give simple guide to get dress before class	3	3	4	36
112	The device is able to play games with children	3	2	5	30
113	The device is able to sanitize house	4	3	4	48
114	The device is able to make children to study and monitor them	3	3	4	36
115	The device will alert children if they lost focus during classes/lessons	3	3	4	36
116	The device will alert children to look at the screen or open the book or listen to the teacher	3	3	4	36
117	The device is able to advice/suggest how to spend free time	3	3	4	36
118	The device is able to ventilate room	4	3	4	48
119	The device will stop child from touching dangerous thing (broken glass, open wire, fire etc.)	4	3	4	48

120	The device will remind to measure temperature	3	2	5	30
121	The device is able to purify the air	3	2	4	24
122	The device is able to wipe, clean and sanitize table and floor	4	2	4	32
123	The device's weight is suitable to be carried by user around the house	4	3	4	48
124	The device is able to detect small changes of a child while changing diaper	4	3	4	48
125	The device's function is only to support parents or nursery/kindergarten teacher	4	3	4	48
126	The device is able to do the task for maid or nurse	4	3	3	36
127	The device is able to greet user or stranger at the front door	4	3	4	48
128	The cleaning part of the device is able to be detached.	3	3	4	36
129	The device is able to hold a baby like a mother.	3	2	3	18
130	The device function is able to be customized according to customer preference or budget	4	3	3	36
131	The device is able to scan and detect user's focus in class	3	3	4	36
132	The device is able to have conversation with children	4	2	4	32
133	The device is able to be used in kindergarten or nursery	4	3	3	36
134	The device is able to open and close window and curtain	3	3	4	36
135	The device's shape is round	3	2	4	24
136	The device is able to give milk and bath, and change diaper	3	3	3	27
137	The device price is affordable	5	1	3	15
138	The device relaxes the baby	4	2	4	32
139	The device is able to provide human touch and warmth while changing the diaper	4	3	3	36
140	The device will remind parents if they did not look after the children (ex. Looking at the phone)	3	3	4	36
141	The device is able to sweep and vacuum the floor.	4	2	5	40

Table A-5 Rating value of importance, latent-ness, and technological feasibility, and DLN value (V^{DLN}) for evaluator E

No	Interpreted Needs	Importance	Latent-ness	Technological Feasibility	V^{DLN}
1	The device is able to sanitize small item in UV box	3	3	5	45
2	The device will send/update the information of people entering/exiting the house to parents	2	1	5	10
3	The device is able to give right/ precise information to authorities (police, hospital etc.)	2	2	4	16
4	The device is able to contact parents in case of emergency	3	1	4	12
5	The device is able to detect small changes of a child while measuring temperature	2	3	2	12
6	The device is able to change the voice tone.	1	3	3	9
7	The device's power last long	2	2	5	20
8	The device is able to sing lullaby to put child to sleep	2	2	5	20
9	The device is able to play lullaby song from mother's voice	1	2	5	10
10	The device is able to monitor children and notify parent in case of emergency	2	3	4	24
11	The device is able to cut electricity in case of danger	2	2	5	20
12	The device is able to stop water in case of danger	2	3	5	30
13	The device is able to conduct CPR	4	1	5	20
14	The device can be set to use when needed only	4	2	4	32
15	The device can be turn on and off by the user	5	1	5	25
16	The device is able to detect eye contact and head's tilting and turning angle	2	4	4	32
17	The device is able to interact with children with voice and facial expression	2	3	4	24
18	The device is able to play with children with voice and facial expression	3	3	4	36
19	The device will only clean the part of the house set by user	4	4	4	64
20	The device's function to interact with children can be turned off	2	3	5	30

21	The device' function to alert and scold children can be set off	2	2	5	20
22	The device is able to recognize items (food or not) that a child wants to put in mouth	3	3	3	27
23	The device is able to monitor baby sleeping	3	3	4	36
24	The device is able to interact with children with display	3	2	5	30
25	The device's functioning time is able to be set by user	3	3	5	45
26	The device's function can be set to take care other things than a baby	3	3	3	27
27	The device is able to correct the position of blanket	2	2	4	16
28	The device will notify authorities (police etc.) if the person in/around the house is suspicious	4	2	5	40
29	The device is able to clean up and arrange toys according to type	4	3	3	36
30	The device is able to teach with voice and facial expression	3	3	4	36
31	The device is able to suggest new/suitable game for parents and children	3	1	5	15
32	The device's functions are able to be set up only for house chores	4	3	5	60
33	The device's functions are able to be set up not to connect with children	4	4	5	80
34	The device is able to give human-like touch	4	3	5	60
35	The device is able to give a human-like warm hug	3	3	5	45
36	The device is able to give facial expression	3	2	5	30
37	The device's hand is able to hold child's hand until he/she falls asleep	3	2	4	24
38	The device is able to pat child while slowing the pace until he/she falls asleep	2	3	3	18
39	The device is able to correct a child sleeping posture	2	2	3	12
40	The device is able to sanitize a lot of toys at the same time	2	4	5	40
41	The device is able to measure temperature (room and body)	2	3	5	30
42	The device is able to contact authorities (police/hospital) in case of emergency or accident	4	1	5	20

43	The device is able to detect small changes in child compare to other day	3	3	4	36
44	The device is able to sanitize and keep mask	2	2	5	20
45	The device's temperature is same as human	3	3	5	45
46	The device's texture is soft like silicon	3	3	5	45
47	The device is able to be used indoor/outdoor	2	3	5	30
48	The device is able to calm the child	3	3	4	36
49	The device is able to wake the child up	3	2	5	30
50	The device is able to react fast in case of emergency	3	3	4	36
51	The device is able to react fast in case of danger	3	2	4	24
52	The device is able to clean up broken glass, spilled water etc.	3	1	5	15
53	The device is able to prevent child from choking	3	2	4	24
54	The device will remind the schedule for next class	3	2	5	30
55	The device will remind to finish homework before next class	3	2	5	30
56	The device will remind to prepare for next class	3	1	5	15
57	The device is able to alert parents when the baby wake up	3	3	4	36
58	The device is able to operate with small power	2	2	5	20
59	The device has a power saving mode	3	1	5	15
60	The device is able to sanitize the house using alcohol sanitizer or UV light	3	2	5	30
61	The device is able to scan and recognize user/stranger	3	2	5	30
62	The device can clean the house while moving around the house	3	1	5	15
63	The device will alert user with alarm in case of danger	3	2	5	30
64	The usage time of the display by the children can be set	4	2	5	40
65	The device is able to sanitize bag & books before and after school	2	1	5	10
66	The device is able to scan and detect most touch part of the house and sanitize	3	2	5	30
67	The device will do other house chores while parents take care of children	4	2	5	40

68	The device will take care of other house chores while parents with the baby	4	2	5	40
69	The device's texture feels like human skin	3	3	5	45
70	The device able to put blanket on a sleeping child	3	2	5	30
71	The device is able to give milk to children only when needed	3	2	4	24
72	The device is able to judge the level of sickness and notify parents or authorities (hospital etc.)	4	3	3	36
73	The device is able to put child to sleep	3	3	4	36
74	The device is able to manage the schedule for children	3	3	5	45
75	The device's size is able to be customized according to child age or user preference	3	3	5	45
76	The device is able to take care other child while parents taking care the other	4	2	4	32
77	The device's part can be use and operate separately	3	3	5	45
78	The device is able to give children a treat once they finished homework/ quizzes	2	3	5	30
79	The device is able to give children refreshment after finished class/lesson	2	2	4	16
80	The device is able to teach and play with children	3	2	4	24
81	The device is able to alert children for their schedule	3	2	5	30
82	The device will monitor children movement in the house	3	3	5	45
83	The device is equipped with camera with make-up filter	2	4	5	40
84	The device's is able to remind parents and children to communicate to each other	2	3	4	24
85	The device puts out soap for hand washing	2	1	5	10
86	The device is able to measure body temperature	2	1	5	10
87	The device is able to measure heart beat	3	1	5	15
88	The device measure heart beat by connecting to heartbeat sensor placed near the body	2	3	5	30

89	The device is able to sanitize a lot of books at the same time	2	3	5	30
90	The device is able to decide who to notify first (parents or authorities)	2	3	4	24
91	The device is able to monitor people/ stranger inside/ outside/ around the house	3	3	4	36
92	The device's display is interactive	2	4	4	32
93	The device is able to scan and recognize people outside /around the house	3	3	4	36
94	The device will tell parents when to change the diaper	3	3	4	36
95	The device is able to connect parents and child using the display	2	3	5	30
96	The device is able to teach from display	2	3	5	30
97	The device will remind user to wash hand with soap	2	4	5	40
98	The device is made from strong material	2	3	5	30
99	The device is able to follow order from user (to call someone or to bring something etc.)	4	1	5	20
100	The device will suggest activities for parents and children to do together	3	2	5	30
101	The device's function can be selected by user	3	2	5	30
102	The device is able to scold or warn children	3	2	5	30
103	The device is able to teach user	3	3	5	45
104	The device is able to play, dance, sing and karaoke with user	3	2	4	24
105	The device is able to move slow or fast according to the task/activity	2	3	4	24
106	The device is able to be used in any situation (post-covid19)	3	2	4	24
107	The device is able to set to freely move and set to still	3	3	5	45
108	The device is suitable to support working mother or housewife	4	3	5	60
109	The device is able to make children focus during online class	4	5	3	60
110	The device will remind to dress properly before class	2	3	5	30
111	The device is able to give simple guide to get dress before class	2	3	5	30
112	The device is able to play games with children	3	3	3	27

113	The device is able to sanitize house	3	2	3	18
114	The device is able to make children to study and monitor them	3	5	3	45
115	The device will alert children if they lost focus during classes/lessons	4	4	3	48
116	The device will alert children to look at the screen or open the book or listen to the teacher	4	4	3	48
117	The device is able to advice/suggest how to spend free time	2	3	4	24
118	The device is able to ventilate room	3	2	5	30
119	The device will stop child from touching dangerous thing (broken glass, open wire, fire etc.)	3	3	4	36
120	The device will remind to measure temperature	2	2	5	20
121	The device is able to purify the air	4	2	5	40
122	The device is able to wipe, clean and sanitize table and floor	4	2	5	40
123	The device's weight is suitable to be carried by user around the house	3	1	5	15
124	The device is able to detect small changes of a child while changing diaper	2	3	3	18
125	The device's function is only to support parents or nursery/kindergarten teacher	2	3	4	24
126	The device is able to do the task for maid or nurse	3	3	4	36
127	The device is able to greet user or stranger at the front door	3	3	5	45
128	The cleaning part of the device is able to be detached.	3	4	5	60
129	The device is able to hold a baby like a mother.	3	3	4	36
130	The device function is able to be customized according to customer preference or budget	5	2	5	50
131	The device is able to scan and detect user's focus in class	3	5	4	60
132	The device is able to have conversation with children	3	2	4	24
133	The device is able to be used in kindergarten or nursery	3	2	5	30
134	The device is able to open and close window and curtain	3	1	5	15
135	The device's shape is round	2	4	5	40
136	The device is able to give milk and bath, and change diaper	3	2	3	18

137	The device price is affordable	5	1	5	25
138	The device relaxes the baby	3	3	4	36
139	The device is able to provide human touch and warmth while changing the diaper	3	3	3	27
140	The device will remind parents if they did not look after the children (ex. Looking at the phone)	3	3	4	36
141	The device is able to sweep and vacuum the floor.	3	2	5	30

Table A-6 Rating value of importance, latent-ness, and technological feasibility, and DLN value (V^{DLN}) for evaluator F

No	Interpreted Needs	Importance	Latent-ness	Technological Feasibility	V^{DLN}
1	The device is able to sanitize small item in UV box	3	2	5	30
2	The device will send/update the information of people entering/exiting the house to parents	5	2	5	50
3	The device is able to give right/ precise information to authorities (police, hospital etc.)	2	3	4	24
4	The device is able to contact parents in case of emergency	5	1	5	25
5	The device is able to detect small changes of a child while measuring temperature	4	4	5	80
6	The device is able to change the voice tone.	1	4	5	20
7	The device's power last long	4	1	5	20
8	The device is able to sing lullaby to put child to sleep	2	3	5	30
9	The device is able to play lullaby song from mother's voice	3	3	5	45
10	The device is able to monitor children and notify parent in case of emergency	5	2	5	50
11	The device is able to cut electricity in case of danger	2	4	4	32
12	The device is able to stop water in case of danger	2	5	4	40
13	The device is able to conduct CPR	4	2	5	40
14	The device can be set to use when needed only	3	2	5	30
15	The device can be turn on and off by the user	4	1	5	20

16	The device is able to detect eye contact and head's tilting and turning angle	2	4	5	40
17	The device is able to interact with children with voice and facial expression	2	4	5	40
18	The device is able to play with children with voice and facial expression	2	3	5	30
19	The device will only clean the part of the house set by user	3	4	5	60
20	The device's function to interact with children can be turned off	4	4	5	80
21	The device' function to alert and scold children can be set off	4	3	5	60
22	The device is able to recognize items (food or not) that a child wants to put in mouth	5	1	5	25
23	The device is able to monitor baby sleeping	5	1	5	25
24	The device is able to interact with children with display	5	1	5	25
25	The device's functioning time is able to be set by user	3	3	5	45
26	The device's function can be set to take care other things than a baby	1	2	5	10
27	The device is able to correct the position of blanket	1	2	5	10
28	The device will notify authorities (police etc.) if the person in/around the house is suspicious	4	2	4	32
29	The device is able to clean up and arrange toys according to type	2	3	5	30
30	The device is able to teach with voice and facial expression	3	3	5	45
31	The device is able to suggest new/suitable game for parents and children	1	5	5	25
32	The device's functions are able to be set up only for house chores	3	4	3	60
33	The device's functions are able to be set up not to connect with children	1	4	5	20
34	The device is able to give human-like touch	1	5	4	20
35	The device is able to give a human-like warm hug	1	5	4	20
36	The device is able to give facial expression	4	3	5	60
37	The device's hand is able to hold child's hand until he/she falls asleep	3	3	5	45

38	The device is able to pat child while slowing the pace until he/she falls asleep	3	3	5	45
39	The device is able to correct a child sleeping posture	4	2	5	40
40	The device is able to sanitize a lot of toys at the same time	3	3	5	45
41	The device is able to measure temperature (room and body)	5	1	5	25
42	The device is able to contact authorities (police/hospital) in case of emergency or accident	5	2	4	40
43	The device is able to detect small changes in child compare to other day	4	3	5	60
44	The device is able to sanitize and keep mask	3	3	5	45
45	The device's temperature is same as human	2	5	5	50
46	The device's texture is soft like silicon	4	4	5	80
47	The device is able to be used indoor/outdoor	5	3	5	75
48	The device is able to calm the child	2	5	4	40
49	The device is able to wake the child up	3	3	5	45
50	The device is able to react fast in case of emergency	5	1	5	25
51	The device is able to react fast in case of danger	5	1	5	25
52	The device is able to clean up broken glass, spilled water etc.	5	2	5	50
53	The device is able to prevent child from choking	5	2	4	40
54	The device will remind the schedule for next class	2	3	5	30
55	The device will remind to finish homework before next class	2	3	5	30
56	The device will remind to prepare for next class	2	3	5	30
57	The device is able to alert parents when the baby wake up	5	2	5	50
58	The device is able to operate with small power	4	3	5	60
59	The device has a power saving mode	3	4	5	60
60	The device is able to sanitize the house using alcohol sanitizer or UV light	3	1	5	15
61	The device is able to scan and recognize user/stranger	5	1	5	25
62	The device can clean the house while moving around the house	3	2	5	30

63	The device will alert user with alarm in case of danger	5	2	5	50
64	The usage time of the display by the children can be set	4	2	5	40
65	The device is able to sanitize bag & books before and after school	3	1	5	15
66	The device is able to scan and detect most touch part of the house and sanitize	3	2	5	30
67	The device will do other house chores while parents take care of children	2	3	5	30
68	The device will take care of other house chores while parents with the baby	2	3	5	30
69	The device's texture feels like human skin	1	4	4	16
70	The device able to put blanket on a sleeping child	1	3	5	15
71	The device is able to give milk to children only when needed	5	1	4	20
72	The device is able to judge the level of sickness and notify parents or authorities (hospital etc.)	5	2	4	40
73	The device is able to put child to sleep	2	3	5	30
74	The device is able to manage the schedule for children	4	3	5	60
75	The device's size is able to be customized according to child age or user preference	4	2	5	40
76	The device is able to take care other child while parents taking care the other	4	4	5	80
77	The device's part can be use and operate separately	4	2	5	40
78	The device is able to give children a treat once they finished homework/ quizzes	1	3	5	15
79	The device is able to give children refreshment after finished class/lesson	1	3	5	15
80	The device is able to teach and play with children	2	1	5	10
81	The device is able to alert children for their schedule	3	1	5	15
82	The device will monitor children movement in the house	5	1	5	25
83	The device is equipped with camera with make-up filter	1	5	5	25

84	The device's is able to remind parents and children to communicate to each other	4	4	5	80
85	The device puts out soap for hand washing	1	3	5	15
86	The device is able to measure body temperature	5	1	5	25
87	The device is able to measure heart beat	5	1	5	25
88	The device measure heart beat by connecting to heartbeat sensor placed near the body	5	1	5	25
89	The device is able to sanitize a lot of books at the same time	1	1	5	5
90	The device is able to decide who to notify first (parents or authorities)	5	2	5	50
91	The device is able to monitor people/ stranger inside/ outside/ around the house	5	1	5	25
92	The device's display is interactive	3	4	5	60
93	The device is able to scan and recognize people outside /around the house	5	1	5	25
94	The device will tell parents when to change the diaper	4	4	5	80
95	The device is able to connect parents and child using the display	5	1	5	25
96	The device is able to teach from display	4	1	5	20
97	The device will remind user to wash hand with soap	2	3	5	30
98	The device is made from strong material	5	3	5	75
99	The device is able to follow order from user (to call someone or to bring something etc.)	5	3	5	75
100	The device will suggest activities for parents and children to do together	1	5	5	25
101	The device's function can be selected by user	5	3	5	75
102	The device is able to scold or warn children	2	3	5	30
103	The device is able to teach user	2	3	5	30
104	The device is able to play, dance, sing and karaoke with user	2	3	5	30
105	The device is able to move slow or fast according to the task/activity	4	2	5	40
106	The device is able to be used in any situation (post-covid19)	5	4	5	100

107	The device is able to set to freely move and set to still	3	3	5	45
108	The device is suitable to support working mother or housewife	2	5	5	50
109	The device is able to make children focus during online class	2	4	4	32
110	The device will remind to dress properly before class	1	4	5	20
111	The device is able to give simple guide to get dress before class	1	3	5	15
112	The device is able to play games with children	2	4	5	40
113	The device is able to sanitize house	2	2	5	20
114	The device is able to make children to study and monitor them	2	3	5	30
115	The device will alert children if they lost focus during classes/lessons	2	2	5	20
116	The device will alert children to look at the screen or open the book or listen to the teacher	2	2	5	20
117	The device is able to advice/suggest how to spend free time	1	5	5	25
118	The device is able to ventilate room	4	2	5	40
119	The device will stop child from touching dangerous thing (broken glass, open wire, fire etc.)	5	2	5	50
120	The device will remind to measure temperature	5	1	5	25
121	The device is able to purify the air	5	1	5	25
122	The device is able to wipe, clean and sanitize table and floor	3	1	5	15
123	The device's weight is suitable to be carried by user around the house	4	2	5	40
124	The device is able to detect small changes of a child while changing diaper	3	4	5	60
125	The device's function is only to support parents or nursery/kindergarten teacher	2	5	4	40
126	The device is able to do the task for maid or nurse	1	5	4	20
127	The device is able to greet user or stranger at the front door	1	5	4	20
128	The cleaning part of the device is able to be detached.	4	1	5	20
129	The device is able to hold a baby like a mother.	1	4	4	16

130	The device function is able to be customized according to customer preference or budget	5	1	5	25
131	The device is able to scan and detect user's focus in class	1	4	4	16
132	The device is able to have conversation with children	3	3	5	45
133	The device is able to be used in kindergarten or nursery	4	5	2	40
134	The device is able to open and close window and curtain	4	2	5	40
135	The device's shape is round	4	1	5	20
136	The device is able to give milk and bath, and change diaper	2	4	4	32
137	The device price is affordable	3	5	5	75
138	The device relaxes the baby	2	5	4	40
139	The device is able to provide human touch and warmth while changing the diaper	1	2	3	6
140	The device will remind parents if they did not look after the children (ex. Looking at the phone)	4	2	5	40
141	The device is able to sweep and vacuum the floor.	2	1	5	10

Table A-7 Rating value of importance, latent-ness, and technological feasibility, and DLN value (V^{DLN}) for evaluator G

No	Interpreted Needs	Importance	Latent-ness	Technological Feasibility	V^{DLN}
1	The device is able to sanitize small item in UV box	3	2	5	30
2	The device will send/update the information of people entering/exiting the house to parents	4	1	5	20
3	The device is able to give right/ precise information to authorities (police, hospital etc.)	5	1	4	20
4	The device is able to contact parents in case of emergency	5	1	5	25
5	The device is able to detect small changes of a child while measuring temperature	3	1	5	15
6	The device is able to change the voice tone.	2	2	5	20
7	The device's power last long	4	1	5	20
8	The device is able to sing lullaby to put child to sleep	2	4	5	40

9	The device is able to play lullaby song from mother's voice	2	4	5	40
10	The device is able to monitor children and notify parent in case of emergency	5	1	4	20
11	The device is able to cut electricity in case of danger	4	1	5	20
12	The device is able to stop water in case of danger	4	1	5	20
13	The device is able to conduct CPR	4	1	5	20
14	The device can be set to use when needed only	3	2	5	30
15	The device can be turn on and off by the user	1	1	5	5
16	The device is able to detect eye contact and head's tilting and turning angle	2	3	5	30
17	The device is able to interact with children with voice and facial expression	4	3	5	60
18	The device is able to play with children with voice and facial expression	4	1	5	20
19	The device will only clean the part of the house set by user	2	3	5	30
20	The device's function to interact with children can be turned off	1	3	5	15
21	The device' function to alert and scold children can be set off	1	3	5	15
22	The device is able to recognize items (food or not) that a child wants to put in mouth	5	1	5	25
23	The device is able to monitor baby sleeping	3	2	5	30
24	The device is able to interact with children with display	5	1	4	20
25	The device's functioning time is able to be set by user	2	1	5	10
26	The device's function can be set to take care other things than a baby	3	4	4	48
27	The device is able to correct the position of blanket	2	3	5	30
28	The device will notify authorities (police etc.) if the person in/around the house is suspicious	4	1	4	16
29	The device is able to clean up and arrange toys according to type	3	1	5	15
30	The device is able to teach with voice and facial expression	2	1	5	10

31	The device is able to suggest new/suitable game for parents and children	3	2	3	18
32	The device's functions are able to be set up only for house chores	4	1	5	20
33	The device's functions are able to be set up not to connect with children	2	3	5	30
34	The device is able to give human-like touch	4	3	4	48
35	The device is able to give a human-like warm hug	4	3	4	48
36	The device is able to give facial expression	4	3	5	60
37	The device's hand is able to hold child's hand until he/she falls asleep	3	3	5	45
38	The device is able to pat child while slowing the pace until he/she falls asleep	3	3	5	45
39	The device is able to correct a child sleeping posture	3	3	5	45
40	The device is able to sanitize a lot of toys at the same time	1	1	5	5
41	The device is able to measure temperature (room and body)	4	1	5	20
42	The device is able to contact authorities (police/hospital) in case of emergency or accident	4	1	4	16
43	The device is able to detect small changes in child compare to other day	3	1	4	12
44	The device is able to sanitize and keep mask	1	1	5	5
45	The device's temperature is same as human	2	2	4	16
46	The device's texture is soft like silicon	2	1	5	10
47	The device is able to be used indoor/outdoor	4	1	5	20
48	The device is able to calm the child	3	2	4	24
49	The device is able to wake the child up	2	1	5	10
50	The device is able to react fast in case of emergency	3	1	4	12
51	The device is able to react fast in case of danger	3	1	4	12
52	The device is able to clean up broken glass, spilled water etc.	3	1	5	15
53	The device is able to prevent child from choking	4	1	4	16
54	The device will remind the schedule for next class	2	1	5	10

55	The device will remind to finish homework before next class	3	2	5	30
56	The device will remind to prepare for next class	3	2	5	30
57	The device is able to alert parents when the baby wake up	2	2	4	16
58	The device is able to operate with small power	4	1	5	20
59	The device has a power saving mode	4	1	5	20
60	The device is able to sanitize the house using alcohol sanitizer or UV light	4	1	5	20
61	The device is able to scan and recognize user/stranger	3	1	5	15
62	The device can clean the house while moving around the house	2	2	5	20
63	The device will alert user with alarm in case of danger	4	1	4	16
64	The usage time of the display by the children can be set	2	1	5	10
65	The device is able to sanitize bag & books before and after school	2	1	5	10
66	The device is able to scan and detect most touch part of the house and sanitize	4	1	5	20
67	The device will do other house chores while parents take care of children	4	1	4	16
68	The device will take care of other house chores while parents with the baby	4	1	4	16
69	The device's texture feels like human skin	3	3	4	36
70	The device able to put blanket on a sleeping child	2	2	5	20
71	The device is able to give milk to children only when needed	3	1	4	12
72	The device is able to judge the level of sickness and notify parents or authorities (hospital etc.)	3	1	4	12
73	The device is able to put child to sleep	3	1	5	15
74	The device is able to manage the schedule for children	3	1	5	15
75	The device's size is able to be customized according to child age or user preference	4	1	5	20
76	The device is able to take care other child while parents taking care the other	4	3	4	48

77	The device's part can be use and operate separately	2	3	5	30
78	The device is able to give children a treat once they finished homework/ quizzes	2	2	5	20
79	The device is able to give children refreshment after finished class/lesson	2	2	5	20
80	The device is able to teach and play with children	5	1	5	25
81	The device is able to alert children for their schedule	3	1	5	15
82	The device will monitor children movement in the house	4	1	5	20
83	The device is equipped with camera with make-up filter	1	1	5	5
84	The device's is able to remind parents and children to communicate to each other	2	2	5	20
85	The device puts out soap for hand washing	1	1	5	5
86	The device is able to measure body temperature	3	1	5	15
87	The device is able to measure heart beat	4	1	5	20
88	The device measure heart beat by connecting to heartbeat sensor placed near the body	4	1	5	20
89	The device is able to sanitize a lot of books at the same time	1	1	5	5
90	The device is able to decide who to notify first (parents or authorities)	2	4	4	32
91	The device is able to monitor people/ stranger inside/ outside/ around the house	3	3	5	45
92	The device's display is interactive	2	1	5	10
93	The device is able to scan and recognize people outside /around the house	3	2	5	30
94	The device will tell parents when to change the diaper	4	4	4	64
95	The device is able to connect parents and child using the display	4	1	5	20
96	The device is able to teach from display	4	1	5	20
97	The device will remind user to wash hand with soap	3	3	5	45
98	The device is made from strong material	3	1	5	15

99	The device is able to follow order from user (to call someone or to bring something etc.)	5	1	4	20
100	The device will suggest activities for parents and children to do together	2	3	3	18
101	The device's function can be selected by user	4	1	5	20
102	The device is able to scold or warn children	3	1	4	12
103	The device is able to teach user	2	1	5	10
104	The device is able to play, dance, sing and karaoke with user	4	1	5	20
105	The device is able to move slow or fast according to the task/activity	4	1	5	20
106	The device is able to be used in any situation (post-covid19)	4	2	4	32
107	The device is able to set to freely move and set to still	3	2	5	30
108	The device is suitable to support working mother or housewife	2	1	4	8
109	The device is able to make children focus during online class	2	4	4	32
110	The device will remind to dress properly before class	3	4	5	60
111	The device is able to give simple guide to get dress before class	3	3	5	45
112	The device is able to play games with children	3	2	5	30
113	The device is able to sanitize house	3	1	5	15
114	The device is able to make children to study and monitor them	2	2	5	20
115	The device will alert children if they lost focus during classes/lessons	3	4	5	60
116	The device will alert children to look at the screen or open the book or listen to the teacher	3	4	5	60
117	The device is able to advice/suggest how to spend free time	1	3	3	9
118	The device is able to ventilate room	2	3	5	30
119	The device will stop child from touching dangerous thing (broken glass, open wire, fire etc.)	4	1	5	20
120	The device will remind to measure temperature	3	1	5	15
121	The device is able to purify the air	4	1	5	20
122	The device is able to wipe, clean and sanitize table and floor	4	1	5	20
123	The device's weight is suitable to be carried by user around the house	3	3	5	45

124	The device is able to detect small changes of a child while changing diaper	3	4	5	60
125	The device's function is only to support parents or nursery/kindergarten teacher	2	3	4	24
126	The device is able to do the task for maid or nurse	4	1	4	16
127	The device is able to greet user or stranger at the front door	2	2	5	20
128	The cleaning part of the device is able to be detached.	3	1	5	15
129	The device is able to hold a baby like a mother.	2	3	4	24
130	The device function is able to be customized according to customer preference or budget	5	1	5	25
131	The device is able to scan and detect user's focus in class	2	3	5	30
132	The device is able to have conversation with children	3	1	5	15
133	The device is able to be used in kindergarten or nursery	2	1	5	10
134	The device is able to open and close window and curtain	3	2	5	30
135	The device's shape is round	1	3	5	15
136	The device is able to give milk and bath, and change diaper	5	1	4	20
137	The device price is affordable	5	1	5	25
138	The device relaxes the baby	3	2	4	24
139	The device is able to provide human touch and warmth while changing the diaper	1	3	5	15
140	The device will remind parents if they did not look after the children (ex. Looking at the phone)	5	4	5	100
141	The device is able to sweep and vacuum the floor.	2	1	5	10

Table A-8 Rating value of importance, latent-ness, and technological feasibility, and DLN value (V^{DLN}) for evaluator H

No	Interpreted Needs	Importance	Latent-ness	Technological Feasibility	V^{DLN}
1	The device is able to sanitize small item in UV box	3	2	5	30
2	The device will send/update the information of people entering/exiting the house to parents	4	2	5	40

3	The device is able to give right/ precise information to authorities (police, hospital etc.)	4	2	4	32
4	The device is able to contact parents in case of emergency	4	1	5	20
5	The device is able to detect small changes of a child while measuring temperature	3	2	3	18
6	The device is able to change the voice tone.	2	3	5	30
7	The device's power last long	3	2	4	24
8	The device is able to sing lullaby to put child to sleep	3	3	5	45
9	The device is able to play lullaby song from mother's voice	3	3	5	45
10	The device is able to monitor children and notify parent in case of emergency	5	1	5	25
11	The device is able to cut electricity in case of danger	4	1	3	12
12	The device is able to stop water in case of danger	4	1	3	12
13	The device is able to conduct CPR	4	1	3	12
14	The device can be set to use when needed only	3	2	5	30
15	The device can be turn on and off by the user	3	3	5	45
16	The device is able to detect eye contact and head's tilting and turning angle	3	2	4	24
17	The device is able to interact with children with voice and facial expression	3	1	5	15
18	The device is able to play with children with voice and facial expression	3	1	3	9
19	The device will only clean the part of the house set by user	3	3	4	36
20	The device's function to interact with children can be turned off	3	3	4	36
21	The device' function to alert and scold children can be set off	3	2	5	30
22	The device is able to recognize items (food or not) that a child wants to put in mouth	4	3	3	36
23	The device is able to monitor baby sleeping	5	1	5	25
24	The device is able to interact with children with display	3	1	5	15
25	The device's functioning time is able to be set by user	3	3	5	45

26	The device's function can be set to take care other things than a baby	3	2	3	18
27	The device is able to correct the position of blanket	2	3	3	18
28	The device will notify authorities (police etc.) if the person in/around the house is suspicious	5	1	5	25
29	The device is able to clean up and arrange toys according to type	3	2	3	18
30	The device is able to teach with voice and facial expression	3	1	5	15
31	The device is able to suggest new/suitable game for parents and children	3	3	4	36
32	The device's functions are able to be set up only for house chores	3	3	4	36
33	The device's functions are able to be set up not to connect with children	3	2	4	24
34	The device is able to give human-like touch	3	2	4	24
35	The device is able to give a human-like warm hug	3	2	3	18
36	The device is able to give facial expression	4	1	5	20
37	The device's hand is able to hold child's hand until he/she falls asleep	3	3	4	36
38	The device is able to pat child while slowing the pace until he/she falls asleep	3	3	4	36
39	The device is able to correct a child sleeping posture	3	3	3	27
40	The device is able to sanitize a lot of toys at the same time	3	3	4	36
41	The device is able to measure temperature (room and body)	4	1	5	20
42	The device is able to contact authorities (police/hospital) in case of emergency or accident	5	1	5	25
43	The device is able to detect small changes in child compare to other day	3	3	3	27
44	The device is able to sanitize and keep mask	3	2	5	30
45	The device's temperature is same as human	3	2	5	30
46	The device's texture is soft like silicon	4	2	5	40
47	The device is able to be used indoor/outdoor	5	1	5	25
48	The device is able to calm the child	3	2	4	24
49	The device is able to wake the child up	3	2	5	30

50	The device is able to react fast in case of emergency	5	1	4	20
51	The device is able to react fast in case of danger	5	1	4	20
52	The device is able to clean up broken glass, spilled water etc.	3	1	5	15
53	The device is able to prevent child from choking	4	2	1	8
54	The device will remind the schedule for next class	3	3	5	45
55	The device will remind to finish homework before next class	3	3	5	45
56	The device will remind to prepare for next class	3	3	5	45
57	The device is able to alert parents when the baby wake up	3	2	5	30
58	The device is able to operate with small power	3	2	4	24
59	The device has a power saving mode	3	3	4	36
60	The device is able to sanitize the house using alcohol sanitizer or UV light	3	2	4	24
61	The device is able to scan and recognize user/stranger	5	3	5	75
62	The device can clean the house while moving around the house	3	3	5	45
63	The device will alert user with alarm in case of danger	5	3	5	75
64	The usage time of the display by the children can be set	3	3	5	45
65	The device is able to sanitize bag & books before and after school	3	3	4	36
66	The device is able to scan and detect most touch part of the house and sanitize	3	3	4	36
67	The device will do other house chores while parents take care of children	3	3	3	27
68	The device will take care of other house chores while parents with the baby	3	2	3	18
69	The device's texture feels like human skin	3	3	5	45
70	The device able to put blanket on a sleeping child	3	4	3	36
71	The device is able to give milk to children only when needed	3	4	3	36
72	The device is able to judge the level of sickness and notify parents or authorities (hospital etc.)	5	1	3	15

73	The device is able to put child to sleep	3	2	2	12
74	The device is able to manage the schedule for children	3	3	5	45
75	The device's size is able to be customized according to child age or user preference	3	2	3	18
76	The device is able to take care other child while parents taking care the other	3	2	3	18
77	The device's part can be use and operate separately	3	3	5	45
78	The device is able to give children a treat once they finished homework/ quizzes	3	3	5	45
79	The device is able to give children refreshment after finished class/lesson	3	3	5	45
80	The device is able to teach and play with children	3	3	3	27
81	The device is able to alert children for their schedule	3	3	5	45
82	The device will monitor children movement in the house	5	1	5	25
83	The device is equipped with camera with make-up filter	3	2	5	30
84	The device's is able to remind parents and children to communicate to each other	4	2	4	32
85	The device puts out soap for hand washing	3	3	5	45
86	The device is able to measure body temperature	4	1	5	20
87	The device is able to measure heart beat	4	2	5	40
88	The device measure heart beat by connecting to heartbeat sensor placed near the body	4	2	5	40
89	The device is able to sanitize a lot of books at the same time	3	2	5	30
90	The device is able to decide who to notify first (parents or authorities)	4	3	4	48
91	The device is able to monitor people/ stranger inside/ outside/ around the house	5	1	5	25
92	The device's display is interactive	3	3	4	36
93	The device is able to scan and recognize people outside /around the house	4	1	5	20
94	The device will tell parents when to change the diaper	4	2	4	32

95	The device is able to connect parents and child using the display	4	3	5	60
96	The device is able to teach from display	3	2	5	30
97	The device will remind user to wash hand with soap	3	2	5	30
98	The device is made from strong material	3	2	5	30
99	The device is able to follow order from user (to call someone or to bring something etc.)	5	3	5	75
100	The device will suggest activities for parents and children to do together	3	3	4	36
101	The device's function can be selected by user	3	3	4	36
102	The device is able to scold or warn children	3	2	5	30
103	The device is able to teach user	3	4	4	48
104	The device is able to play, dance, sing and karaoke with user	3	3	4	36
105	The device is able to move slow or fast according to the task/activity	3	3	4	36
106	The device is able to be used in any situation (post-covid19)	4	2	4	32
107	The device is able to set to freely move and set to still	3	3	4	36
108	The device is suitable to support working mother or housewife	3	3	4	36
109	The device is able to make children focus during online class	3	3	4	36
110	The device will remind to dress properly before class	3	3	5	45
111	The device is able to give simple guide to get dress before class	3	3	5	45
112	The device is able to play games with children	3	3	4	36
113	The device is able to sanitize house	3	2	4	24
114	The device is able to make children to study and monitor them	4	3	5	60
115	The device will alert children if they lost focus during classes/lessons	3	3	5	45
116	The device will alert children to look at the screen or open the book or listen to the teacher	3	3	5	45
117	The device is able to advice/suggest how to spend free time	3	3	5	45
118	The device is able to ventilate room	3	2	5	30

119	The device will stop child from touching dangerous thing (broken glass, open wire, fire etc.)	4	1	5	20
120	The device will remind to measure temperature	3	1	5	15
121	The device is able to purify the air	3	1	5	15
122	The device is able to wipe, clean and sanitize table and floor	3	1	4	12
123	The device's weight is suitable to be carried by user around the house	3	1	5	15
124	The device is able to detect small changes of a child while changing diaper	3	1	4	12
125	The device's function is only to support parents or nursery/kindergarten teacher	3	2	4	24
126	The device is able to do the task for maid or nurse	3	3	3	27
127	The device is able to greet user or stranger at the front door	2	3	5	30
128	The cleaning part of the device is able to be detached.	2	3	5	30
129	The device is able to hold a baby like a mother.	3	3	4	36
130	The device function is able to be customized according to customer preference or budget	3	3	4	36
131	The device is able to scan and detect user's focus in class	3	3	4	36
132	The device is able to have conversation with children	4	1	5	20
133	The device is able to be used in kindergarten or nursery	4	3	5	60
134	The device is able to open and close window and curtain	3	3	4	36
135	The device's shape is round	3	3	5	45
136	The device is able to give milk and bath, and change diaper	3	2	3	18
137	The device price is affordable	4	1	4	16
138	The device relaxes the baby	3	3	5	45
139	The device is able to provide human touch and warmth while changing the diaper	3	3	3	27
140	The device will remind parents if they did not look after the children (ex. Looking at the phone)	4	1	4	16
141	The device is able to sweep and vacuum the floor.	3	1	4	12

Table A-9 Rating value of importance, latent-ness, and technological feasibility, and DLN value (V^{DLN}) for evaluator I

No	Interpreted Needs	Importance	Latent-ness	Technological Feasibility	V^{DLN}
1	The device is able to sanitize small item in UV box	3	1	3	9
2	The device will send/update the information of people entering/exiting the house to parents	4	1	4	16
3	The device is able to give right/ precise information to authorities (police, hospital etc.)	4	1	4	16
4	The device is able to contact parents in case of emergency	5	1	4	20
5	The device is able to detect small changes of a child while measuring temperature	4	4	2	32
6	The device is able to change the voice tone.	3	3	5	45
7	The device's power last long	4	1	4	16
8	The device is able to sing lullaby to put child to sleep	2	2	1	4
9	The device is able to play lullaby song from mother's voice	3	2	5	30
10	The device is able to monitor children and notify parent in case of emergency	5	1	3	15
11	The device is able to cut electricity in case of danger	4	2	5	40
12	The device is able to stop water in case of danger	4	3	5	60
13	The device is able to conduct CPR	3	4	3	36
14	The device can be set to use when needed only	3	3	5	45
15	The device can be turn on and off by the user	3	2	5	30
16	The device is able to detect eye contact and head's tilting and turning angle	2	3	5	30
17	The device is able to interact with children with voice and facial expression	3	2	5	30
18	The device is able to play with children with voice and facial expression	4	2	4	32
19	The device will only clean the part of the house set by user	4	3	5	60
20	The device's function to interact with children can be turned off	1	3	5	15

21	The device' function to alert and scold children can be set off	1	3	5	15
22	The device is able to recognize items (food or not) that a child wants to put in mouth	5	1	4	20
23	The device is able to monitor baby sleeping	5	1	4	20
24	The device is able to interact with children with display	5	1	5	25
25	The device's functioning time is able to be set by user	2	3	5	30
26	The device's function can be set to take care other things than a baby	4	2	2	16
27	The device is able to correct the position of blanket	3	2	4	24
28	The device will notify authorities (police etc.) if the person in/around the house is suspicious	4	1	5	20
29	The device is able to clean up and arrange toys according to type	3	4	2	24
30	The device is able to teach with voice and facial expression	4	2	4	32
31	The device is able to suggest new/suitable game for parents and children	2	3	5	30
32	The device's functions are able to be set up only for house chores	2	4	3	24
33	The device's functions are able to be set up not to connect with children	3	4	5	60
34	The device is able to give human-like touch	2	2	4	16
35	The device is able to give a human-like warm hug	3	2	4	24
36	The device is able to give facial expression	4	2	3	24
37	The device's hand is able to hold child's hand until he/she falls asleep	2	3	4	24
38	The device is able to pat child while slowing the pace until he/she falls asleep	3	4	4	48
39	The device is able to correct a child sleeping posture	4	2	3	24
40	The device is able to sanitize a lot of toys at the same time	4	2	4	32
41	The device is able to measure temperature (room and body)	4	2	5	40
42	The device is able to contact authorities (police/hospital) in case of emergency or accident	4	1	5	20

43	The device is able to detect small changes in child compare to other day	4	3	3	36
44	The device is able to sanitize and keep mask	3	4	4	48
45	The device's temperature is same as human	2	2	4	16
46	The device's texture is soft like silicon	4	2	4	32
47	The device is able to be used indoor/outdoor	4	3	5	60
48	The device is able to calm the child	3	3	4	36
49	The device is able to wake the child up	3	4	5	60
50	The device is able to react fast in case of emergency	5	1	4	20
51	The device is able to react fast in case of danger	5	1	4	20
52	The device is able to clean up broken glass, spilled water etc.	5	1	4	20
53	The device is able to prevent child from choking	5	1	4	20
54	The device will remind the schedule for next class	3	2	5	30
55	The device will remind to finish homework before next class	2	2	4	16
56	The device will remind to prepare for next class	2	2	4	16
57	The device is able to alert parents when the baby wake up	4	4	4	64
58	The device is able to operate with small power	3	4	5	60
59	The device has a power saving mode	2	4	5	40
60	The device is able to sanitize the house using alcohol sanitizer or UV light	3	2	5	30
61	The device is able to scan and recognize user/stranger	4	1	5	20
62	The device can clean the house while moving around the house	3	3	3	27
63	The device will alert user with alarm in case of danger	4	2	4	32
64	The usage time of the display by the children can be set	4	3	5	60
65	The device is able to sanitize bag & books before and after school	3	1	5	15
66	The device is able to scan and detect most touch part of the house and sanitize	4	1	4	16
67	The device will do other house chores while parents take care of children	4	2	2	16

68	The device will take care of other house chores while parents with the baby	4	2	2	16
69	The device's texture feels like human skin	3	2	4	24
70	The device able to put blanket on a sleeping child	3	3	4	36
71	The device is able to give milk to children only when needed	4	5	3	60
72	The device is able to judge the level of sickness and notify parents or authorities (hospital etc.)	4	1	4	16
73	The device is able to put child to sleep	4	2	4	32
74	The device is able to manage the schedule for children	2	3	5	30
75	The device's size is able to be customized according to child age or user preference	4	2	5	40
76	The device is able to take care other child while parents taking care the other	4	2	2	16
77	The device's part can be use and operate separately	2	4	5	40
78	The device is able to give children a treat once they finished homework/ quizzes	3	3	4	36
79	The device is able to give children refreshment after finished class/lesson	3	3	5	45
80	The device is able to teach and play with children	4	2	4	32
81	The device is able to alert children for their schedule	3	3	5	45
82	The device will monitor children movement in the house	5	1	5	25
83	The device is equipped with camera with make-up filter	4	1	5	20
84	The device's is able to remind parents and children to communicate to each other	2	3	4	24
85	The device puts out soap for hand washing	1	4	4	16
86	The device is able to measure body temperature	4	3	5	60
87	The device is able to measure heart beat	4	3	5	60
88	The device measure heart beat by connecting to heartbeat sensor placed near the body	4	3	4	48

89	The device is able to sanitize a lot of books at the same time	3	2	5	30
90	The device is able to decide who to notify first (parents or authorities)	3	2	5	30
91	The device is able to monitor people/ stranger inside/ outside/ around the house	4	1	5	20
92	The device's display is interactive	3	2	5	30
93	The device is able to scan and recognize people outside /around the house	4	1	5	20
94	The device will tell parents when to change the diaper	4	3	4	48
95	The device is able to connect parents and child using the display	5	3	5	75
96	The device is able to teach from display	4	3	5	60
97	The device will remind user to wash hand with soap	3	2	5	30
98	The device is made from strong material	4	3	5	60
99	The device is able to follow order from user (to call someone or to bring something etc.)	5	3	5	75
100	The device will suggest activities for parents and children to do together	2	3	4	24
101	The device's function can be selected by user	4	3	5	60
102	The device is able to scold or warn children	5	2	4	40
103	The device is able to teach user	4	2	5	40
104	The device is able to play, dance, sing and karaoke with user	3	2	4	24
105	The device is able to move slow or fast according to the task/activity	4	2	5	40
106	The device is able to be used in any situation (post-covid19)	4	2	4	32
107	The device is able to set to freely move and set to still	3	5	5	75
108	The device is suitable to support working mother or housewife	4	1	3	12
109	The device is able to make children focus during online class	2	4	3	24
110	The device will remind to dress properly before class	1	4	5	20
111	The device is able to give simple guide to get dress before class	2	4	5	40
112	The device is able to play games with children	3	2	5	30

113	The device is able to sanitize house	4	1	5	20
114	The device is able to make children to study and monitor them	4	1	4	16
115	The device will alert children if they lost focus during classes/lessons	3	2	3	18
116	The device will alert children to look at the screen or open the book or listen to the teacher	3	2	5	30
117	The device is able to advice/suggest how to spend free time	2	4	4	32
118	The device is able to ventilate room	4	2	4	32
119	The device will stop child from touching dangerous thing (broken glass, open wire, fire etc.)	5	1	4	20
120	The device will remind to measure temperature	4	3	5	60
121	The device is able to purify the air	2	3	5	30
122	The device is able to wipe, clean and sanitize table and floor	4	1	4	16
123	The device's weight is suitable to be carried by user around the house	4	2	5	40
124	The device is able to detect small changes of a child while changing diaper	4	2	2	16
125	The device's function is only to support parents or nursery/kindergarten teacher	4	2	2	16
126	The device is able to do the task for maid or nurse	4	2	2	16
127	The device is able to greet user or stranger at the front door	4	1	3	12
128	The cleaning part of the device is able to be detached.	3	5	5	75
129	The device is able to hold a baby like a mother.	4	2	4	32
130	The device function is able to be customized according to customer preference or budget	5	1	5	25
131	The device is able to scan and detect user's focus in class	3	3	4	36
132	The device is able to have conversation with children	5	1	3	15
133	The device is able to be used in kindergarten or nursery	4	1	2	8
134	The device is able to open and close window and curtain	4	1	4	16
135	The device's shape is round	4	3	5	60
136	The device is able to give milk and bath, and change diaper	4	2	2	16

137	The device price is affordable	4	1	5	20
138	The device relaxes the baby	4	2	3	24
139	The device is able to provide human touch and warmth while changing the diaper	4	2	3	24
140	The device will remind parents if they did not look after the children (ex. Looking at the phone)	4	1	4	16
141	The device is able to sweep and vacuum the floor.	3	2	5	30

Table A-10 Rating value of importance, latent-ness, and technological feasibility, and DLN value (V^{DLN}) for evaluator J

No	Interpreted Needs	Importance	Latent-ness	Technological Feasibility	V^{DLN}
1	The device is able to sanitize small item in UV box	3	1	5	15
2	The device will send/update the information of people entering/exiting the house to parents	3	2	5	30
3	The device is able to give right/ precise information to authorities (police, hospital etc.)	3	1	5	15
4	The device is able to contact parents in case of emergency	5	1	5	25
5	The device is able to detect small changes of a child while measuring temperature	4	4	4	64
6	The device is able to change the voice tone.	2	5	3	30
7	The device's power last long	4	1	5	20
8	The device is able to sing lullaby to put child to sleep	3	3	5	45
9	The device is able to play lullaby song from mother's voice	3	4	5	60
10	The device is able to monitor children and notify parent in case of emergency	5	1	5	25
11	The device is able to cut electricity in case of danger	5	1	5	25
12	The device is able to stop water in case of danger	5	1	5	25
13	The device is able to conduct CPR	4	1	4	16
14	The device can be set to use when needed only	4	1	5	20
15	The device can be turn on and off by the user	5	1	5	25

16	The device is able to detect eye contact and head's tilting and turning angle	3	2	5	30
17	The device is able to interact with children with voice and facial expression	4	2	5	40
18	The device is able to play with children with voice and facial expression	4	2	5	40
19	The device will only clean the part of the house set by user	4	2	5	40
20	The device's function to interact with children can be turned off	3	4	5	60
21	The device' function to alert and scold children can be set off	4	4	5	80
22	The device is able to recognize items (food or not) that a child wants to put in mouth	5	1	4	20
23	The device is able to monitor baby sleeping	5	1	5	25
24	The device is able to interact with children with display	4	2	4	32
25	The device's functioning time is able to be set by user	5	1	5	25
26	The device's function can be set to take care other things than a baby	4	2	5	40
27	The device is able to correct the position of blanket	3	3	4	36
28	The device will notify authorities (police etc.) if the person in/around the house is suspicious	4	1	5	20
29	The device is able to clean up and arrange toys according to type	3	2	5	30
30	The device is able to teach with voice and facial expression	3	2	5	30
31	The device is able to suggest new/suitable game for parents and children	3	3	5	45
32	The device's functions are able to be set up only for house chores	4	1	5	20
33	The device's functions are able to be set up not to connect with children	2	4	5	40
34	The device is able to give human-like touch	3	2	5	30
35	The device is able to give a human-like warm hug	3	2	4	24
36	The device is able to give facial expression	4	2	5	40
37	The device's hand is able to hold child's hand until he/she falls asleep	4	3	5	60

38	The device is able to pat child while slowing the pace until he/she falls asleep	3	4	5	60
39	The device is able to correct a child sleeping posture	3	4	4	48
40	The device is able to sanitize a lot of toys at the same time	4	1	5	20
41	The device is able to measure temperature (room and body)	4	1	5	20
42	The device is able to contact authorities (police/hospital) in case of emergency or accident	5	1	5	24
43	The device is able to detect small changes in child compare to other day	4	2	5	40
44	The device is able to sanitize and keep mask	4	1	5	20
45	The device's temperature is same as human	3	4	5	60
46	The device's texture is soft like silicon	3	4	5	60
47	The device is able to be used indoor/outdoor	4	1	5	20
48	The device is able to calm the child	3	2	4	24
49	The device is able to wake the child up	3	2	5	30
50	The device is able to react fast in case of emergency	5	1	5	25
51	The device is able to react fast in case of danger	5	1	5	25
52	The device is able to clean up broken glass, spilled water etc.	4	1	5	20
53	The device is able to prevent child from choking	5	1	5	25
54	The device will remind the schedule for next class	3	2	5	30
55	The device will remind to finish homework before next class	3	1	5	15
56	The device will remind to prepare for next class	3	2	5	30
57	The device is able to alert parents when the baby wake up	4	2	5	40
58	The device is able to operate with small power	4	1	5	20
59	The device has a power saving mode	4	1	5	20
60	The device is able to sanitize the house using alcohol sanitizer or UV light	4	1	5	20
61	The device is able to scan and recognize user/stranger	5	1	5	25
62	The device can clean the house while moving around the house	4	1	5	20

63	The device will alert user with alarm in case of danger	5	1	5	25
64	The usage time of the display by the children can be set	4	2	5	40
65	The device is able to sanitize bag & books before and after school	4	1	5	20
66	The device is able to scan and detect most touch part of the house and sanitize	4	1	5	20
67	The device will do other house chores while parents take care of children	4	1	3	12
68	The device will take care of other house chores while parents with the baby	4	1	3	12
69	The device's texture feels like human skin	3	4	5	60
70	The device able to put blanket on a sleeping child	2	3	4	24
71	The device is able to give milk to children only when needed	3	2	4	24
72	The device is able to judge the level of sickness and notify parents or authorities (hospital etc.)	5	1	4	20
73	The device is able to put child to sleep	2	1	4	8
74	The device is able to manage the schedule for children	3	3	5	45
75	The device's size is able to be customized according to child age or user preference	3	1	5	15
76	The device is able to take care other child while parents taking care the other	4	1	3	12
77	The device's part can be use and operate separately	2	5	5	50
78	The device is able to give children a treat once they finished homework/ quizzes	3	4	5	60
79	The device is able to give children refreshment after finished class/lesson	3	3	5	45
80	The device is able to teach and play with children	3	1	4	12
81	The device is able to alert children for their schedule	3	2	5	30
82	The device will monitor children movement in the house	4	1	5	20
83	The device is equipped with camera with make-up filter	5	2	5	50

84	The device's is able to remind parents and children to communicate to each other	4	2	5	40
85	The device puts out soap for hand washing	3	4	5	60
86	The device is able to measure body temperature	4	1	5	20
87	The device is able to measure heart beat	4	1	5	20
88	The device measure heart beat by connecting to heartbeat sensor placed near the body	4	1	5	20
89	The device is able to sanitize a lot of books at the same time	2	2	5	20
90	The device is able to decide who to notify first (parents or authorities)	5	1	5	25
91	The device is able to monitor people/ stranger inside/ outside/ around the house	5	1	5	25
92	The device's display is interactive	4	1	5	20
93	The device is able to scan and recognize people outside /around the house	5	1	5	25
94	The device will tell parents when to change the diaper	4	2	5	40
95	The device is able to connect parents and child using the display	4	2	5	40
96	The device is able to teach from display	4	2	5	40
97	The device will remind user to wash hand with soap	3	1	5	15
98	The device is made from strong material	5	1	5	25
99	The device is able to follow order from user (to call someone or to bring something etc.)	3	1	5	15
100	The device will suggest activities for parents and children to do together	4	1	5	20
101	The device's function can be selected by user	3	2	5	30
102	The device is able to scold or warn children	3	2	4	24
103	The device is able to teach user	3	2	5	30
104	The device is able to play, dance, sing and karaoke with user	2	2	4	16
105	The device is able to move slow or fast according to the task/activity	3	3	5	45
106	The device is able to be used in any situation (post-covid19)	5	1	4	20

107	The device is able to set to freely move and set to still	4	2	5	40
108	The device is suitable to support working mother or housewife	5	1	4	20
109	The device is able to make children focus during online class	3	2	4	24
110	The device will remind to dress properly before class	2	2	5	20
111	The device is able to give simple guide to get dress before class	2	2	4	16
112	The device is able to play games with children	3	4	5	60
113	The device is able to sanitize house	3	1	5	15
114	The device is able to make children to study and monitor them	3	4	4	48
115	The device will alert children if they lost focus during classes/lessons	2	3	4	24
116	The device will alert children to look at the screen or open the book or listen to the teacher	3	2	5	30
117	The device is able to advice/suggest how to spend free time	2	5	4	40
118	The device is able to ventilate room	3	1	5	15
119	The device will stop child from touching dangerous thing (broken glass, open wire, fire etc.)	5	1	5	25
120	The device will remind to measure temperature	1	2	5	10
121	The device is able to purify the air	3	1	5	15
122	The device is able to wipe, clean and sanitize table and floor	3	1	5	15
123	The device's weight is suitable to be carried by user around the house	4	1	5	20
124	The device is able to detect small changes of a child while changing diaper	3	2	4	24
125	The device's function is only to support parents or nursery/kindergarten teacher	4	3	3	36
126	The device is able to do the task for maid or nurse	4	3	3	36
127	The device is able to greet user or stranger at the front door	4	4	3	48
128	The cleaning part of the device is able to be detached.	3	2	5	30
129	The device is able to hold a baby like a mother.	3	1	4	12

130	The device function is able to be customized according to customer preference or budget	5	1	5	25
131	The device is able to scan and detect user's focus in class	3	1	4	12
132	The device is able to have conversation with children	4	2	4	32
133	The device is able to be used in kindergarten or nursery	4	3	3	36
134	The device is able to open and close window and curtain	4	2	5	40
135	The device's shape is round	2	4	5	40
136	The device is able to give milk and bath, and change diaper	3	2	3	18
137	The device price is affordable	5	1	5	25
138	The device relaxes the baby	4	3	4	48
139	The device is able to provide human touch and warmth while changing the diaper	4	1	3	12
140	The device will remind parents if they did not look after the children (ex. Looking at the phone)	4	2	5	40
141	The device is able to sweep and vacuum the floor.	3	1	5	15