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Assessment of Human-Robot Interaction between Householders and Robotic Vacuum Cleaners

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***Abstract*— The study presented in this paper investigates the application of the Hybrid Model, which is the combination of the two strategies of the Built-to-Order Model and the Dynamic Eco-strategy Explorer Model, to robotic vacuum cleaners. The Hybrid Model aims to switch the market power from seller-driven perception to buyer-driven one by creating an individual perspective from the eye of users rather than traditional customer segmentation. The human-centered approach established theoretically has been tested with a determined procedure that includes prototyping, testing, and evaluating the proposed customization system for robotic vacuum cleaners to increase the interaction degree with purchasers. In this case, robotic vacuum cleaners have been chosen to implement and assess the hypothesis. Firstly, the successful prototyping of the Hybrid Model requires well customer analysis and habits determination to build well-constructed and coherent interaction between the purchaser and the robot. We utilized a content analysis of robotic vacuum cleaners and elaborative, conventional interviews with early adopters and early majority of this technology in Turkey to establish credible scenarios and product options during the phases of the Hybrid Model practice. The results of the interview were discussed, and the evaluations have been reported.**

Keywords*— robot customization, the hybrid model, human-robot interaction, experience design, purchasing practice, cleaning, robotic vacuum cleaners, household practices, social robots

I. Introduction

Technological features of social service robots are developed continuously to make life easier. Robots started to appear more and more in daily life, both in the industrial sense and in-home and office environments. The digital revolution of smart home technologies, especially technologies like robotic vacuum cleaners, is already commonplace as social actors in many parts of the world. Although the robots are in contact with their users more and more, the scientific literature and industry research both are on the technical side of robots than their social interactions with their users. There is a gap in the customization of the robots by considering the users' needs and meeting their demands. In this phase, we proposed the idea of combining two strategies applied, Build-to-Order (BTO) [1] and the Dynamic Eco-strategy Explorer Model (DEEM) [2], into the Hybrid Model [3]. The initial aim of the Hybrid Model is to achieve maximum user satisfaction by increasing the interaction level and allowing the user to customize their domestic home robots. Robotic vacuum cleaners, called robovac, are selected to apply and assess this idea due to their mainstream use. This approach enables the user to build modular and customizable robots and to create sample robovac models, as we call **RoboCuD**, which fulfills the consumer needs and increases the interaction between the user and the robot in terms of efficiency and effectiveness. This research is grounded on determining interaction channels that affect human-robot interaction, such as robot-environment interaction and robot-robot interaction. The interaction of robots with the environment affects their communication with humans. Therefore, the features of robots should be shaped according to the environment they operate in, in addition to user needs and satisfaction. Near future of service robots market would be determined by a well oriented technology strategy. The management of technology might provide a sound roadmap for proper advancement of the robovacs.

II. Literature Review

A. Robotic Vacuum Cleaners

Creating fully autonomous cleaning robots for indoor floor cleaning has become more popular, whereas the idea of having a robot cleaning assistant at home is not a new phenomenon [4]. This situation can be attributed to the task of cleaning, which is one of the most required tasks to maintain a healthy environment in a physical and psychosocial way for modern people. It can be explained as being a mandatory and unavoidable household chore repeated in a continuous loop and requiring some level of labor despite the help of cleaning tools.

According to the study of Prassler et al. [5], the primer prototypes of the vacuum cleaner robots looked like to have huge market potential is presented around 1991. The first-ever robotic vacuum cleaner "Trilobite" emerged in 1996 with basic programming features and limited vacuuming mechanism by Swedish household and professional appliances manufacturer Electrolux [5][6]. Recent robovac models include internet connectivity with mobile applications that allow the robot to run automatically, referring to pre-set schedule [7]. Moreover, advanced robotic technologies enable automation and remote control by providing cloud computing and communication between things [8]. As a matter of fact, iRobot Roomba is considered the most studied robot vacuum cleaner [4], and it is the most highly adopted computational robot in the world [9]. Today, iRobot launched Roomba S9 and i7+, which have AI technology to detect objects and learn the environment with continuous improvement.

B. Classification of Vacuum Cleaner Robots

Despite the advanced technological discoveries, enhancements, and implementations, the market has robotic vacuum cleaners from different technological advancement levels, as acceptance and entry to homes from various economic classes and customer perceptions. These levels are originated as the defined adoption and marketing strategy by the producing parties. Market segmentation is the process of companies dividing the market into groups, taking into account specific characteristics in order to achieve the highest profitability or growth rate of the market. To create an individual, granular perspective from the eye of users, companies utilize the customer segmentation strategy. Customer segmentation classifies the customer base that the product or service aims to capture as combinations of demographic, geographic, behavioral, and psychographic pillars. With the intent to identify the needs, wishes, and behaviors of users, customer segmentation tries to divide and cluster them as distinct entities [10]. The best potential profit to be created is determined by analyzing each segment's revenue and cost impacts. After considering the segments created, the target customer group that will go parallel with the company's vision and make a profit is selected. For each product, there are several user bases, which can be diversified according to users' core preferences and characteristics. Brand vision, or to be more specific, the aim of the product to be launched, designates the focus group. However, it also does not fulfill the entire understanding of the customer groups. From the user's perspective, it limits the customization preferences of the individual. From this perspective, our study aims to offer a value-based option to the user rather than a price-based approach and predict that companies will profit while applying this.

C. Interaction Types and Classification

Robotic vacuum cleaners are technological devices with a very high rate of interaction within their operation, i.e., collecting data about their work and giving feedback to their owners about that data. They must interact with the environment, humans, animals, and, if any, other robotic devices [11][12]. A cross-section of the general life cycle or a task list of an idealized robotic vacuum cleaner with advanced technological capabilities can be utilized to describe the interaction of robot vacuum cleaners.

The robot collects information about its workspace. The work environment must be learned and recorded through processes such as mapping and recognition (robot-environment and object interaction). Additionally, if a smart home system with which the vacuum cleaner may interact, necessary steps should be taken for collaboration (robot-robot and robot-system interactions). The mentioned interactions are classified by following Linjawi and Moore's study [13]. The interaction is divided into three subsections. According to their research, the interaction of the robot with the perception of the environment and objects in the environment can be positioned under ***physical interaction***, the interactions of robots with other intelligent systems and robots under cognitive and ***perceptual interaction***, and finally, all kinds of communication with humans under the section of ***social interaction.*** This classification also agrees with the study of Forlizzi et al. [11].

D. Explanation of the Hybrid Model

The main problem of the design and production industry, especially in terms of User Experience Design in short UX Design, is that designers and developers try to predict users' behavior without providing any User Research. Despite traditional methods fulfilling customers' demand using their investigations and they choose a limited set of product configurations, the Hybrid Model pursue to initiate an interactive process design that includes purchase, usage, and enhancement phases. In order to achieve this ideal, we integrated two models, the DEEM and the BTO, into the Hybrid Model. A more detailed explanation for the Hybrid Model, the conference paper elaborating the phases of the model can be found in Fig.1. [3]. The research indicated in this paper is part of the advancement of the Hybrid Model.

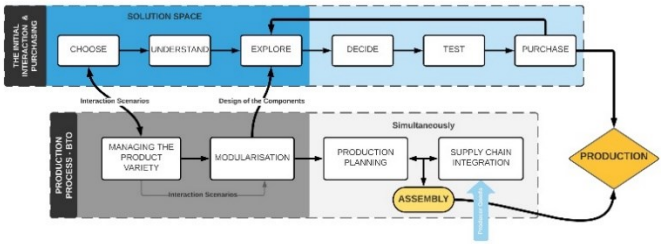

Fig. 1. The phases of the Hybrid Model [3]

So, to avoid this chaos, a simple multipartite graph will be used to explain the simple implementation of this model and for the RoboCuD Home we are developing. In the first stage, we create a set that we call '***Prerequisites'*** that define the ecosystem in which the robot will be used by the customer before recommending it to the user. In a way, ***'Cases'*** denotes persons. They are user groups created regarding the information received from the user in the solution space phase. ***'Robots'*** are the robovacs that will be recommended according to the needs of these user groups Fig.2. Therefore, the Multipartite System customizes your preferences on the recommended robovac. Establishing accurate information gathering and evaluation needs and preferences of the purchaser is one of the most critical points of the Hybrid Model. By using Multipartite Evaluation, the proposed model aims to fulfill customers' expectations of comfort, cleanliness, and convenience, [14] and the five dimensions of social products [12] which are highlighted by Shove, in a most sustainable way.

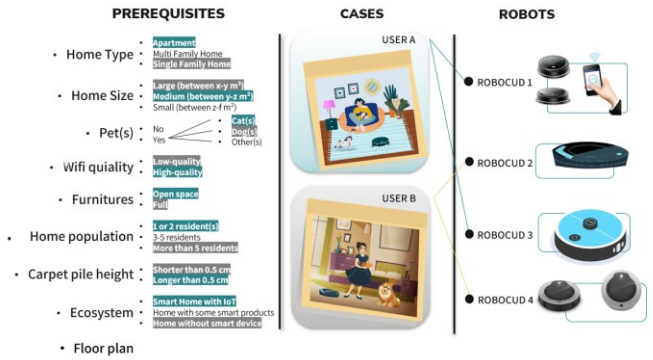

Fig. 2. Multipartite Evaluation System Study to recommend the most suitable robot

III. METHODOLOGY

To prevent the aforementioned problem of the user experience design, which is that UX designers are prone to estimate the behavior of the user, we run user research that tries to determine behavioral trends arising from human-robot interaction. Besides, this user research is also necessary to accurately define ***Cases*** coming from ***Prerequisites*** that will be used for Hybrid Model.

In order to determine the behavioral orientations of the robot vacuum cleaner users, we conducted an elaborate, conversational, semi-structured, online interview evaluating the purchasing, product installation, and usage processes of early adopters and early majority in Turkey, which is our current sample with a brief demographic survey. The interviews were held with 15 different householders and lasted around 15 minutes to 45 minutes, according to the answers of the users. Each interview started with information on data gathering and analysis. The conversations were voice recorded with the permission of the interviewees, and they were transcripted and anonymized for analysis.

TABLE I. PROFILES OF INTERVIEWEES

Demographics of Interviewees					
No	***Age***	***Gender***	***Occupation***	***Kid(s)***	***Pet(s)***
1.	27	F	Architect	-	1 Cat
2.	26	F	Economist	-	1 Cat
3.	31	F	Industrial Engineer	1 Baby	-
4.	43	F	Academician, Computer Engineer	1 Kid	-
5.	27	F	Academician, Dietician	-	-
6.	27	F	Medical Doctor	-	1 Dog
7.	27	F	Advertiser	-	1 Cat, 1 Dog
8.	35	M	Mechanical Engineer	1 Baby	
9.	26	F	Scientist	-	-
10.	30	M	Mechanical Engineer	-	-
11.	27	F	Industrial Designer	-	-
12.	32	F	Academician, Industrial Designer	-	1 Cat
13.	27	F	Industrial Designer	-	-
14.	29	F	Industrial Designer	1 Baby	1 Bird
15.	38	M	Academician, Industrial Designer	1 Baby	-

Users' attitudes towards specific keywords were observed and noted according to the dynamics of the conversation. Their personal testimonies were examined in order to learn their interaction level with the vacuum cleaner robot and evaluate the convenience between the robot and the environment. The awareness of the user tried to be measured based on the answers to specific questions. Participants were founded via social media, online forums, and events. Five of the participants were design industry professionals working on design and technology. Their answers were evaluated by comparing the heterogeneous group that consisted of ten people coming from various professions and educational backgrounds.

All participants have automated vacuum cleaners that can be classified as mid-range. Six of the participants were couples without children, five were couples with children, two were living with their parents or siblings, and two were sole adults. Seven of the participants have pets, mainly cats, but two have dogs, one has a hamster, and one has a bird. All interviewees were aged between 26 and 38 years lived in four big cities of Turkey, Istanbul, Ankara, Izmir, and Bursa. Some demographic information of the users is demonstrated in Table I.

The data from the interviews were analyzed and summarized in a report. In this paper, the focus will be on identifying the expectations of the users, how they evaluate the product before purchasing the product, their usage habits, what problems they have experienced and how they deal with them, and their attitudes and prejudices towards the idea of improving, customizing and updating their own robots. In the end, interviewees discussed potential steps to address the shared challenges and opportunities. Selected quotes were translated from Turkish to English for reporting purposes. Quotes that are used to exemplify our findings are attributed to participant code names, i.e., *"Quote"* (*P#No*).

IV. FINDINGS & RESULTS

Our results are divided into four major sections: (A) Integration into the daily life of the autonomous cleaning robot is a new notion, even for a conscious customer. Therefore, it is an unclear and surprising purchasing process, (B) Satisfying the expectation vs. increasing demand, (C) An inherent tendency toward anthropomorphizing, (D) 'Customization' can be considered as a self-product enhancement process.

A. Integration into the daily life of the autonomous cleaning robot is a new notion, even for a conscious customer. Therefore, it is an unclear and surprising purchasing process

Robotic vacuum cleaners were often bought with low expectations before being selected by early adopters. Although they were excited when purchasing the product, they did not set their expectations too high because they preferred to stay in the middle segment in terms of price. Even if they would like to benefit from robovacs, they did not initially want to risk their money.

As an early adopter, *(P2)* consciously researched the product based on her experience from manual vacuuming experience in general by making a price evaluation. She can be considered a user who knows what she wants from the robot vacuum cleaner. Although her mother's dust and fur allergy, the family adopted a kitten. Therefore, she had a feature set in her mind for the robot vacuum cleaner she wanted to buy, such as being able to clean the house autonomously and remotely or cleaning the entire house in one go. And naturally, she bought the robot within the framework of these features. Nevertheless, still, she indicates, *"It was actually a bit like make a bet by pulling a wishbone because there were not many people buying and using it when we got it."*

Moreover, even the householders, who could consciously evaluate the purchasing process, could not determine successfully what features to consider for their living environment to meet the cleaning standards they grew accustomed to while buying the robot. We can relate this to the fact that the use of the service robot is a new process for all householders. Their usage process resulted in them realizing what attributes for this new robotic device they needed by gaining experience in using the product. In a way, it is like the educational process. As they use the product, they discover what the product should have in its working environment and acquire to have in order to meet their cleaning expectations. As a result, two distinguished behavior patterns emerge.

1) First, since they cannot influence (personalize) the product in their hands, they adjust the environment and their own behavior accordingly [12]: We can also call this a positive attitude. They are somehow satisfied with the product and try to keep it in their lives. *(P14)* remarked about this situation as follows: *"I think it definitely motivates us to tidy up. Especially in the mornings because we should not leave anything on the floor. If we do not collect toys or accessories, it (robovac) gets stuck immediately, toys or parts of toys get into it, something weird happens."* and *"Indeed, the motivation provided by the robot has become a habit for us. We have even discussed it with my husband before. Now we cannot stand seeing the house messy anymore. Even if she (her baby daughter) will be at home in the morning and mess up her toys around again, we tidy the house in the evening and go to bed. I think robovac provides a routine."*

As a product designer, *(P13)* knows what to look for in the product she needs. However, still, *"I had problems in the beginning due to inexperience."* she says. The house where she lives with her older brother is prone to gather dust due to its proximity to the main street. Since both she and his older brother generally have many workloads, even though regular cleaning is essential, it makes them very tired. *"I also have a hernia. It is really a pain to vacuum,"* she states directly. *(P13)* also said, *"The product has three suction levels, quiet, medium, and turbo. When the home gets too dusty, I always run it in turbo mode, and it makes so much noise. The sound bores my brother a lot. That is why we usually prefer to run robovac just before leaving the house or control it remotely when there is no one at home."* She has solved this situation by arranging the house according to the mode it will operate -only vacuuming or vacuuming + moping- before leaving home to go to work. There is no problem in terms of compatibility between robot and furniture: *"All our furniture is high from the ground. That was the main reason why we chose to use a robotic vacuum cleaner a little bit. If the furniture were not suitable, we probably would not have chosen it."*

Another different usage routine belongs to (*P12)*. She stated that she lives with her cat in a small, multi-furnished apartment. Especially cat litter and dark furniture colors make continuous vacuuming necessary for her home. However, since there are too many items at home, she does not operate the robovac much when she is not at home. As a result of this, she has created a cleaning routine with robovac which they divide the work simultaneously and in an organized manner. Otherwise, the robovac would topple the furniture or get stuck somewhere in her home. Householders (*P2*) and (*P5*) keep their homes tidy even before buying the robot and do not even have a problem with these kinds of issues after purchasing the product. They are aware of the physical limits of the product and take simple precautions accordingly when setting the work plan and area. They state that there is a severe decrease in the use of manual or upright vacuum cleaners due to robovac. In particular*, (P4), (P7), (P9), (P10), (P12)*, and (*P13)* stated that the product substituted the conventional vacuum cleaner in daily life at a high rate.

2) Second, some householders gradually reduce the use of robovac, seeing that the product does not work in harmony with the environment and does not meet their expectations: This is also observed in adherence to conventional cleaning standards and routine. Even the most unproblematic robovac users suffer from unsuccessful interaction with the environment at some points. Therefore, it is possible to evaluate an example of this situation in *(P3)*'s experience with robovac.

(P3) stated that she is conscientious and meticulous about cleaning. She has high cleaning standards. Additionally, she is aware that she must tidy the house routinely before operating the robot. Instead of doing this, she prefers to do her old-fashioned cleaning routine. *"The robot is not very smart."* At the same time, the robovac cannot enter into details. Either it can suck a sock or stumble a cable. Moreover, these situations instigate her to think that it does not meet her high cleaning standards. Yes, she admitted that robovac had helped somehow, but she also sees it as a burden. *"As a result, the robotic vacuum cleaner did not work fully. I used to command over the phone when we were not at home. However, it always got stuck in a sock or tangled with cables, and consequently, it did not work efficiently. That is what happened most of the time,"* she says. Therefore, she has stopped using the robot vacuum at the moment.

Another example of the second pattern is *(P11)*. The cleaning robot cannot fully perceive the environment. Therefore, it topples the items that (*P11*) values at home - such as her guitar – or she has to carry the robovac constantly in their duplex house back top to bottom or vice versa, and this situation triggered her negatively. Concurrently, since it cannot return to the base station when its battery is out of charge down upstairs, it creates overtime such as searching and finding the product. However, she has not stopped using the product. Nevertheless, she said she did not want to use it much, especially after the robot dropped her guitar.

B. Satisfying the expectation vs. increasing demand

The regular, effective use of the robot vacuum cleaner and compatibility with the home environment may give the user a feeling of comfort. Moreover, it may increase the tendency to be clean and tidy in daily life. This situation can be expressed as a *"gives me sanity,"* as one of the early adopters in a study discussing the energy consumption of robotic vacuum cleaners in Australia [7]. However, from another point of view, users also unconsciously increase their expectations for the robovac over time. Despite their routine in using the smart robot vacuum cleaner, the pre-cleaning process can cause her to *"whine"-(P13)*. She accentuated this as, *"Yes, it is torture to remove the*

little gadgets around. One has to pay attention to cables, socks, scarves, earphones falling on the floor. However, it is not much, as I said, it might be a little spoiled, I guess. Because it is not that difficult." Furthermore, about the sound of the robovac, she also admits, *"When you think about its sound, it makes less noise compared to vacuum cleaners with dust bags, but still a lot. I do not know, but it is probably our caprice."*

(P14) also acknowledged that she and her husband think, *"It is getting dumber as we get accustomed to the robot, psychologically or not."* This situation can be inferred that those problems start when a robot vacuum cleaner cannot do what users do in the process of using a manual vacuum cleaner, and they need a preliminary preparation process. Even if householders indicate their satisfaction with robovac, the comfort they have become accustomed to is enough for them to complain about even the slightest problem. Further, they forget that they have nothing left to do but tie up the mess. Evidently, they are raising their demands from the robovac unconsciously.

Furthermore, they can start to utilize it not only for cleaning. For instance, (*P7*) admits that she uses the notification system stemmed from the integration between her smartwatch and robovac to wake up mornings. Although she criticizes specific features, again, she utilizes its autonomy as an assistant by bringing it in front of her bedroom door in the mornings with its noise for the same purpose. From some point, users want to benefit from the robovac, such as regular home assistants.

C. An inherent tendency toward anthropomorphizing

Householders are prone to behave and communicate towards these intelligent and autonomous artifacts socially compared to other electronic household items. The attribution of some human characteristics to robovacs can be noticed directly [11][12]. Users ascribe human characterizations, gender, and personality to their robovac. In this case, when the robovac has a problem, or when it gets stuck somewhere, the situation of addressing it as if it is living thing arises. Householders display some signs of affection, intimacy, anger other kinds of humanistic sentiments for robovac in various ways.

In particular, *(P7)*, she named his Robovac the Nimbus 2000 (such as her dog's name Dobby), although it represents a flying broom from his favorite Harry Potter series, used for non-cleaning purposes. Moreover, she adds that they treat the robovac as a person. Mainly, she expressed that her husband sometimes fights with 'his' as if the robot was a child.

When (*P5)* compared the robot vacuum with other home electronics, and she said, *"I think it is different because we are used to other electronic devices working, so we are not surprised when they do their jobs. We do not say, 'How good is the air-cooling system of the refrigerator!' However, when the robotic vacuum cleaner vacuums the floor, for example, my mother or someone who does not have a robot vacuum in their house indicates how well its vacuum is. It is definitely unlike other home electronics. More sincere and intimate. For example, when she crashes into something, we say, 'Do not hit your head there, girl!' or something like that."*

Another user (*P6)* cannot spare much time for cleaning because she must work in the hospital for long periods. However, she mentioned that despite living in a house with a dog, the robovac provides a noticeable benefit in cleaning. Even she cannot use all of the qualities as an "*analogue person"* in her own words. She conceded, *"As if it is another living. It makes me feel like some other living creature stays with me."*

(P13) stated that even though it is sometimes annoying to prepare for the robot beforehand, she and her brother call to robovac as Alfonso in between, and adding, *"It is not the same as my relationship with other domestic appliances or electronic devices. I enjoy it more when dealing with it, humorously"* She recounts her own story, even though she needs to deal with specific environmental-product interaction issues: *"...I usually become annoyed. I said it a few times: 'This robot is not that smart after all.'When we had internet problems, he (robovac) could not find the charging stand because of the unavailable mapping feature. He wandered around too much that he finally ran out of charge under the bed. I said many times: 'Where is this idiot?!' and 'This idiot has got into a place, as he is not around.' We looked for him all over the place. Then he finally came out from under the bed."*

And even *(P11)* is inclining toward reducing her robovac use due to some incidents, she maintained, *"Her name is Tatyana. It is definitely more enjoyable than other home appliances. Because there is a moving object acting like a cute little design solving your job. It lightens the house chores that you really need to put effort into. So, of course, I would rather have a chat with a smart and autonomous robovac than a smart fridge."*

From all this discussion, it can be ascertained that the anthropomorphizing stemmed from the active social interaction. Specifically, users are inclined to perceive the relationship between themselves and some kind of living thing. In a way, they meet; they begin to see; if they catch a good frequency, they keep in touch; they notice their positive and negative sides and act accordingly. If the drawbacks of the robovac predominate the advantages at some point, there are two possible ways in the current marketing system; the user could consider practicing a brand-new model or give up to use of the robovac. Besides, the anthropomorphizing and the unconsciously increasing expectation during the practice of the product may indicate that the user's ability to customize the product throughout the product life cycle will increase and maximize the effective use of the social robots, in our case, robovacs.

D. 'Customization' can be considered as a self-product enhancement process

As a result of the interviews, it turns out that householders are aware that issues can be solved by changing the features of either the product they use or their home environment after experiencing the usage of robovacs and noticing some characteristics of the product such as the relationship with the environment, or the digitally communicating abilities. While most problems can be solved with mini-interferences or changes, they need to buy a new product and do not need such a change for now. Users stated that they would prefer to improve the product rather than buy a new product, If the robot vacuum has the possibility to become the best they can use by referring to their needs and the problems they experience later, and If the price is compared to an affordable amount in terms of performance. At this point, we asked the user what they would do if they were given a chance to add or remove the features that

they wanted to change to learn their ideas about customization of product structure. (P12) stated, *"I am a person who already applies the product enhancement and update approach in my own life*," and continued, *"Therefore, when there is such an opportunity, I prefer to upgrade the product. Of course, if the decision is left to me, considering the financial possibilities, even if not all at once, I would go for the improvement process step-by-step. Replacing the entire product with a new one is not an easy decision, but changing parts is much easier, so if there were such an approach, I would take advantage of it."*

(P2) explained her approach to this idea as follows: *"I would look at it in terms of price-performance. When compared, I would examine whether it would be more reasonable to buy a new product based on price-performance. If I could buy an advanced product at a more affordable price, I would probably not prefer to improve the robot. However, if the price is more affordable than buying a new one, I can go for such an improvement."* When we asked the question to *(P7)*, who recently experienced a 'poopocalypse' [15] that happens to most robot vacuum cleaner users, who live with pets, she indicated, *"I would definitely use this poop detector. However, I do not really care about the other features, to be honest. Maybe camera integration can be considered. If there were a chance to get the camera integration, I would utilize it to check the house after starting to work on-site."* Moreover, even she stated that before, *"I wanted a high-tech model. However, then I noticed that the robot was capable of doing everything I wanted. It was not worth paying three times the same amount for the overdeveloped one."*

V. Conclusion

Social service robots continue to impact our lives effectively. This interview concludes that the integration of an intelligent service robot into daily life is a fairly new concept for many people. Even those who think they know what they want when buying products can admit that their basic needs differ from their expectations after experiencing the usage of the robovac. At the same time, users who continue to use their products are aware that the problems they encounter can be solved with more minor effects rather than buying a new product. Most of the participants also stated that they would welcome the idea when a fully compatible integration system is offered to their products at an affordable price. However, the features of the developed mechanical and technological systems need to be effectively transferred to the users. For example, the iRobot Roomba J7+ has the ability to collect more dirt than most of the robots on the market, with the right brush combination, without burdening the suction power. There is an obvious correlation between brush type and power of the suction motor that affects the efficiency of the robovac (www.irobot.com). From this perspective, the Hybrid Model should accurately transfer the knowledge about technology. This factor can be considered a significant challenge. Moreover, for the Hybrid Model to be successful, it is necessary to precisely convey to the user what the parts do, rather than the technical features of how the component works.

Consequently, as expected, since the robovac will be designed as an intermediary channel in the product interaction process in the use of the hybrid model during the purchasing process, the variety of robot usage scenarios and the product to be recommended according to the expectations are essential. For this, various scenarios, personas, and product concept products will be created using the information gathered from the interviews. After the indicative ones in terms of use are decided among the designed outputs, they will be used in the prototyping and testing process of the Hybrid Model. Designing an adaptive service robot in short term may not be feasible since preferences of users are diverse and expectation of users are high. The analysis of this paper gives insight for a customization framework and supportive technology strategy.

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