Adapting Products for Elderly: Generic Design Taxonomies

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Abstract. As the ageing demographic has grown over time, it has brought with it both obstacles and opportunities for development and fulfilment. Due to their reduced physical capability, the elderly are unable to comfortably perform their everyday activities with the exiting products used in the activities of daily living. However, they are familiar with how these existing products work and how to use them. As a result, these well-known existing products should be modified and redesigned to suit the needs of the elderly. The objectives of this paper are to study the problems faced by the elderly while using the existing products in daily activities and modify/redesign them according to the needs of the elderly. To achieve these objectives, this paper proposes two generic design taxonomies that are developed based on the literature review and research. These taxonomies are developed to help designers to determine design priorities based on the needs of the elderly and facilitate the process of redesigning existing products for the elderly. The usage of the proposed taxonomies will reduce the product development time. In this paper, the taxonomies are used to create survey questionnaires for the elderly to identify trouble using existing products in-order to adapt them. The survey is conducted to study the problems faced by the elderly while using existing kitchen containers.

Keywords: Elderly · Taxonomy · Product design · Adapting products to elderly

1 Introduction

When people age, their operational capability declines, causing a variety of problems and limiting their potential to adapt to the constantly evolving world [1, 2]. According to the World Health Organization (WHO), the global population aged 60 and above is estimated to reach 2 billion by 2050, increasing the composition to about 22% from 12% in 2015 [3]. With a growing ageing population, there is a need to develop products and services for the elderly that will provide improved health and a higher quality of life for their entire lifetime [4].

While younger users have well-defined capabilities and can adjust to whatever product they use, the elderly are often ignored and considered only in the design of

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assistive and specialized devices such as mobility or disability aids [5, 6]. Despite attempts to study the elderly's Activities of Daily Living (ADL) and improve some of the existing products used in our daily lives, their needs are not well understood and addressed. A different product development approach aiming specifically at understanding the needs and problems of the elderly in relation to any product being developed for them can assist designers in creating better products for the elderly. Existing products are well-known and have been used to assist us in our daily activities for decades. The elderly have become familiar with the these products work. Too much of change can intimidate them. However, slight modifications to these existing products according to their needs will result in better products for the elderly and will also help them adapt to these new designs easily.

With this in mind, two generic design taxonomies are developed. The **E**lderly User-**A**ctivity-**F**eatures-**C**oncerns (**EAFC**) taxonomy seeks to capture the voice of the elderly, analyze their condition and environment related to the activities, review their experience with existing products, and identify the challenges they encounter while using products to conduct everyday activities. The **B**ody **M**ovements-**I**mprovements-**F**eatures (**BIF**) taxonomy will suggest possible improvements and modifications to existing designs based on the body movements involved.

Although the developed taxonomies can be used in a variety of ways during the design process, how they are used as a guide to frame questions for surveys and evaluate existing products with the elderly as primary users is demonstrated. The EAFC taxonomy is used to create a questionnaire to (a) identify current products that the elderly have trouble using, and (b) capture the concerns that the elderly have with the products found in the previous survey. The findings of the second study will be reviewed and BIF Taxonomy will be used to develop some ideas for redesigning products for the elderly.

2 Methods for Developing Products for the Elderly: Literature Review

While the challenge of designing for the elderly necessitates well-considered steps, the approaches themselves have a much broader spectrum of use. The aim of the literature review is to explore the taxonomies and design processes of products for the elderly. A product design taxonomy can be used as a reference for the study of features, functions, and interaction with the product by the elderly. A taxonomy can also be used to classify and organize subject specific concepts. Section 2.1 reviews the products, design approaches followed, and taxonomies used to redesign products for the elderly. The taxonomies used in the domain of elderly population, their drawbacks and what is needed are discussed in Sect. 2.2.

2.1 Products Redesigned for the Elderly

The success of certain Activities of Daily Living (ADL) by elderly people, such as mobility, hobbies, shopping, and social interactions, has been linked to problems with environmental assistance [7]. The elderly needed further functional training for the products they use or require assistance [7].

Raviselvam et al. [8, 9] studied body functions such as grasping, manipulating, and reaching using the International Classification of Functioning, Disability, and Health (ICF) codes. Water bottle cap, soda can, mattress, and sewing needle were modified and designed in response to the desires and recommendations of elderly participants.

Wu et al. [2] studied nail clipping postures and classified them as two-point pinch, lateral pinch, and grasping hold. Toenail clipping postures were classified as leg crossed posture, sole supinated posture, and sole pronated posture [2]. The authors redesigned the nail clipper with a power grasp handle, a knife angle of 114° to ensure a neutral wrist angle, and a pedal plate to reduce lumbar angle.

Dekker et al. [10] built a test frame with adjustable vertical, front, and side supports, as well as a height-adjustable toilet bowl, to investigate the types of supports used by the Dutch elderly. The type of support structure chosen when sitting, standing, and performing the task, the heights preferred to hold the support, and how force is applied are all studied and analyzed during the test. The elderly's activity efficiency can be enhanced by providing support mechanism that enable body muscles to facilitate each other during the movement.

Demirbilek et al. [11] developed the Usability, Safety, Attractiveness Participatory (USAP) design model, which classifies the relationship among elderly's requirements, design constraints, and technical requirements. The USAP design model was used to create door handles for the elderly.

In a study conducted by Koppa et al. [12] on preferred refrigerator configuration, elderly participants preferred different numbers of shelves, types of shelves, and locations for items. As a result, they drew the conclusion that product flexibility must be a key design objective [12]. Guan [13] presented leisure chair design guidelines for the elderly based on product attention factors, drawbacks, material characteristics, and styles of existing leisure chairs.

2.2 Discussion on the Taxonomies Used

Activities of Daily Living (ADL), ICF codes, and taxonomies relying on surveys and questionnaires about specific products are some of the taxonomies used by the designers. The development strategies of most of the design projects discussed in Sect. 2.1 were based on product-specific taxonomies established by observations, experiments, and interviews with the elderly. The ADL and ICF taxonomies assist designers in studying and analyzing the activities conducted by the elderly, as well as the body movements and functions associated with those activities, but they do not provide any information on user interaction and user experience. The product and the activity are not studied with respect to the user. Hence, they are more applicable and widely used in the field of medical domain and healthcare.

As a result, a design taxonomy that can be applicable to products for elderly is needed. Furthermore, while redesigning products for the elderly, it is important to evaluate current products in terms of their requirements. Since no taxonomy has been able to do this, this paper would propose two generalized design taxonomies and explain their use in the design process. The elderly can carry out their everyday tasks more effectively with improved products.

3 Design Methodology

Involving target audience in the design process has become a crucial component while defining design requirements for elderly. It is important to consider an economical and efficient approach for precisely identifying the needs of the elderly users and adapting them to product characteristics. Given that the elderly are familiar with existing products, evaluating them in light of their requirements would provide greater and quicker outcomes in terms of product modification. An approach that employs the Elderly User-Activity-Features-Concerns (EAFC) and the Body Movements-Improvements-Features (BIF) taxonomies is illustrated for this reason. The procedure is depicted in Fig. 1. The process flow and taxonomies are explained in the subsequent sections.

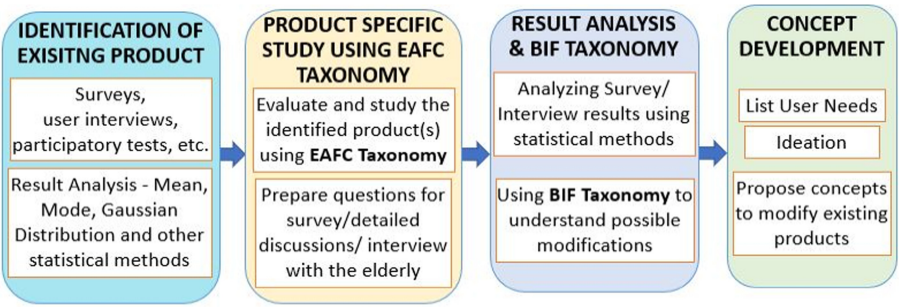

Fig. 1. Modifying existing products for the elderly

3.1 Identification of Existing Product for Redesign

The first step is to recognize objects that lead to discomfort for the elderly and, as a result, need to be redesigned to address their pain points and needs. This can be accomplished in a variety of ways. Previous literature on the activities of daily living of the elderly offers information on a variety of issues that the elderly experience, as do participatory surveys performed for research. Such data can be used, or new experiments and surveys can be conducted about everyday activities and corresponding products used. In either case, the aim is to find objects being used by the elderly that need to be improved.

Following the collection of responses of the elderly on existing products, analysis of these responses/results must be done. For the study, various statistical techniques such as measuring the mean, mode of the data obtained, gaussian distribution curve, and so on can be used.

3.2 EAFC Taxonomy

Once the product has been identified, it should be analyzed using the taxonomy, and questions specific to the product's use, interaction, and issues encountered by the elderly in using it should be framed for more surveys, one-on-one interviews, and focus

group discussions with the elderly. The key aim is to determine the elderly's needs in relation to the identified product for that is being modified. The EAFC taxonomy is shown in Fig. 2 and the components are explained below.

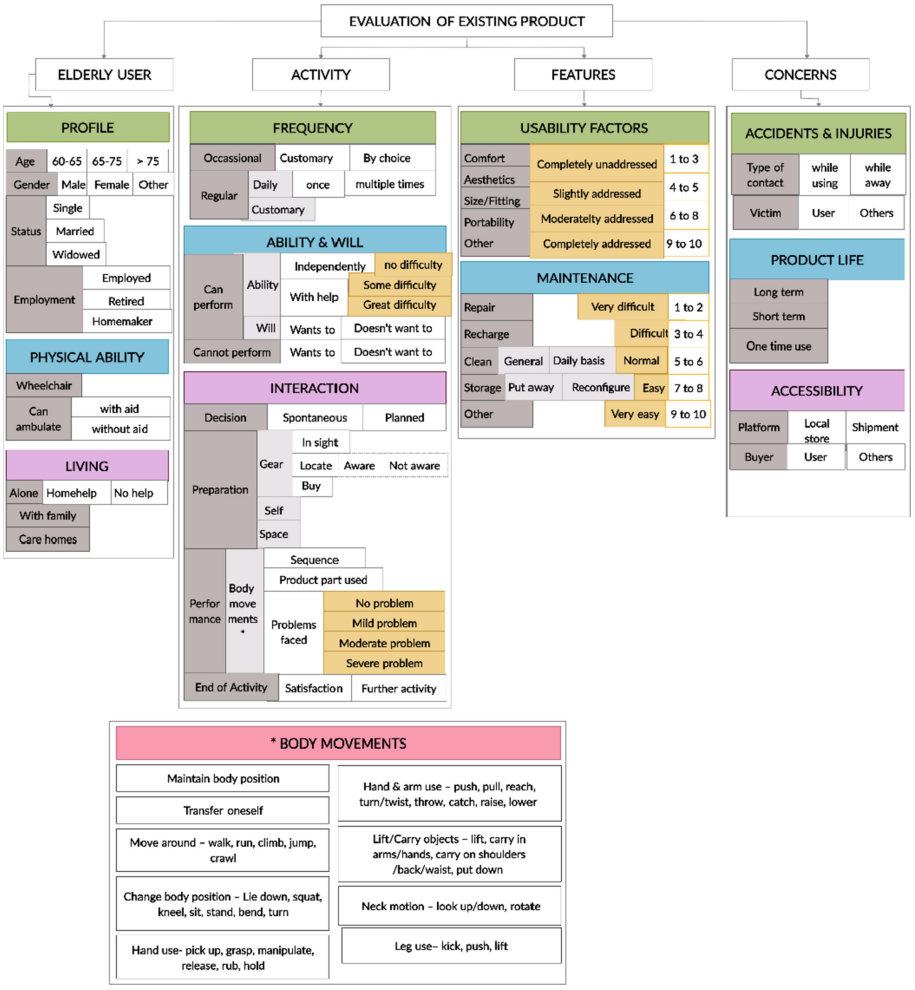

Fig. 2. Elderly User-Activity-Features-Concerns (EAFC) taxonomy

Elderly User. The Elderly User component branches into further key components which are elderly users' profiles, as well as their physical and living environments. The intended users' specifics are critical facets of the design process. Details such as age, gender, and physical condition are normally obtained and assessed for elderly users. Apart from that, the living environments of the elderly can influence their socio-cultural factors, mental well-being, special needs, and, in some situations, the magnitude of

product modification demand. Knowing whether elderly people are working, not working, or retired will help designers better understand their knowledge base and ability to execute the desired tasks.

Activity. It is just as important to analyze the activity as it is to analyze the target users and product. The frequency of the task can provide information about both product specific and user specific details. The user's ability and willingness to conduct the task are also essential factors to consider. The user may be doing repetitive work that he or she does not like to do, or the user may be unable to carry out the task but would like to. The final part is Interaction, which can be used to research how people engage with the product. Any interaction begins with the decision to execute the task/use the product and ends with satisfaction or leads to additional activity. Preparation for using the product and carrying out the task, as well as performance based on body movements, are also included. Parameters to study the subcomponents (e.g., no difficulty, some difficulty, great Difficulty) can be used. Some are presented in the taxonomy.

Features. Usability factors are the characteristics of a product that the user focuses on when doing an activity. These factors may be used to assess the product's major characteristics that must be addressed from the end user's perspective. Both post/pre-usage activities are included in the maintenance component. Analyzing this based on the ease of performance by the elderly can assist designers in providing improved modifications to existing products, thereby leading to greater user satisfaction. As shown, the parameters used to study the subcomponents can be related to numbers to scale more effectively.

Concerns. Accidents and injuries associated with the activity must be studied to develop design targets that limit or exclude their risk [11, 14]. We appear to overlook the consequences when they do not occur often. However, for elderly users, even a minor injury will cause significant pain in the long term. Whether the elderly want long term use products or want products with shorter life can be studied. Are the elderly able to buy the products themselves, and do they have a say in the type of product purchased will provide information about their preferences and practices followed.

3.3 Result Analysis and BIF Taxonomy

Statistical approaches can be used to analyze product-specific survey findings that are quantitative in nature, like they were used in Sect. 3.1. Following the identification of core issues and expectations of the elderly in the form of both quantitative and qualitative data, the designers will focus on developing a final list of user needs that must be met.

Body Movement-Improvements-Features (BIF) taxonomy is recommended to assist designers in making decisions for product modifications based on body movements involved in using a product and difficulties encountered by the elderly in making these movements. Figure 3 shows the BIF Taxonomy. The BIF taxonomy contains all mobility functions, from switching simple body positions to moving around. The designer must define the movements needed for the operation and use of the product

being redesigned. Some design features for the corresponding movements have been proposed based on the literature study.

The elderly can lose control of their movement and fall when shifting body positions, switching, or moving around. Providing support structure, whether as part of the product or where the product may be used or positioned, will help to achieve stabilized body movements [10]. When executing hand tasks and gestures including neck motions, neutral joint postures during product use and task execution transfer more force, offer better surface contact, and aid the elderly [2, 15]. Product measurements that support the neutral posture of the body parts and joints included should be used as corresponding product features. Not all products are aimed at facilitating postures that allow for a stronger grip and full force transmission from the user. For the aged, these postures would cover a significant portion of the body. Hence product features that offer larger surface are for contact should be considered [2, 15]. Finally, if necessary, alternative body parts can be used in certain modifications.

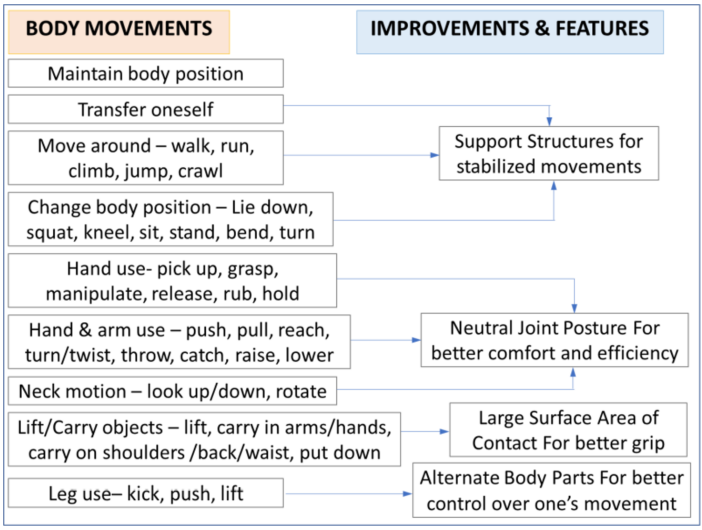

Fig. 3. Body Movements-Improvements-Features (BIF) taxonomy

3.4 Concept Development

The previous steps would provide the designer with the majority of the details needed to complete the final phase. The final step is to explore, brainstorm, and create ideas to change the design of a current product based on the desires and recommendations of the elderly.

4 Case Study: Redesigning Products for the Elderly

The method previously discussed was used to propose recommendations for the modifying and redesigning kitchen containers for the elderly. The primary principle of the design was the determined challenge for the elderly in opening and handling the container during emptying. The steps followed according to the proposed methodology are discussed below.

4.1 Survey to Identify Products that Cause Major Discomfort

Participants over the age of 65 were given a questionnaire with a list of tasks and asked to rate the tasks on a scale of 1 to 10, with 1 being very difficult and 10 being very easy, based on the products used [16]. The questionnaire described basic daily tasks such as opening a sealed water bottle, drinking coffee from teacups and mugs, combing their hair with combs, unscrewing the lids of kitchen containers, and so on with the help of a picture of the products. The questionnaire was circulated online through emails and text messages amongst the younger relatives of the elderly who were asked to discuss the questions with the elderly participants and then provide answers to avoid any form of confusion. The results of the survey are tabulated in Table 1.

Table 1. Preliminary survey results

Products	No. of responses	Maximum value	Minimum value	Mean	Standard deviation
Spoon - to eat meals	24	10	1	7.125	2.490
Teacup - To drink tea/coffee	24	10	1	7.792	2.265
Mug - to drink milk/coffee/tea	24	10	1	6.958	2.596
Sealed bottles - Opening bottle caps	24	10	1	5.792	2.553
Kitchen Tongs - To lift hot utensils and move them off the stove burner	23	10	1	6.304	2.548
Knife - to cut/chop fruits and vegetables	23	10	1	6.783	2.335
Kitchen Containers - Unscrewing the lid to use the items inside for meal preparation	23	10	1	5.913	2.875
Scissors - to cut packets of milk and other items	24	10	1	7	2.396
Utensil/Pan Handles - lift and move them off the stove	23	10	1	6	2.697

(*continued*)

Table 1. (*continued*)

Products	No. of responses	Maximum value	Minimum value	Mean	Standard deviation
Vegetable Peeler - to peel fruits and vegetables	23	10	1	5.913	2.827
Utensil scrubber - to clean utensils and vessels	23	10	1	7	2.796
Comb - To comb hair everyday	24	10	1	8	2.303
Toothbrush - to brush the teeth	24	10	1	8.125	2.692
Toothpaste - squeezing the toothpaste out	24	10	1	7.708	2.710
Liquid hand wash dispenser - Press down to dispense out the liquid	24	10	1	8.083	2.205
Bathroom Tumbler - to draw water from a bucket for washing/bathing	24	10	1	7.542	2.484

According to the survey results sealed bottles, kitchen containers, and vegetable peeler had the lowest scores of 5.792, 5.913 and 5.913 respectively compared to other products. To demonstrate the proposed methodology, kitchen containers will be used in the subsequent phases for redesigning for the elderly.

4.2 EAFC Taxonomy Applied to Kitchen Containers

The EAFC taxonomy was used to evaluate existing kitchen containers, with the elderly as primary users. Questions about existing kitchen containers are framed, and a questionnaire is designed to conduct a survey like the one described in Sect. 4.1. The questionnaire was divided into 3 sections: participant profile, existing kitchen containers, and interaction with the product. Each section's questions are listed below.

Participant Profile

1. What is your age group?
   - 65–70
   - 71–75
   - 76–80
   - Above 80
2. Select your gender.
   - Male
   - Female
   - Other

3. Do you use a wheelchair?
   - Yes
   - No
4. If you do not use a wheelchair, how do you ambulate?
   - Independently
   - Walking Stick or other aid
   - With the help of a person
   - Other
5. How do you live?
   - Alone, without caretaker
   - Alone, with caretaker
   - With Family
   - Old age care home

Existing Kitchen Containers

1. Are you able to use kitchen jars for cooking and other kitchen activities in your everyday life?
   - Yes
   - Yes, but I do not want to
   - No, but I want to
   - No and I do not want to
2. If yes, how frequently do you use them?
   - Multiple times everyday
   - Once everyday
   - 1–2 times every week
3. Select the level of difficulty while using the containers.

1–2	3–4	5–6	7–8	9–10
Very difficult	Difficult	Moderate	Easy	Very easy
Cannot perform the activity independently	Can perform the activity independently with great difficulty	Can perform the activity independently with some difficulty	Can perform the activity independently with negligible difficulty	Can perform the activity fully independently without any difficulty

4. Rate the containers you use based on the following factors.

Factors	Completely unaddressed			Slightly addressed		Moderately addressed			Completely addressed	
Comfort	1	2	3	4	5	6	7	8	9	10
Right size										
Easily portable										
Aesthetics										
Durability										

5. How easy or difficult are the following tasks?

Cleaning	Very difficult	Difficult	Normal	Easy	Very easy
Filling the containers					
Taking items out of the containers					
Storing					

Interaction with the Product

1. Where do you keep these containers in the kitchen?
   - Overhead cabinets
   - Cabinets below kitchen countertop
   - On kitchen countertop
   - Separate storage - cupboard/storeroom/shelf
   - Other
2. The sequence of body movements involved in container usage are: Reach/raise/lower -> grasp -> pick up/lift -> hold/carry -> manipulate -> put down. Select the container part used to perform each of the activity and the corresponding level of difficulty.

	Product part used			Problem level			
Reach/raise/lower hand	Lid	Mid body	Base	No problem	Mild problem	Moderate problem	Severe problem
Grasp the container							
Pick up/lift the container							
Hold/Carry the container							
Manipulate the container to open/close							
Put down							
Place the container back							

3. Do you experience strain in your wrist muscles while/after using the container?
   - Yes

- No
- Sometimes

Do you sometimes drop the containers accidently?

- Yes, very frequently.
- Yes, sometimes.
- No, I don't.

4.3 BIF Taxonomy Applied to Existing Kitchen Containers

The survey on existing kitchen containers is still ongoing. It is distributed to younger relatives of the elderly participants in a manner similar to that used in the previous survey. Survey results are assumed for the purpose of demonstrating the methodology, and the BIF taxonomy is used.

Reach/raise/lower, grasp, pick up/lift, hold/carry, manipulate, put down is the sequence of body movements which involve lifting or carrying objects in the arms and hands. As a result, a greater surface area of contact must be given to ensure the elderly users' comfort and protection.

4.4 Proposing Concepts for Modification of Kitchen Containers

The improvements suggested by the BIF taxonomy are considered after studying the body movements involved and the product part utilized. As seen in Fig. 4, kitchen containers have three main components that are used in carrying out tasks: the lid, the mid body, and the base of the container. These pieces are held or grasped by the users to lift, use, or place the containers.

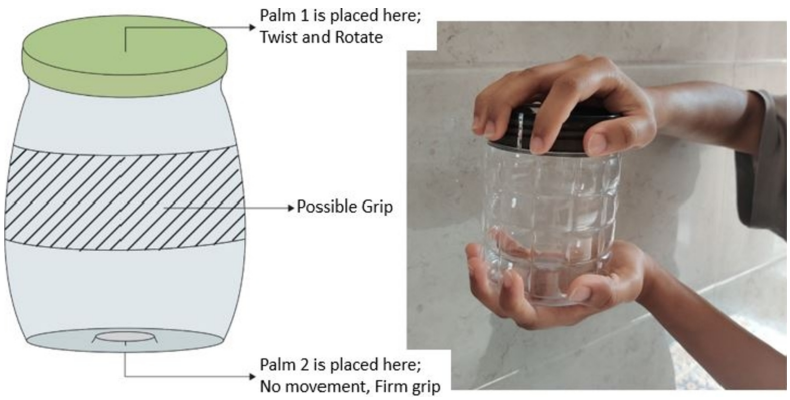

Fig. 4. Hand grip analysis of a kitchen jar with threaded lid

The user needs identified are as follows.

- To facilitate manipulation and grasping, the container lid should have a larger surface area for contact and tighter grip.

- The container's base should be enhanced for a tight grip when handling.
- Extra grip in the middy body can be provided.

Other requirements, such as size, portability, maintenance, and product life, may be researched and identified after the survey is completed. Because of assumptions, the user needs are restricted to just the body movements involved and the changes proposed in the BIF taxonomy. Based on these, some concepts for modifying existing kitchen containers are sketched and are shown in Fig. 5.

In both Fig. 5(a) and Fig. 5(b), some modifications for the lids of existing kitchen containers with a flat surface are seen. A container with a convex curved lid and a thicker base for improved grip as shown in Fig. 5(a). Lids with several convex curved surfaces, a handle, a pop-out knob, a lid with place for individual fingers, and a lid with a spoon fixed to its inner surface are the modifications shown.

Fig. 5. (a) & (b) Concept sketches for modification of existing kitchen containers

5 Discussion and Limitation

Taxonomies in general help in studying and understanding the concepts related to a subject. They organize all the factors related to these concepts by creating subject specific understanding and related terms. The EAFC (Elderly user-Activity-Features-Concerns) and BIF (Body movements-Improvements-Features) design taxonomies, are developed by considering all the factors associated with the process of redesigning existing products for the elderly. EAFC design taxonomy is considered to evaluate the existing product by the elderly to understand the requirements and the problems faced. Whereas, BIF design taxonomy as subset of EAFC taxonomy is developed to identify the improvements required in the existing product based on the body movements, functional capabilities of the elderly and their interactions with the product.

The developed taxonomies are generic and can be used to study the problems faced by the elderly while using any existing product. While these taxonomies can be used in various stages of product development process, in this paper they are used to design survey questionnaires and related design modifications. It is evident from the surveys that some existing day-to-day products do not meet the needs of the elderly, which is causing problems for the elderly when using them. But the elderly are familiar with the functioning and usage of these existing products. Hence, to facilitate the modification and redesign of these products, EAFC and BIF taxonomies are used.

Although the first survey findings proved to be very useful in shortlisting the products that need improvements, there are some limitations. Many of the male participants did not respond to the questions about kitchen items. When they were directly approached to find out why, it was discovered that it was due to a lack of expertise with kitchen-related activities. The findings were not analyzed with this circumstance in mind. Hence, this should be further investigated. Since the second survey is still ongoing, the concepts proposed to modify existing kitchen containers are based only on the body movements associated with using kitchen containers and only the BIF taxonomy is used for this. Other factors such as aesthetics, maintenance, accidents and injuries as shown in the EAFC taxonomy will be studied following the completion of the second survey.

While the proposed taxonomies can be very useful for redesigning existing products for the elderly, there are some limitations. Firstly, the taxonomies can be used and referred to while studying and redesigning existing products. If one needs to design a completely new product for the elderly, the taxonomies may not be very insightful and helpful. Secondly, as discussed in the previous paragraph, it is evident from the survey that if the elderly user is not familiar with the product being redesigned, the survey cannot be analyzed as it stands. Hence, these limitations need to be considered and further investigated.

6 Conclusion and Future Work

Given that the elderly are familiar with current products that are designed for the general population but used by both the elderly and the general population, it is important to assess these products first. It is more useful to the elderly if current

products are slightly modified and redesigned for them. These objectives are facilitated by the proposed taxonomies and method. Both the EAFC and BIF taxonomies help with the product design process by revealing the issues that the elderly face that need to be resolved and the design priorities that must be established to fix these issues. These are generic taxonomies that can be used to redesign existing products that the elderly use in their everyday activities. Such approaches to design process simplify the product development cycle as it becomes easier with taxonomies specific to the primary users to address issues, come back to certain steps and modify according to the needs of the primary users. It facilitates adapting/redesigning existing products for elderly instead of designing products from scratch.

The proposed methodology for using taxonomies and including the elderly in product design is being implemented. Section 4 addressed some of the completed phases. Following the conclusion of the second survey, more user needs will be added, and further ideas for redesigning kitchen containers to meet the needs of the elderly will be proposed. More iterative processes during the study will help refine designs and design more precise products in the future. The taxonomies may be used to evaluate the concepts or ideas that may be proposed in initial steps.

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