A SMART MASS CUSTOMIZATION DESIGN TOOL: A CASE STUDY OF A PORTABLE RAMP FOR WHEELCHAIR USERS

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by

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ABSTRACT

A SMART MASS CUSTOMIZATION DESIGN TOOL: A CASE STUDY OF A PORTABLE RAMP FOR WHEELCHAIR USERS

This study focuses on exploration of wheelchair users' expectations from portable ramps and their adoption factors, then correspondingly offers a smart mass customization design tool. Briefly, portable ramps are generally used by wheelchair users, provide temporary solution to increase accessibility in their daily lives. Different types of portable ramps can be found in the market and their modification flexibility cannot go beyond just length modification, or they just allow to select some restricted width options. However, portable ramps are quite suitable for mass customization concept which can help to satisfy potential customer while being involved in design step.

In this context, three research methods were applied; semi structured-face-to-face interview, observation and experimental study. The constructs of survey were extracted from literature and patent reviews, then refined during interviews and observations studies. Wheelchair users answered a web-based survey with 72 questions related with 35 constructs. The survey uncovered that personalization, flexibility and extension capability is highly demanded by wheelchair users. At the end of the study, a smart mass customization design tool has been developed which potential users or sales representatives are able to easily interact with to customize the portable ramp. To this end, a case study is conducted with a rollable ramp which is designed and developed within the scope of 1512 – Entrepreneurship Multi-phase Programme (Teknogirişim Sermaye Desteği Programı) of The Scientific and Technological Research Council of Turkey. The methodology and its implementation are described elaborately, and example of a parametric smart customization tool design are illustrated in this study.

ÖZET

AKILLI BİR KİTLESEL BİREYSELLEŞTİRME TASARIM ARACI: TEKERLEKLİ SANDALYE KULLANICILARINA YÖNELİK TAŞINABİLİR RAMPA TASARIMI ÜZERİNE BİR VAKA ÇALIŞMASI

Bu çalışma, tekerlekli sandalye kullanıcılarının taşınabilir rampalardan beklentilerinin ve bu ürünlere olan adaptasyonlarını ortaya çıkararak akıllı bir kitlesel bireyselleştirme tasarım aracı sunulmasına odaklanmıştır. Kısaca özetlemek gerekirse, taşınabilir rampalar genellikle tekerlekli sandalye kullanıcıları tarafından, günlük yaşamlarında erişilebilirliği artırmak için geçici bir çözüm sunması nedeniyle kullanılmaktadır. Piyasada bulunan farklı tipte taşınabilir rampaların sunduğu modifikasyonlar sadece uzunluk modifikasyonunun ötesine geçemezler veya sadece kullanıcıların sınırlı genişlik aralığında seçim yapmasına izin verirler.

Bu bağlamda, üç araştırma yöntemi benimsenmiştir; yarı yapılandırılmış yüz yüze görüşme, gözlem ve deneysel çalışma. Tasarım girdileri literatür ve patent incelemeleri sonucu oluşturularak, görüşme ve gözlem çalışmaları sırasında belirlenmiştir. Tekerlekli sandalye kullanıcıları, 35 tasarım girdisiyle alakalı 72 adet soru içeren web tabanlı bir anketi cevaplamıştır. Anket çalışması, kişiselleştirme, esneklik, uzatılabilirlik gibi tasarım girdilerinin tekerlekli sandalye kullanıcıları tarafından talep edildiği ortaya çıkarılmıştır. Çalışmanın sonunda, potansiyel kullanıcıların veya satış temsilcilerinin taşınabilir bir rampayı kişiselleştirmek için etkileşime girebilecekleri akıllı bir kitlesel bireyselleştirme tasarım aracı sunulmuştur. Bu amaçla, Türkiye Bilimsel ve Teknolojik Araştırma Kurumu (TÜBİTAK) 1512 –Teknogirişim Sermaye Desteği Programı kapsamında tasarlanan ve geliştirilen, rulo olabilen bir rampa ile bir vaka çalışması yapılmıştır. Çalışma süresince, metodoloji ve uygulaması detaylı bir şekilde açıklanarak ve parametrik bir akıllı bireyselleştirme aracı tasarımı örneklerle sunulmuştur.

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CHAPTER 1

INTRODUCTION

This study presents design parameters of portable wheelchair ramps which are important for wheelchair users, and a smart design tool which helps potential customers to design a portable ramp within the mass customization concept.

1.1. Problem Definition

Wheelchair users try to reach a wide range and large number of destinations in their daily lives, such as banks, stores, religious buildings, workplace, friends' and relatives' homes and health professionals' offices. As they try to reach their destinations, wheelchair users encounter many different barriers like curbs, lack of ramps or ramps that are too steep etc. (Meyers et al., 2002).

Portable ramps, used generally by wheelchair users, offer a temporary solution to increase accessibility and mobility. In the most general sense, it is expected that these ramps should be compact and lightweight in terms of ease of handling and storage. Different types of portable ramps in the market which can be used by wheelchair users are generally non modular (telescopic and foldable types), while there are few examples of modular ramps called rollable ramps which allow users to modify its length while attaching or detaching modules. However, every wheelchair user has different expectations beyond length modification. These expectations can be related with physical capacity, type of wheelchair, type of handicap, type of residence, need of an accompanying person and so on.

1.2. Aim of the Study

All these various kinds of necessities have led to further modifications like width, weight, material, load bearing capacity, factor of safety etc. which can be implemented on the design according to user's expectations and needs. Moreover, developing materials

and manufacturing technology allow manufacturers to provide endless opportunities to redesign and develop customized products.

To meet all these expectations, it is aimed to design a smart mass customization tool for wheelchair users which is user-friendly, interactive and dynamic as well. While users are interacting with the tool, parametric changes are simultaneously shown which help users to make decisions dynamically by altering the desired design parameters. The interface of the tool leads the users during customization process to prevent making mistakes while both giving some warning massages and restricting some parameters according to previous choices.

1.3. Research Questions

There are two main research question in this research. These are:

1. Which design parameters of portable wheelchair ramps are important for wheelchair users?
2. How to design a smart design tool which helps potential customers to design a portable wheelchair ramp within the mass customization concept?

1.4. Structure of the Study

In Chapter 1, problem definition, aim of the study and research questions are briefly summarized. Chapter 2 gives brief information about the literature related with mass customization and portable ramps. Moreover, Chapter 2 explains design parameters which are also addressed in following chapters as well. In Chapter 3, methodology of the study is presented. Chapter 4 constitutes framework of the study and Chapter 5 presents the findings of the study. Chapter 6 comprises mass customization tool. And finally, Chapter 7 presents the conclusion of the study.

CHAPTER 2

LITERATURE AND PATENT REVIEW

This chapter gives brief information about portable ramps, technology acceptence model and mass customization concept.

2.1. Portable Ramps

Portable ramps are categorized into four main types in terms of deployment methods. These deployment types are listed as telescopic, rollable, foldable and scissors (Fig. 2.1) (Kumtepe, 2018).

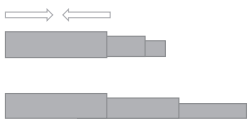
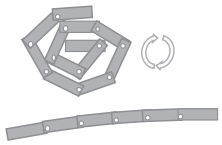
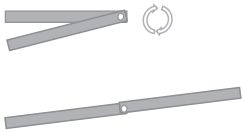
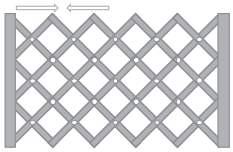
TELESCOPIC	ROLLABLE	FOLDABLE	SCISSORS
			
U.S. Patent No. 20,130,028,693 A1, 2013	U.S. Patent No. 7,958,586 B1, 2011	U.S. Patent No. 20,020,108,190 A1, 2002	Patent No. 20,110,072,596 A1, 2011
U.S. Patent No. US5813071 A, 1998	U.S. Patent No. 20,060,214,456 A1, 2006	U.S. Patent No. 20,090,300,860 A1, 2009	
U.S. Patent No. US5312149, 1994	U.S. Patent No. 6,643,878 B2, 2003	U.S. Patent No. 6,378,927 B1, 2002	
	Patent No. 20,020,088,065 A1, 2003		

Figure 2.1. Categorization of Deployable Ramps

Telescopic structures consist of hollow cross-sectional profiles that slide into another member to achieve deployment. This type of ramp can be categorized under the title of telescopic ramps.

Rollable ramps consist of serial chain members which are able to rotate about the connection axes. Thus, they can be rolled out like a carpet on one side and carry load on the other side due the constructional design of the load-bearing members with mechanical motion limits.

Foldable ramps generally consist of hinges and load bearing panels. These two main members provide jackknife-like deployment.

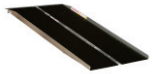
Scissors type ramps consist of scissor members to achieve deployment. There is only one patented example in the literature, and it has no real-life product in the market. Categorization of Deployable Ramps (Kumtepe, 2018).

2.2. Portable Ramps in Industry

There are many different brands of portable ramps in the world market. In general, all portable ramps have similar four main deployment types which allow them to be compact enough for carrying. They are generally made of conventional materials like aluminum to provide lightness; however, there are a few examples of portable ramps which are made of composite materials in the market.

Products in the market have some both similar and dissimilar features in terms of material, price, deployment type, weight etc. The comparison of these features according to products in the market can be seen from Table 2.1.

Table 2.1. Comparing alternatives of portable ramps in the market

	Brand	Product Image	Price (USD)	Material	Modularity	Type of Deployment	Weight (kg)	Load Bearing Capacity	Legth (cm)	Width (cm)	Handle	Anti-skidness	Outdoor
1	**HomCom**		$240.00	Aluminum	No	Foldable	27 kg	272 kg	305 cm	74 cm	Yes	Yes	Yes
2	**Titan Ramps**		$370.00	Aluminum	No	Foldable	24 kg	Not Given	244 cm	76 cm	Yes	Not Given	Yes
3	**EZ-ACCESS TRIFOLD**		$360.00	Aluminum	No	Foldable	28 kg	363 kg	244 cm	76 cm	Yes	Yes	Yes
4	**EZ-ACCESS SINGLEFOLD GRAPHITE FIBER**		$1,446.00	Graphite Fiber	No	Foldable	Not Given	300 kg	208 cm	76 cm	Yes	Yes	Yes
5	**Prairie SFW530**		$220.00	Aluminum	No	Foldable	11 kg	363 kg	152 cm	76 cm	Yes	Yes	Yes

(Cont. on next page)

Table 2.1. (Cont.)

6	DecPac Fiberglass Ramps		$640.00	Fiberglass	No	Foldable	12 kg	300 kg	132 cm	81 cm	Yes	Yes	Yes
7	**iRamp Carbon**		$5,187.00	Carbon Fiber	No	Foldable	5 kg	250 kg	150 cm	75 cm	Yes	Yes	Yes
8	**Roll-A-Ramp**		$935.00	Aluminum	Yes	Rollable	18 kg	453 kg	182 cm	66 cm	No	Not Given	Yes
9	**Rulo Rampa**		$350.00	Aluminum	Yes	Rollable	9 kg	1,000 kg	100 cm	80 cm	Not Given	Not Given	Yes
10	**Rage Powersports**		$190.00	Aluminum	No	Telescopic	17 kg	272 kg	304 cm	Two Piece	Yes	Yes	Yes
11	**CF-RAMP**		$500 - $1000	Carbon Fiber & Aluminum	Yes	Rollable	6.3 kg	300 kg	100 cm	80 cm	Yes	Yes	Yes

According to this comparison in Table 2.1, it is possible to say that price of the product is mostly determined by its material.

2.3. Mass customization

In 1916, Ford launched revolutionary mass-produced Model T to the market which, allowed the company to sell an automobile at $360 while the average price was over $2000. This revolutionary production method was rapidly adopted by many other industrialized countries all over the world (Forza & Salvador, 2014). However, the main principles of mass production (MP) are predominantly far from satisfying customer expectations because of the pure identical, standardized and/or quite similar products which are produced throughout the inflexible production line (Blecker & Friedrich, 2007).

The main reason behind the idea of mass customization (MC) can be basically explained with the changes in economic and political balances while the global market is becoming saturated with customers' continuously increasing knowledge, discernment and quality perception. Moreover, improved education level and easy access to information have been creating customers who are highly demanding and discriminating, which continuously creates a highly competitive global market (Carson et al., 2005; Duray, 2011; Fogliatto & Da Silveira, 2011). Moreover, customers are satisfied with the customized product not only because of perceiving hedonic, functional, and social value (Merle et al., 2010) but also engaging in the customization process itself (Yoo & Park, 2016). Increased user involvement in design activities is called as mass individualization (MI). In MI, the user is able to design the desired product by using an Open Product Architecture (OPA) rather than selecting only product modules to create a new configuration. MI strives to allow the user to be involved in the design process while reaching the time-cost efficiency level of the MC system (Koren et al., 2013; Rincon-Guevara et al., 2019). However, there is a fuzzy boundary between MC and MI, while according to many authors, a product can be considered "customized" when one or more processes (including design step) throughout the supply chain are carried out (Davis 1989; Gilmore & Pine 1997; Da Silveira, 2001; Forza & Salvadore, 2014).

Moreover, modern manufacturing techniques (Additive manufacturing, rapid prototyping, and material technologies…) allow companies to produce customized and

individualized products as well while trying to reach the speed of agile manufactruing methods. To this end, currently many researchers (Yao et al., 2017; Jiang et al., 2017; Schulz et al., 2019; Srinivasa & Rengarajan 2018; Kang et al., 2018; Huiwen et al., 2019; Attaran, 2017; Gardan, 2017; Verwulge et al., 2018; Przemysław & Krzysztof, 2016; Rincon-Guevara, 2019) focus on mass customization approach to additive manufacturing tecniques. One of the most important aspects of mass customization is supply chain (Liu et al., 2018; Zhang et al., 2019; Xiong et al., 2018; Suzić et al., 2018; Attaran, 2017) and delivery time (Wang et al., 2016; Przemysław & Krzysztof, 2016; Buergin et al., 2018; Forza, 2014) management while agile manufacturing is important for both manufacturers and customers. Researchers also concentrate on supply chain and distribution management integration with mass customization approach.

2.3.1. Level of Mass Customization

The term mass customization can be considered an oxymoron consisting of two opposite concepts (Pine et al., 1993; Tseng & Jiao, 2001; Blecker & Friedrich, 2007) such as mass production and craftsmanship. In the most general sense, mass production aims to produce cost and time efficiency products with the help of standardization, while craft production is willing to tailor pure customized products according to customer's brief (Blecker & Abdelkafi, 2006; Forza & Salvador, 2014). However, mass production strives to reach both cost and time efficiency of mass production while achieving wide range of variety level of craft production (Fig. 2.2).

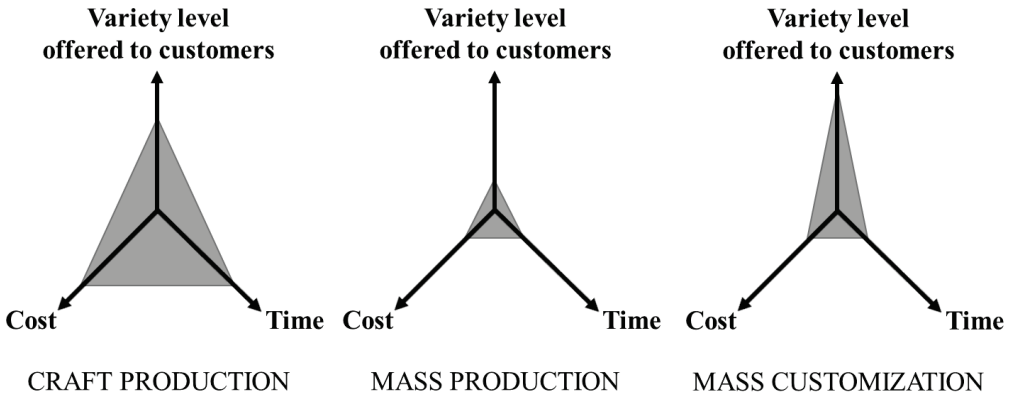


Figure 2.2. Relationship between production type and variety level offered to customers

(Source: Forza & Salvador, 2014)

The first appearance of the term “mass customization” in the literature as a research topic was in 1989 with Stanley M. Davis’ publication “From Future Perfect: Mass Customization”, and he also presented the idea that the customization works can be conducted at many points in the supply chain. Moving to 1993, the concept gained popularity with Pine's book “Mass Customization” (Jørgensen, 2006).

According to several authors, a product can be considered a ‘customized product’ when one or more processes (design, fabrication, assembly and distribution) throughout the supply chain are carried out according to the customers’ specific requisitions. The lowest level of customization can be considered a variety without customization (Davis, 1989; Gilmore & Pine, 1997; Da Silveira, 2001; Forza & Salvadore, 2014). Customization activities in the whole manufacturing process conducted by customers enable categorization of mass customization strategies (Fig. 2.3), which are as follows:

1. Pure customization: Customers get involved in the design process to identify and implement their needs and expectations. This type of strategy allows customers to customize all steps in the manufacturing process (design, fabrication, assembly, and distribution). Industrial machineries, buildings and craftsmanship shops can be exemplified as pure customization.
2. Customized fabrication: Generally, customized fabrication offers the customers a base product which will be modified according to customers’ choices within the range of company’s product family. As an example, fitted kitchens consist of some standard fixtures and different type of modular woods which can be easily modified by changing board lengths to fit customers’ kitchens as desired.
3. Customized assembly: The most popular example of this case is Dell (American multinational computer technology company in Round Rock, Texas, United States), which provides many options such as screen size, memory capacity, number of usb ports, etc. In addition, the company allows you to customize computer shell with an uploaded image to the company’s website.
4. Customized Distribution: In this strategy, customers do not involve design, fabrication or assembly stages of production; however, they may demand different distribution types, such as air express or shipping, and may specify package type such as single or one by one package.
5. Variety without customization: Customers do not involve any of the manufacturing activity to customize product or service. However, companies may still offer a wide range of product varieties, so customers may choose the

one which is most desired. The large supermarkets can be exemplified for this case where there are numbers of different products to choose (Forza & Salvador, 2014).

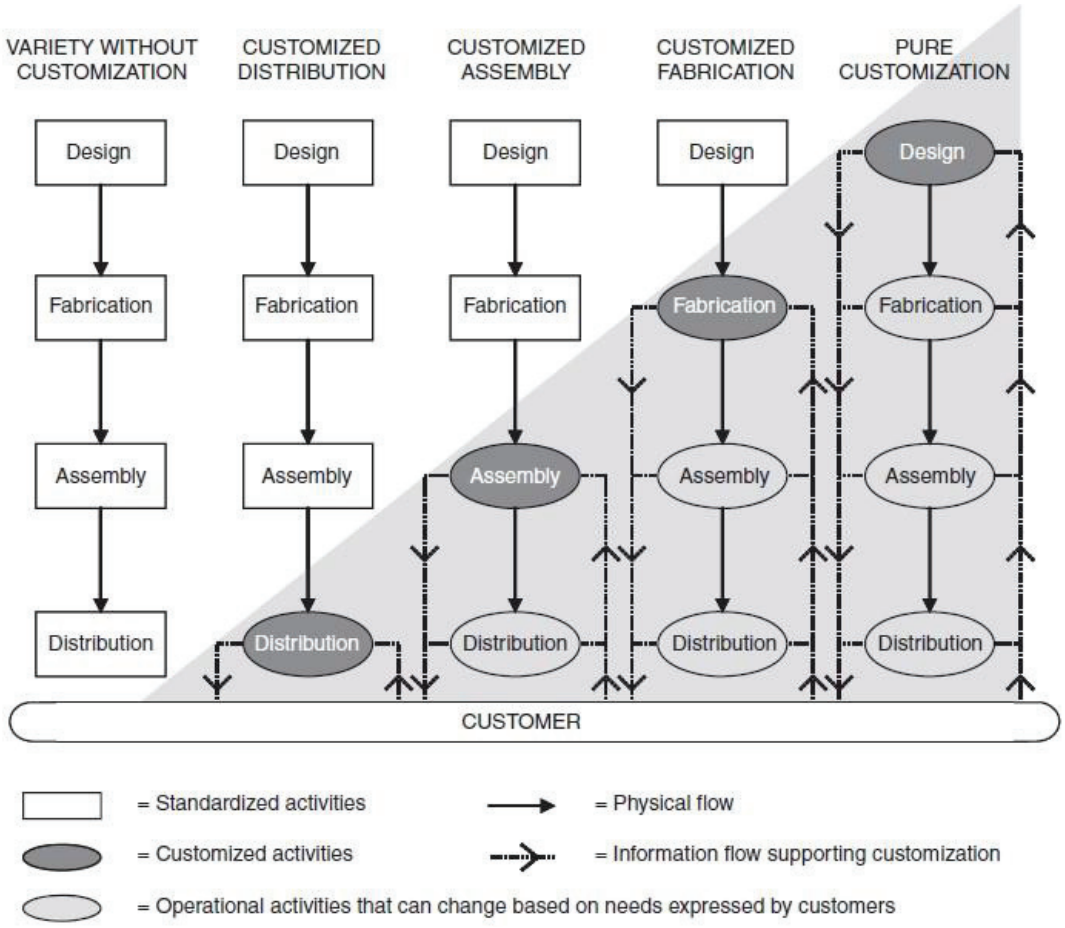


Figure 2.3. Scope of product configuration

(Source: Forza & Salvador, 2014).

2.3.2. Mass Customization Approaches

Gilmore and Pine (1997) identified four approaches (collaborative, adaptive, cosmetic, and transparent) to customization based on their empirical observations among worldwide companies who embraced mass customization (Table 2.2.).

Table 2.2. Four approaches for mass customization

(Source: Gilmore & Pine II, 1997)

Approaches	**Collaborative**	**Adaptive**	**Cosmetic**	**Transparent**
Definition	Customers' needs are understood and analyzed and used in manufacturing process directly.	Customers are able to customize the basic product while using it.	Customers are enticed by products offered in different formats.	Customers are provided unique goods or services without explicitly demanding or being aware of customization.
Company	Paris Miki, a Japanese eyewear retailer	Lutron Electronics Company of Coopersburg, Pennsylvania	The Planters Company in Suffolk, Virginia	ChemStation of Dayton, Ohio
Product / Service	Eyewear	Lighting System	Packaging	Industrial Soap
Example	Analyzing customer's face, recommending a distinctive lens size and shape, displaying the product on the digital image of customer's face.	Allowing the customer to create different lighting effects (romantic, party, calm…) with a single program rather than using separate light switches.	Offering the same product with customized package (the customer's name, different display…)	Tracking and analyzing each customer's usage patterns for presciently delivering more soap without any customer's demand.

Today, customers should not be seen as a part of a massive market in which companies offer monotype and standardized mass products. Almost every customer must be treated as unique to steal her/his heart in this highly competitive market.

2.3.2. Mass Customization and Modularity

The term modularity has a close relationship with mass-customization (Charles & Kratochvil, 2005; Xiao et al., 2016; Buergin et al., 2018; Wee & Aurisicchio, 2018; Montalto et al., 2018; Hankammer et al., 2018; Modrak & Soltysova, 2018; Elgh et al., 2018; Suzić et al., 2018) since it has been introduced as a manufacturing concept. However, further customization such as material selection and/or load bearing capacity can be adapted to the concept of mass-customization with a user-friendly interface which allows customers to select desired parameters to customize their ramp within a wide range of scope while seeing cost changes in customized design.

The modularity concept has inspired many companies (Scania Trucks in 60's and Dell Computers in 70's), which have embraced the modular mass customization concept and have been following the same principles with LEGO since then (Carson et al., 2005). Today, customers all around the world are able to customize and purchase their product using a user-friendly customization generator on the companies' websites (Fig2.4 and Fig 2.5).

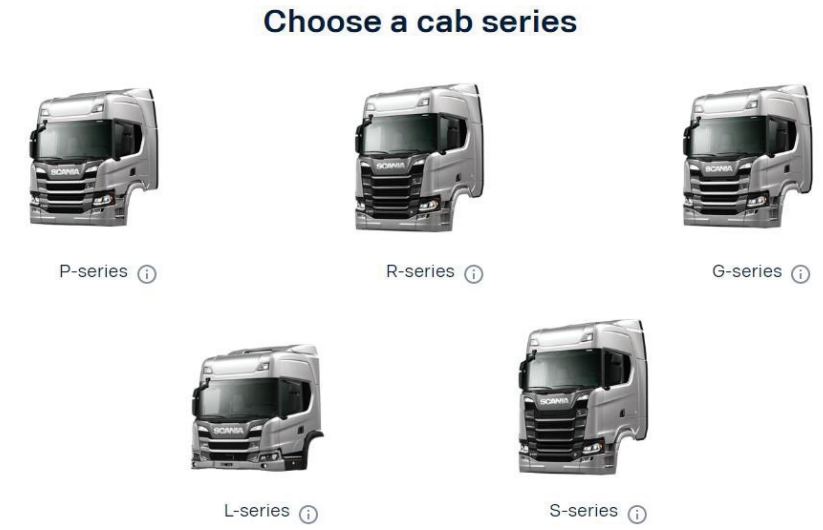


Figure 2.4. General overview of Scania customization webpage

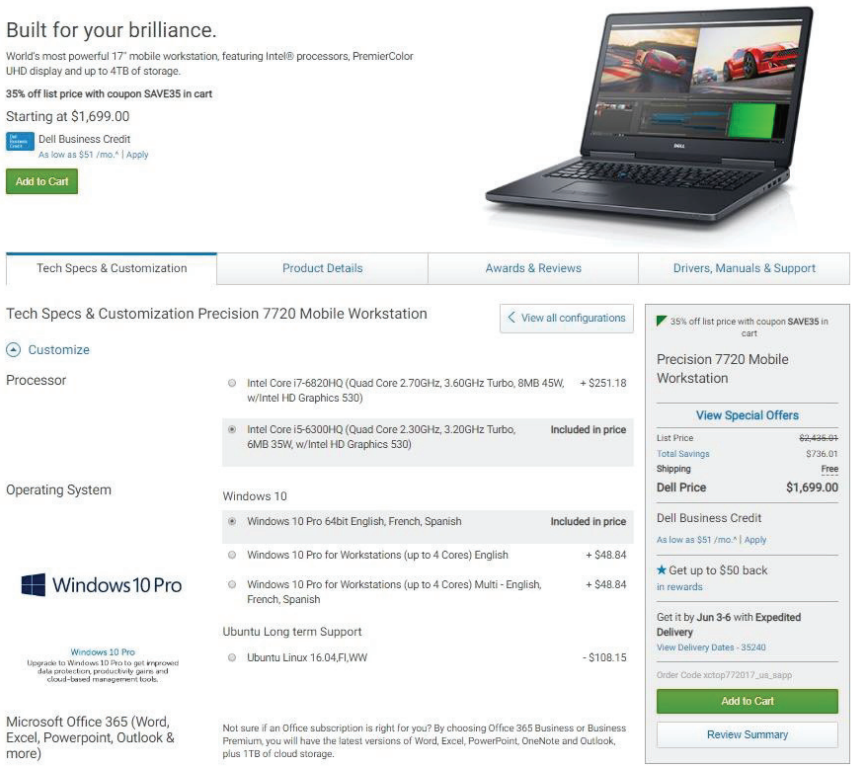


Figure 2.5. General overview of Dell customization webpage

2.4. Technology Acceptance Model

Technology Acceptance Model (TAM) (Davis et al., 1989), is one of the most popular models of acceptance theory, which is used for prediction of user behavior towards a new technology while uncovering their perception of usefulness, ease-of-use, attitude toward using and intention to use (Fig 2.6).

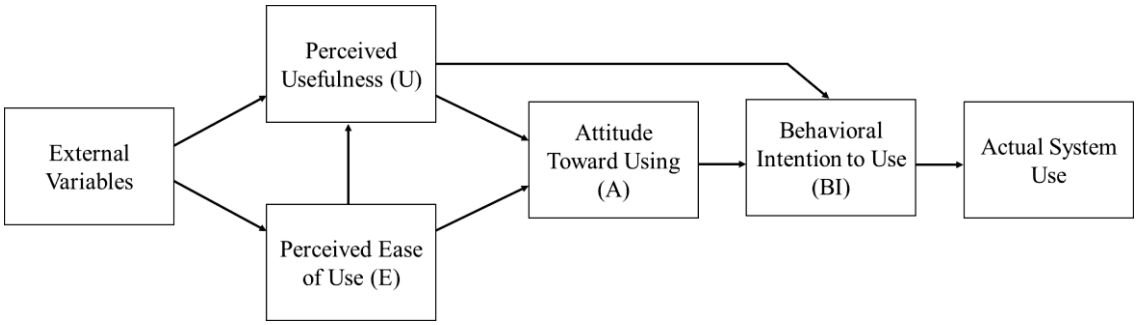


Figure 2.6. First modified version of Technology Acceptance Model (TAM)

(Source: Davis et al., 1989)

However, Davis and Venkatesh (1996) proposed the final version of TAM (Fig. 2.7) in which attitude construct was eliminated after they realized that perceived usefulness and ease of use were found to have a direct influence on intention (Lai, 2017).

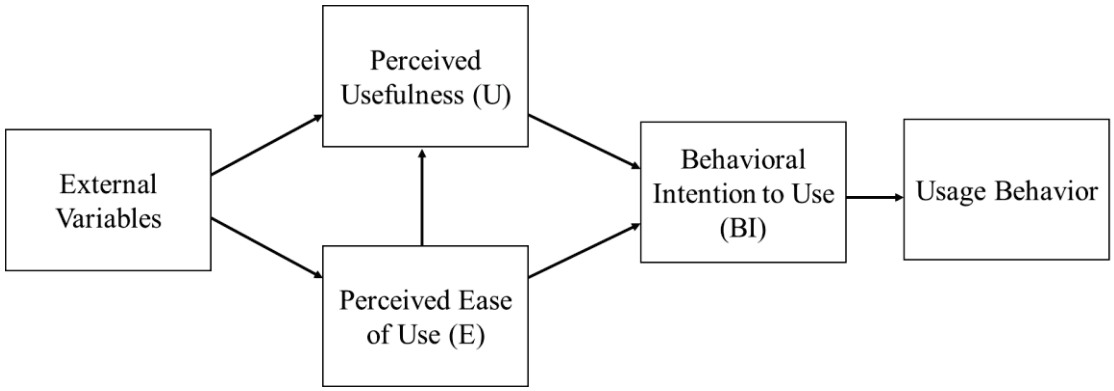


Figure 2.7 Final version of Technology Acceptance Model (TAM)

(Source: Davis and Venkatesh, 1996)

2.5. Extension of Technology Acceptance Model

Venkatesh and Davis (2000) proposed Technology Acceptance Model 2(TAM 2), which is the extension of TAM. They included subjective norms, voluntariness and image

as social influence determinant; moreover, job relevance, output quality and result demonstrability as cognitive instrumental determinant in TAM 2 (Fig. 2.8). All these variables have significant effects on user acceptance of information technology and proposed technology. They also reveal that TAM 2 can be applied in both voluntary and mandatory environments.

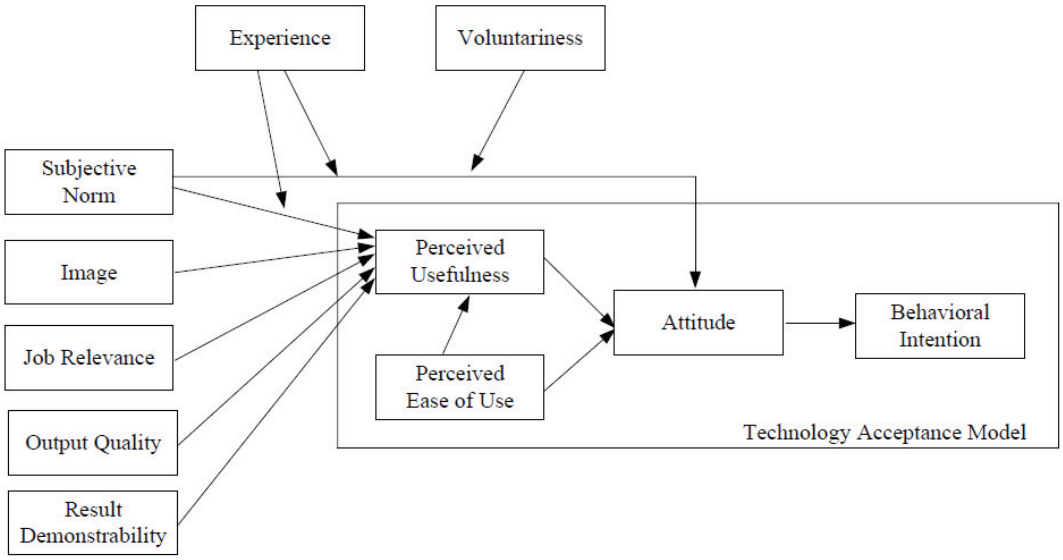


Figure 2.8. Technology Acceptance Model 2

(Source: Venkatesh & Davis, 2000)

In 2008, Venkatesh and Bala proposed a combined model, of TAM 2 and Venkatesh's (2000) model of the determinants of the pervieved ese of use, which is known as TAM 3. The model was tested in settings of IT implementations (Lai, 2017).

CHAPTER 3

METHODOLOGY

This study presents qualitative and quantitative methods. Table 3.1. shows the scope of the project and its implementation. It was applied 3 consecutive steps to discover what might be the influential factors that provide a base for a good design. To collect potential users' opinion, we had used the prototype and its images that had been developed during a prior project. The project consisted a master thesis, a financially supported development study.

Table 3.1. Methodology of the study

	Study	**Time Period**	**Analysis and Output**
1	Preliminary Studies	July 2015 - May 2018	Building a full functional prototype within a TUBİTAK 1512 supported project and ME graduate studies
2	Observation of user experience	May 2018 - June 2018	Strength and weakness analysis and further dimensions to explore
3	Interview with the users (semi-structured, face-to-face, depth)	June 2018 - July 2018	10 potential users, 10 questions, analyze the responds and produce 48 critical parameters
4	Systematic review	July 2018 - October 2018	Refined design parameters, conceptual design of the MC design tool
5	Requirement exploration survey	October 2018- April 2019	Web-based questionnaire, 35 construct, 72 questions, 46 participants
6	Mass customization assistance tool	April 2019 - July 2019	Design and develop a customization tool based on the findings of requirement exploration survey

3.1. Preliminary Studies

A full functional prototype is built during preliminary studies. Preliminary studies present numerical, analytical and empirical works for the design of a deployable portable ramp and its implementation with parametric study while the whole structure of the study is integrated in Design Thinking approach.

3.2. Observation of User Experience

Field tests were conducted between June and July 2018. Field tests were voluntarily conducted with 10 active wheelchair users with ages ranging in between 15-50 in Dokuz Eylül University Hospital and Private Physical Therapy Centers in Izmir, Turkey. Participants under the age of 18 attended the field tests with the permission of their parents. During observation, weaknesses and strengths of the product were collected.

3.3. Interview with the User

Users' opinions and suggestions about prototype were taken during field test in terms of ramp width, load-bearing capacity, anti-slip surface sufficiency and efficiency. During the field tests, opinions and suggestions of both the participants and the relatives of some participants were collected from 10 potential users with 11 questions. The responds were analyzed, and 48 critical parameters were produced.

3.4. Systematic Review

After observation and interview user experiences were collected. Then parameters were determined and systematically reviewed. Generated parameters were examined under the six main category. Afterwards, 48 critical parameters were refined and produced 27 design parameters.

3.5. Requirement Exploration Survey

The purpose of the experimental study is to uncover the factors that affect wheelchair users' adoption on rollable portable ramps. A web-based data collection instrument containing two main parts, namely product information and questionnaire for regression analysis and descriptive analysis, was developed to collect data from participants. Google Forms was used for data collection. The questionnaire was conducted with a web-based data collection instrument. The product information part consists of a photograph and a video of the product and questionnaire consists of 72

questions. Collected data from participants was used for regression and descriptive analysis. All the answers were scaled 1 to 5 in which 1 represents strongly disagree, 3 means neither agrees nor disagrees, and 5 equals strongly agree. Participants selected 1 to 5 to specify the level of the agreement to the questions.

3.6. Mass Customization Assistance Tool

The designed Mass customization tool was generated in Excel and consisted of 5 main sections that showed parameters, user selection, consistency calculations and warning messages, general information about main parts of the ramp and dynamically changing rolled ramp illustrations. Users could directly interact with the tool to customize the base product.

CHAPTER 4

FRAMEWORK

Framework of the study has been elaborately examined in this chapter. Design parameters, which is important for wheelchair users, have been explained and, a relationship matrix diagram of design parameters for mass customization tool was illustrated to show relations between parameters. At the end, brief information about mass customization tool has been given.

4.1. Preliminary Studies

Preliminary studies were conducted with the financially support of 1512 – Entrepreneurship Multi-phase Programme (Teknogirişim Sermaye Desteği Programı) of The Scientific and Technological Research Council of Turkey (TÜBİTAK) in TEGA Design limited company as a master's thesis in IZTECH mechanical engineering department. In this context, a rollable ramp was designed and manufactured. This prototype was used during this study to collect user experience.

4.1.1 Semi-Structured Face-to-Face Interview

After understanding and observing problems related with accessibility difficulties of wheelchair users. Semi structured face-to-face interview was conducted in İzmir with 8 wheelchair users with ages ranging in between 13-40 and who have been used wheelchair at least for 1 year were selected in the middle class. This frame was chosen because upper class in society generally is able to find more expensive and permanent solutions to increase their mobility and accessibility in their daily lives.

Interview questions were constituted with the diverse literature review about wheelchair users and their accessibility to uncover their expectations and needs. A basic qualitative research method was used to examine the expectations of wheelchair users.

Interviews were carried out with semi-structured interview questions. Discussions were recorded and written with participants' consent, translated and transcribed. Individual semi-structured interviews were carried out at a location convenient to each participant and conductor. Interviews started with a general question with regard to their feelings about being a wheelchair user and the struggles in their daily lives. Afterward, further questions were addressed to explore their expectations and needs.

Interviews lasted approximately 50-55 minutes, and four main themes and two or three sub-themes formed according to answers were identified during the interview, as shown in appendix.

4.1.2. Final Design and Building a Functional Prototype

In the final step of the preliminary study, several types of link geometry forming the rollable ramp were examined and optimum dimensions and geometry were determined during geometric calculations and kinematic analysis. To increase compactness of the ramp in rolled position, smallest enclosing circle algorithm was implemented while ramp weight was calculated simultaneously for optimization.

Moreover, ramp load-bearing plates are made of aluminum honeycomb and carbon fiber sandwich composites which provides high load bearing capacity and lightness. Thus, the final design is 18,87% lighter and 15,4% more compact compared to the best rival product available in the market. The final design can be seen in Fig. 4.1 and 4.2.

4.2. Observation and Collection of User Experience

Field tests (Fig. 4.3) were conducted in between June and July 2018. The first trial of the ramp was conducted by using an empty wheelchair to avoid putting the wheelchair user at risk. During the first trial, some observed problems and implemented solutions are as follows:

- Slipping between ground and approach plate (which was restored adding anti-skid material to the backside of the approach plate)

- Level difference in between ground and approach plate, which creates a small threshold, also causes a reaction force and slipping problem (which was restored using formed aluminum sheet metal)

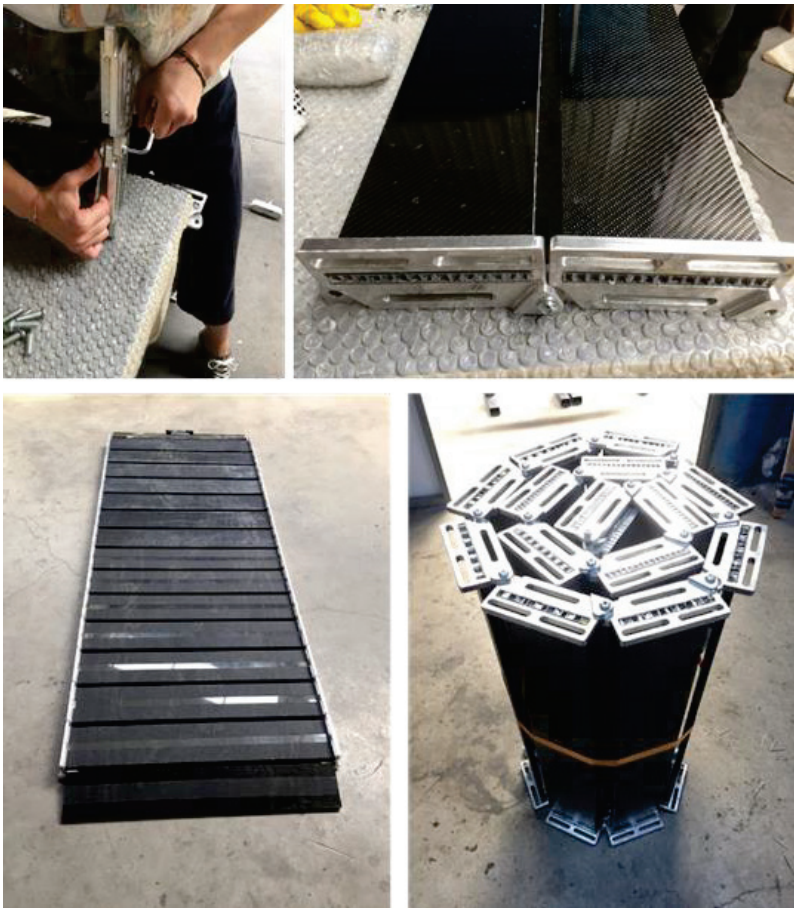


Figure 4.1. General overview of the functional prototype

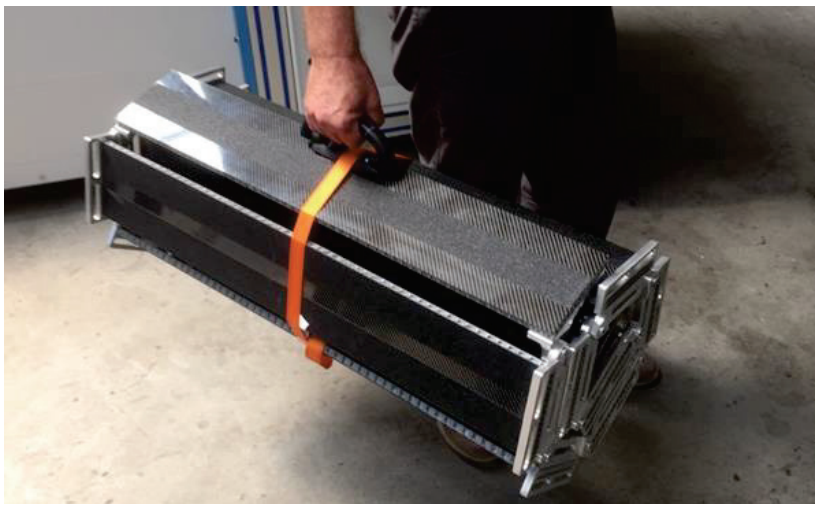


Figure 4.2. 1-meter long ramp in rolled position

After the observed problems were eliminated, field tests were voluntarily conducted with 10 active wheelchair users with ages ranging in between 15-50 in Dokuz Eylül University Hospital and Private Physical Therapy Centers in Izmir, Turkey. Participants under the age of 18 attended the field tests with the permission of their parents. During the field tests, the opinions and suggestions of both participants and the relatives of some participants were collected.

Figure 4.3. Field Tests

According to user observation, interactions between proposed product and wheelchair users have been examined during the field test.

4.2.1. Observed Strengths and Weaknesses of the Product

During observation some interesting product weaknesses were collected. One of the potential participants refused to use the ramp and his approach to material and design itself was very skeptical. He claimed that he had not seen this kind of material before and could not trust to use the ramp, even though all potential participants had been informed briefly that the material and design were safe and had been tested mechanically before the field test. Two of the participants found the crunching sound frightening, which is generated by aluminum honeycomb material inside the carbon fiber sandwich composite panels during dynamic load. However, some participants, who are familiar with the

carbon fiber and its general specifications, approached the ramp very boldly without hesitating.

4.2.2. Collection of User Experience

During the field tests, opinions and suggestions of both the participants and the relatives of some participants were collected from 10 potential users with 11 questions. The responds were analyzed, and 48 critical parameters were produced. Questions:

1. What do you think about the overall design of the ramp (lightness, compactness, portability, modularity, etc.)?
2. Is the width sufficient for you?
3. Were you able to use the ramp comfortably?
4. Were you scared during use of the ramp?
5. Have you ever faced with a sliding problem?
6. Did the handle provided to carry the ramp prevent your passage?
7. Have you ever heard of carbon fiber material?
8. Do you think the load carrying capacity is sufficient?
9. Have you ever used a portable ramp before?
10. If so, could you make an overall evaluation compared to other ramps?
11. Would you like to have such a portable rollable ramp?

4.3. Systematic Review and Evaluation of User Experience

After observation and interview, user experiences were collected. Then parameters were determined and systematically reviewed (Table 4.1). Generated parameters were examined under the six main category. These parameters are respectively related with length customization, structural customization, storage customization, ease of use customization, extra apparatus and equipment need, and price customization.

Table 4.1. Systematic review of collected user experience

PARAMETERS			
A	**Length Customization**	**D**	**Ease of Use Customization**
1	required ramp length	**26**	ease of storage
2	slope angle	**27**	ease of installation
3	barrier length	**28**	ease of assembling
4	wheelchair type	**29**	ease of disassembling
5	required horizontal distance	**29**	ease of handling
6	climb distance and ramp angle correlation	**30**	ease of portability
B	**Structural Customization**	**31**	ease of carrying
7	ramp type	**32**	ease of cleaning
8	ramp mass	**E**	**Extra Apparatus or Equipment**
9	module mass	**33**	telescopic legs
10	factor of safety	**34**	mounted bracket
11	load bearing capacity	**35**	side barrier
12	strength	**36**	handrail
13	safety	**37**	anti-skidness
14	design for everyone	**38**	warnings
15	universality	**39**	water proofness
16	psychologic safety	**40**	uv resistance
17	use condition	**41**	release pin
18	width	**42**	rotation platform
C	**Storage Customization**	**43**	approach plate
19	compactness	**44**	material selection
20	comparing compactness	**F**	**Price Customization**
21	deployability	**45**	price per module
22	modularity	**46**	price per assembly apparatus
23	deployment method	**47**	total price
24	customization ability	**48**	price change
25	type of storage		

However, all these parameters are not suitable to directly customize due to users do not ought to be experts on structural design for calculating load-bearing capacity directly which is required complicated calculations and analysis.

Thus, customization tool intends to interact with users with the concept of "design for everyone" where every potential customer is approached as she/he has never seen this kind of product and customization process before. In other words, potential users are considered inexperienced and uninformed before starting customization process.

Table 4.2. Evaluation of user experience and forming design parameters

	PARAMETERS	INPUT TYPE
1	Barrier to climb (cm)	Manual Input
2	Wheelchair type	Manual Input
3	Slope (100*H/L) %	Computed Value
4	Restricted horizontal distance (cm)	Manual Input
5	Required ramp length (cm)	Computed Value
6	Ramp type	Manual Input
7	Width (mm)	Intermediary
8	Max load (kg)	Manual Input
9	Most suitable load bearing capacity with FoS (kg/2m)	Computed Value
10	Use condition	Manual Input
11	Factor of Safety (FoS)	Computed Value
12	Max (real) load bearing capacity (kg/2m)	Computed Value
13	Ramp mass (kg/m)	Computed Value
14	Total ramp mass (kg)	Computed Value
15	Deployability	Manual Input
16	Compactness (diameter/1m ramp length - mm/m)	Computed Value
17	Total compactness (diameter/m total ramp length - mm/m)	Computed Value
17a	Comparing compactness	Computed Value
18	Type of portability (handle, wheels, none)	Manual Input
19	Type of storage	Manual Input
20	Extra apparatus needed?	Manual Input
20a	Mounted bracket (pair)	Intermediary
20b	Telescopic legs (pair)	Intermediary
20c	Approach plate (pair)	Intermediary
20d	Release pin (pair)	Intermediary
21	Side barrier (extra barrier needed?)	Manual Input
21a	Side barrier (cm)	Intermediary
22	Rotation platform needed?	Computed Value
22a	Rotation platform (qty)	Computed Value
23	Handrail needed?	Manual Input
24	Anti-skidness	Manual Input
25	UV resistance	Manual Input
26	Warnings (no more than 30 words)	Manual Input
26a	Warning message placement	Manual Input
27	Total price (TL)	Computed Value

To this end, design parameters are categorized as Manual Input, Computed Input, Intermediary Input (Table 4.2). Further, all parameters have specific warning messages which are leading and warning users during the customization process to avoid user errors.

4.4. Requirement Exploration Survey

Questionnaire was conducted with a web-based data collection instrument. Questionnaire consiststed of a photograph and video of the product and 72 questions. Collected data from participants was used for regression and descriptive analysis. Google forms was used for data collection and SPSS Statistics software was used for regression and descriptive analysis.

In the survey, a photography of proposed design and a YouTube video about a portable rollable ramp in the market was presented. The names and links of video is;

Taşınabilir rampa:

https://www.youtube.com/watch?v=DmojKH3___o

Participants were expected to answer the questions while considering the photography and the video.

Table 4.3. Demographic questionnaire

Construct	**Question Item**	**Options**
Gender	Select your gender	Female/Male/Not Given
Age	Select your age	24 and below, 25-29, 30-34, 35-39, 40-44, 45 and above
Education Level	Select your education level	Primary school, High school, Collage, University, Master's Degree, Doctorate
Income	Select your monthly income	0-1000 TL 1001-2000 TL 2001-3000 TL 3001-4000 TL 4001 TL and above

The demographic part of the regression questionnaire is shown in Table 4.3. Another part of the questionnaire includes items for regression analysis. Table 4.4. shows the constructs and question items. All the answers were scaled 1 to 5 in which 1 represents strongly disagree, 3 means neither agrees nor disagrees, and 5 equals strongly agree. Participants select 1 to 5 to specify the level of agreement to the questions.

Table 4.4. Constructs and Items

No	Constructs	Items
1	Assistant	Is there someone who can help you when using a wheelchair?
2	Experience	how many years have you been using a wheelchair?
3	Innovativeness	I am cautious in adopting new products.
4	Self_efficacy1	I can easily use it alone.
5	Self_efficacy2	I'm not sure I can use such products.
6	Weight_Prob	I can find a wheelchair suitable for my physical characteristics (weight, height…).
7	Time2Arrive	There are places to go by spending a short time.
8	Concern_Health	I am concerned when using wheelchairs outdoors.
9	PhysicalCon1	I think the ramps in public places are comfortable to use.
10	PhysicalCon2	This product is required for floor conditions where I have to use a wheelchair.
11	Flexibility1	I think it has a flexible structure that allows for personalization at the time of purchase
12	Flexibility2	It can be used in any kind of ground
13	Flexibility3	I want it to have the flexibility to add a number of functions that I consider necessary
14	Flexibility4	If necessary, I can extend and shorten it appropriately.
15	Personalization1	I would like to customize some features to my own wishes.
16	Personalization2	It is a good idea to see the change in price simultaneously while personalizing the product
17	Personalization3	I want to determine features (wideness-angle, width, weight) of it.
18	Personalization4	I would like to determine the safety (barrier height, antiskipness, handrail etc.) of the product myself
19	Personalization5	I would like to determine the basic functions of the product such as ergonomics (storage, portability, installation-uninstallation, assembly and interconnection, etc.)
20	Triability	it is important to give trial time to understand the properties of the product.
21	Image	With using this product, I think I will have a different style among my friends who use it.
22	Compatibility	It is suitable for my style and way of living
23	InternalInfluence	I care about my relatives' opinions on this topic

(Cont. on next page)

Table 4.5. (Cont.)

24	ExternalInfluence	The promotions and advertisements of such products affect me
25	Mobility1	With the help of this product I can go anywhere I want
26	Mobility2	This product provides me more freedom of movement
27	Transport1	I can carry it anywhere
28	Transport2	I think it is easy and practical to carry
29	Regulation	I think that the necessity of keeping this product in public places (banks, hospitals, government offices ...) will provide practical solutions for accessibility and accessibility.
30	Support	I can get technical support quickly and easily
31	Security1	I may come up danger during use.
32	Security2	I find it safe to use.
33	Width	I find its width enough
34	Extend	It is important to be extendable
35	Light	I think it is light
36	Firm	I think it is strong
37	Stable	I think it is stable
38	Ergonomic	I think it is ergonomic
39	Cost	Purchase cost of the product is high (4.000 TL/meter)
40	CostAfford	It is affordable product
41	EoL1	It takes time to learn to use
42	EoL2	I can easily learn how to use
43	EoU1	I do not face difficulty while using.
44	EoU2	I think it is easy foldable
45	EoU3	I find it easy and practical to install
46	Usefulness1	I think it is useful
47	Usefulness2	It makes my daily life easier
48	Usefulness3	It helps my social life
49	Usefulness4	It allows me to easily overcome from obstacle
50	Usefulness5	I can be satisfied with this product
51	Attitude1	It is a good idea to use
52	Attitude2	I recommend to other people
53	Attitude3	I intend to use it
54	Intention1	I intend to buy
55	Intention2	I am planning to buy it soon

(Cont. on next page)

Table 4.6. (Cont.)

	KW	Based on the video and photo you have watched, please indicate which of the following words represent this product (select approximately 3-5 words)
56	dönüştürülebilen	-convertible
57	faydalı	-helpful
58	güvenilir	-reliable
59	hayati	-vital
60	modern	-modern
61	portatif	-portable
62	pratik	-practical
63	rahat	-comfortable
64	ulaşılabilir	-accessible
65	yenilikçi	-innovator
66	sağlam	-strong
67	Animal	If you were designing a logo for this application, which animal would you prefer to use as a representation?
68	Car	which car brand and car's model do you find close to this app?
69	Improvement	What do you recommend for making this product more useful?
70	Comment	Is there something you want to add?

4.5. Mass Customization Assistance Tool

All assembly means were illustrated to inform the users about general view of the product and to comprehend some technical terms and parts before starting the customization process (Fig. 4.4, Table 4.5).

It is aimed that the interface continuously interacts with the users, in aidition guides and warn them during the customization process. Thus, personal user manual for each individual is taken form while users customize their product.

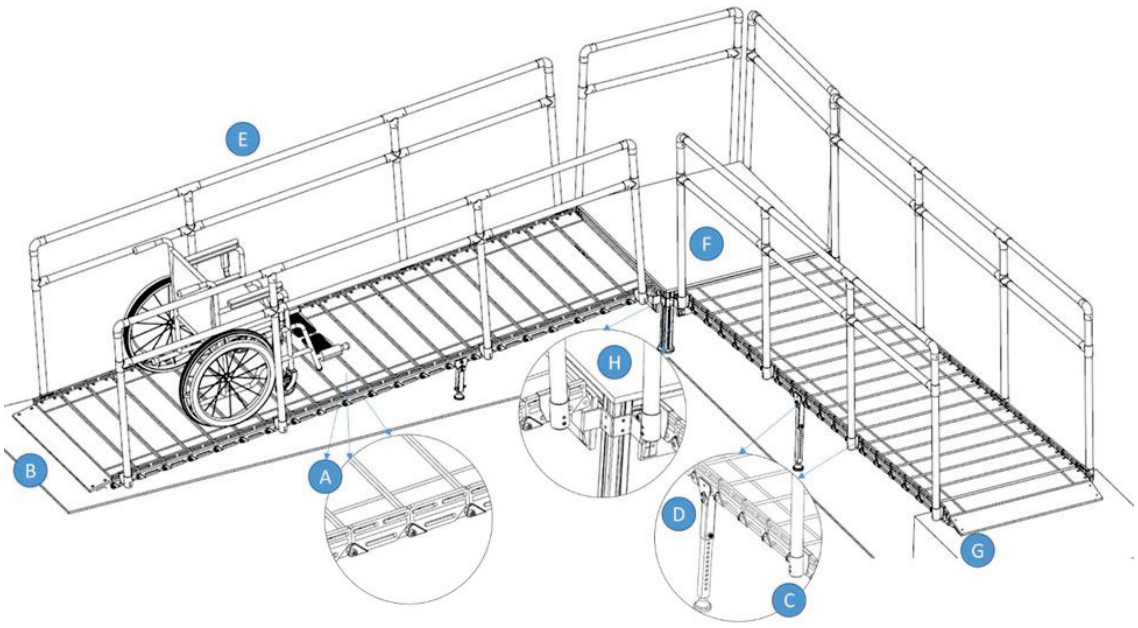


Figure 4.4. Main assembly components

Table 4.7. Components of the ramp assembly

(Source: Kumtepe, 2018)

A	Ramp Modules
B	Approach Plate
C	Handrail's Mounting Bracket
D	Telescopic Legs
E	Handrails
F	Rotation Platform
G	Positioning of the First Module on a Flat Surface
H	Ramp Mounting Bracket

4.5.1. Barrier to Climb

The very first selection during the customization process made by customer is climbing height which can be a threshold or stairs that customers want to climb with the help of the ramp.

4.5.2. Wheelchair Type

There are 3 options to select as a manual input which are:

1. Battery-operated wheelchair
2. Manual wheelchair with an assistant
3. Manual chair without any assistant

This selection leads user to find suitable slope angle without any consideration.

4.5.3. Slope

The slope is a computed value which is automatically selected by interface after evaluating the previous design input (wheelchair type). The slope value is the maximum slope that a battery-operated wheelchair, a manual wheelchair or a manual wheelchair with an assistant can climb according to literature and market survey.

4.5.4. Restricted Horizontal Distance

This input indicates the maximum distance from threshold to the most allowable distant point that ramp can be positioned.

4.5.5. Required Ramp Length

Required ramp length, is computed according to climb height and slope, which offers the most suitable and comfortable ramp climbing for wheelchair user. However, if the required ramp length is longer than restricted horizontal distance, the interface warns the user as showing the excessed distance and slope while offering different solution like using rotation platform for installing the ramp in different configuration.

4.5.6. Ramp Type

In this research this option is not activated to observe only rollable ramp preferences done by users. This manual input consists of “telescopic ramp”, “foldable ramp”, and “rollable ramp” options. However, these types of ramps (telescopic and foldable) are not suitable to further customization due to their non-modular structures which are not allowed users to extend or shorten the ramp length.

Rather than implicating these options mentioned above, users are able to select two options “one-piece” and “two-pieces” from the interface.

4.5.7. Ramp Width

This intermediary input is depended to previous selection. If user selects “two-pieces” option, interface selects 20 cm width automatically. However, if “one-piece” is selected, then user is able to select desired ramp width.

4.5.8. Maximum Load

User should specify the maximum desired load that will be carried by ramp.

4.5.9. The Most Suitable Load Bearing Capacity

Interface rounds maximum desired load up to the closest pre-designed load bearing capacity. For example, if user’s desired load bearing capacity is 250 kg/2m, so the interface rounds up 250 kg/2m to 300 kg/2m. Thus, interface eliminate the intermediate value which is not suitable for manufacturing. In other words, values are not in the interface’s library due to lack of mechanical tests, will be eliminated to accelerate mass customization process. However, this input can be inactivated to directly use user’s preference for manufacturing if interface’s pre-design and pre-computed values are already in the interface’s library.

4.5.10. Use Condition

This manual input is used for determining the factor of safety (FoS) (also called design factor) which can be defined a required constant value, generally determined by standards, laws, specifications or customs, to that a structure must at least equal or exceed. FoS is directly related to use conditions, and for this case FoS determined as below:

1. Individual usage, FoS=1.5
2. Individual usage with an assistant, FoS=2
3. Public usage, FoS=3

Interface informs and warns the user not to use the ramp under the conditions which are not selected by user. In other words, if user selects “individual usage”, then interface warns the user with the “Please do not use the ramp except under the determined use condition” message.

4.5.11. Factor of Safety

This computed input is determined by use condition which is selected by user as mentioned above.

4.5.12. Maximum (Real) Load Bearing Capacity

Real load bearing capacity is computed by multiplication of FoS and the most suitable load bearing capacity. For example, if use condition is selected as “public use” and the most suitable load bearing capacity is determined as 300 kg/2m, thus real load bearing capacity of the ramp will be 900 kg/2m to ensure high FoS for public usage.

4.5.13. Ramp Mass

Ramp mass (kg/m) is computed by interface with the ramp’s unit module mass information in the system library which was generated during parametric structural design phase.

4.5.14. Total Ramp Mass

Total ramp mass (kg) is computed by multiplication of ramp mass and required ramp length.

4.5.15. Deployability

Deployability option is used to select ramp installation type, so user is able to select these options during the customization process as follow:

1. Solid (one-piece): There is no deployment for this case. All modular members are locked to avoid deployment, which is preferred by customers who prefer to install ramp permanently.
2. Rollable Fold: can be rolled out like carpet on one side and carry load on the other side. This type of deployment option is suitable for whom use ramp frequently for temporary installations and have restricted storing area while ramp not in used.
3. Jackknife Fold: consists of hinges and load bearing panels. These two main members provide jackknife-like deployment which is preferred by user who has no difficulty to find a sufficient storing area while the ramp not in used.

4.5.16. Compactness

Compactness is calculated only for rollable ramp to show the diameter of 1-meter-long ramp (mm/m) in rolled position.

4.5.17. Total Compactness

Total compactness is calculated and drawn by interface parametrically, so the interface shows the illustration of rolled ramp and its diameter.

4.5.17.1. Compactness comparison

It is used for illustrating and comparing total ramp diameter with 1-meter-long ramp diameter in rolled positions. In this way, the computed parametric illustration provides a foresight for helping users to visualize and understand how their products will look exactly.

4.5.18. Type of Handling Equipment

Handling type is used for carrying the ramp in a desired place. User is able to select one of these options:

1. None
2. Wheels
3. Handle
4. Wheels & Handle

So, the equipment types are optional and directly effects the product cost.

4.5.19. Type of Storage

This equipment is used for selecting desired storage type while the ramp is not in use. User is able to select one of these options:

1. None
2. Case
3. Belt
4. Case & Belt

Case option is only available for 1-meter-long rolled ramp, while belt is suitable for every diameter in rolled position.

4.5.20. Extra Apparatus

Apparatus consist of pair of mounted brackets, telescopic leg, approach place, and quick release pin. If user selects “yes” option, then sub-options will be activated which

allow user to select amount of needed apparatus. This options directly effects the product cost.

4.5.20.1. Mounted bracket

Mounted brackets are used for attaching and securing the ramp onto a desired place. It is generally preferred if there is no adequate and/or suitable place to locate approach place securely.

4.5.20.2. Telescopic leg

Guaranteed load bearing capacity of ramp is only for 2-meter-long ramps due to structural design. After 2-meter, load bearing capacity will dramatically decrease and deflection will increase. However, interface warns users to use telescopic legs in every 2 meters, thus they can use ramp securely with the help of these extra optional apparatus.

4.5.20.3. Approach plate

Approach plates are used for eliminating the elevation difference between ground and the ramp. One approach plate is placed at the entrance while the other is placed at the end of it. One pair of approach plate has already included the product. However, if users want to divide the ramp for different purposes, they would demand extra telescopic legs.

4.5.20.4. Quick release pin

Ramp's modules are attached together with bolts and nuts. However, if ramp is needed to divide for example, carrying or storing purposes, quick release pins provide users ease of use while dividing the ramp into many pieces.

4.5.21. Extra Barrier

Ramp links' auxiliary function is to provide 25mm long side barrier. However, users would need extra side barrier due to laws, regulations, and/or personal preferences which can be varied according to different place of use, wheelchair types or countries. If user selects option "yes", then "side barrier length" option will be activated.

4.5.21.1. Side barrier length

Users can select the length of easy-attachable side barriers from 1 cm to 10 cm to obtain desired side barrier length.

4.5.22. Rotation Platform

The interface directly warns the user whether rotation platform is required or not due to required ramp length and restricted horizontal distance. If required ramp length is longer than restricted horizontal distance, then interface shows a warning message as "rotation platform is needed". However, user can take the responsibility to exceed suitable slope angle and use the ramp under the conditions of calculated slope angle. At this point users may select "yes" or "no" options according to their decisions.

4.5.22.1. Quantity of rotation platform

This option will be activated if user selects "yes" option in "rotation platform" preferences step. The interface calculates the required quantity according the user's previous selections (required ramp length and restricted horizontal distance).

4.5.23. Handrail

Users can demand handrails which is almost inevitable for some place of use. Users may choose "one-line" or "two –lines" options according to placement of ramp.

For example, user may select “one-line” handrail option while one side of the ramp would probably lean on a wall. Length of the handrail is calculated by interface automatically, so users do not need to worry about exact measurements.

4.5.24. Anti-Skidness

There are only “yes” or “no” options in this step. Is user selects “no” option, then interface warns the user that there is a risk of skidding.

4.5.25. UV Resistance

The user does not have to know technical details of UV resistance. Therefore, interface actually asks users under the which conditions the ramp will be used. Users are able to select one of these options:

1. Residential use
2. Under the shade outdoor use
3. Mostly or permanently outdoor use

Moreover, system warns users not to use the ramp under the conditions of direct sunlight if selection is residential and under the shade outdoor use.

4.5.26. Warning Message

Clients may need a warning message on the ramp, so this option allows users to write a warning message no more than 30 words which will be placed on desired position on ramp. For example, for public use like in a crowed concert organization, clients may want to display a warning message like “No more than 3 people at the same time” or “High-heel shoes are not suitable to use the ramp”.

4.5.26.1. Warning message placement

There are two options to select for displaying the warning message. Users are able to select one of these options:

1. Display on the approach plate
2. Display throughout the ramp

So, message will be placed on the preferred place according to options.

4.6. Relationship Matrix Diagram of Design Parameters

Relationship matrix diagram is used for showing the direct or indirect relationships between the parameters. In this matrix, only direct relationships are illustrated (Fig. 4.5 and 4.6).

4.7. General Overview of the Smart Tool

Designed tool has been generated in Excel, which consists of 5 main section that shows parameters, user selection, consistency calculations and warning messages, general information about main parts of the ramp and dynamically changing rolled ramp illustrations (Fig 4.7). Fully defined formulas can be found in Appendix.

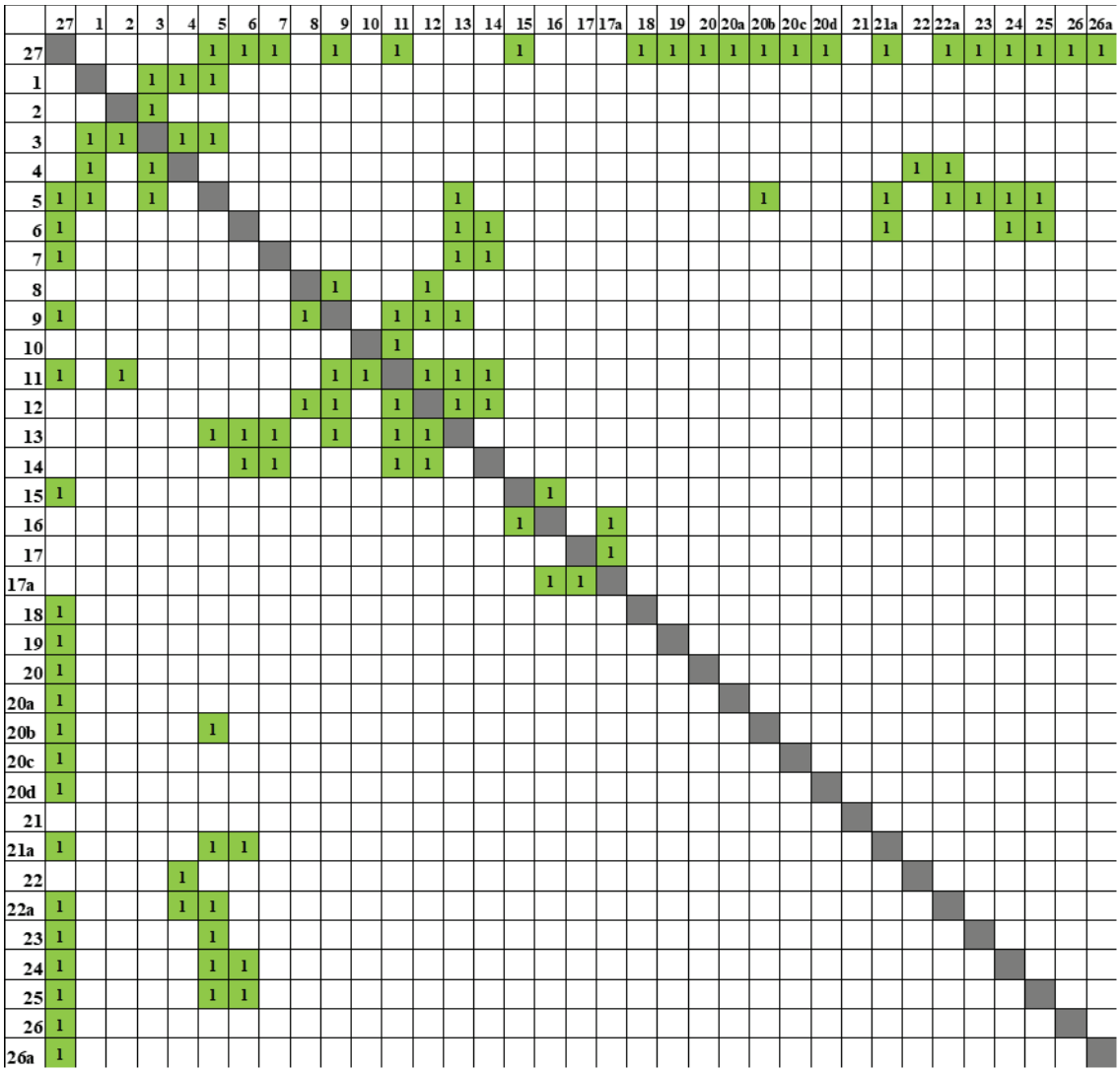


Figure 4.5. Relationship matrix diagram of design parameters

No	PARAMETERS	No	PARAMETERS
27	Total Price (TL)	17a	Comparing compactness
1	Barrier to climb (cm)	18	Type of handling (handle, wheels, none)
2	Wheelchair type	19	Type of storage
3	Slope (100*H/L) %	20	Extra aparatus needed?
4	Restricted horizontal distance (cm)	20a	Mounted Bracket (pair)
5	Required Ramp Length (cm)	20b	Telescopic Legs (pair)
6	Ramp type	20c	Approach Plate (pair)
7	Width (mm)	20d	Release Pim (pair)
8	Max Load (kg)	21	Side Barrier (extra barrier needed?)
9	Most Suitable Load bearing capacity with FoS (kg/2m)	21a	Side Barrier (cm)
10	Use Condition	22	Rotation platform needed?
11	Factor of Safety (FoS)	22a	Rotation platform (qty)
12	Max (real) Load bearing capacity (kg/2m)	23	Handrail needed?
13	Ramp Mass (kg/m)	24	Anti-Skidness
14	Total Ramp Mass (kg)	25	UV Resistance
15	Deployability	26	Warnings (No More Than 300 Characters)
16	Compactness (diameter/1m ramp length - mm/m)	26a	Warning Message Placement
17	Total Compactness (diameter/m total ramp length - mm/m)		

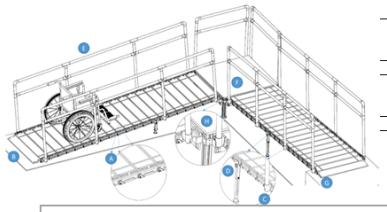
Figure 4.6. Design parameters

	PARAMETERS	USER SELECTION	COMPUTATIONS/APPROPRIATENESS
	Total Price (TL)	2,940.38 ₺	
1	Barrier to climb (cm)	20 cm	11.880 cm maximum distance you can climb at an appropriate angle. This distance cannot be exceeded at an appropriate angle. It is recommended that you add a rotation platform.
2	Wheelchair type	Battery-operated wheelchair	Please select the suitable option to determine the appropriate inclination angle.
3	Slope (100*H/L) %	12	20.202 % computed slope is pro ired rotation platform Recomended maximum slope is
4	Restricted horizontal (cm)	99 cm	The horizontal length required f h appropriate angle is 167 cm The ramp cannot be positioned e angle for this horizontal distance. Please add a rotation platform.
5	Required Ramp Leng	168 cm	Suitable ramp length according .
6	Ramp type	one-piece	Please select width from the lis
7	Width (mm)	700 mm	Please pay attention to wheelch
8	Max Load (kg)	250 kg	Please write the maximum mas ill carry.
9	Most Suitable Load b acity with FoS (kg/2m)	300 kg/2m	Telescopic feet are required for an 2 meters.
10	Use Condition	Individual use	Please do not use your ramp ou ons you determined.
11	Factor of Safety (FoS)	1.5	FoS is determined according to
12	Max (real) Load beari ty (kg/2m)	450 kg/m	Maximum load bearing capacity
13	Ramp Mass (kg/m)	6.02 kg/m	The mass of a 1 meter long ramp
14	Total Ramp Mass (kg)	13.47 kg	The total mass of the ramp.
15	Deployability	Rollable	
16	Compactness (diame mp length - mm/m)	385 mm/m	Illustration A1 shows compactne -long ramp in rolled position.
17	Total Compactness (d m total ramp length - mm/m)	492 mm/m	Illustration A2 shows compactne n-long ramp in rolled position.
17a	Compareing compact	107 mm/m	Illustration B1 shows compariso A2 in rolled position.
18	Type of handling (har els, none)	Handle	It will be shipped with your ram
19	Type of storage	Case	It will be shipped with your ram
20	Extra aparatus neede	Yes	Please select at least 1 item fro
20a	Mounted Bracket (	1	pair
20b	Telescopic Legs (p	1	pair Telescopic feet are not required er than 2 meters.
20c	Approach Plate (p	1	pair
20d	Release Pim (pair)	5	pair
21	Side Barrier (extra barrier needed?)	Yes	Please select barrier height from the list below.
21a	Side Barrier (cm)	4 cm	Modular side barrier will be shipped with your ramp.
22	Rotation platform needed?	No	Rotation Platform Required!
22a	Rotation platform (qty)	0	Rotation platform will be shipped with your ramp
23	Handrail needed?	Two-lines	Handrail dimensions will be calculated according to the ramp length.
24	Anti-Skidness	Yes	Standard anti-skidness.
25	UV Resistance	Mostly or permanently outdoor use	Suitable for outdoor use.
26	Warnings (No More Than 300 Characters)	RAMP IS SUITABLE FOR INDIVIDUAL USE ON	Your warning meeage is suitable for displaying.
26a	Warning Message Placement	Display on the approach plate	The message specified will be displayed in the selected location.

PARAMETERS

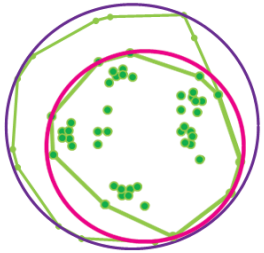
USER SELECTION

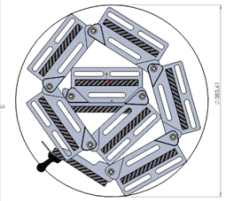
CONSISTENCY CALCULATIONS AND WARNING MESSAGES

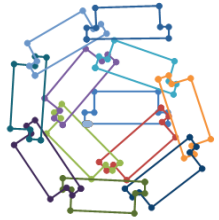


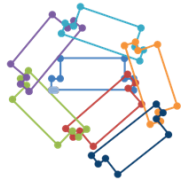
A	Approach Plate
B	Approach Plate
C	Handrail's Mounting Bracket
D	Telescopic Legs
E	Handrails
F	Rotation Platform
G	Positioning of the First Module on a Flat Surface
H	Ramp Mounting Bracket

GENERAL INFORMATION ABOUT MAIN PARTS OF THE RAMP









DYNAMICALLY CHANGING ROLLED RAMP ILLUSTRATIONS

Figure 4.7. General overview of the smart tool

CHAPTER 5

FINDINGS

This chapter summarize the findings of the study. Experimental study, which conducted with SPSS, includes descriptive and regression analyses. ANOVA, correlation and reliability analyses test results.

5.1.Findings of Semi-Structured Face to Face Interview

This research was conducted 3 female and 5 male participants. Table 5.1 shows the profile of interviewees.

Table 5.1. Participants profile of qualitative research

Participant	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cause of handicap	Spinal Cord Injury	Spinal Cord Injury	Cerebral Palsy	Spina Bifida	Spina Bifida	Cerebral Palsy	Spina Bifida	Cerebral Palsy
Age	27	38	18	37	23	12	16	17
Gender	M	M	M	F	F	F	M	M
Occupation	state official	state official	No	no	student	student	no	no
Residence type	flat	Flat	Flat	flat	flat	house	flat	flat
Fixed ramp	yes (self-built)	yes (self-built)	no (financial incapability)	no (built a direct door to garden)	no (want one)	no (want one)	no (not suitable for building one)	no (financial incapability)
Portable ramp	no	No	No	no	no	no	no	no
Battery-operated wheelchair	yes	Yes	No	yes	yes	yes	no	no
Entrance threshold	yes	Yes	Yes	yes	yes	yes	yes	yes
Ownership status	House holder	House holder	Lease holder	House holder	House holder	House holder	Lease holder	Lease holder

The questions begin with identifying potential users' accessibility and usability problems they encountered in everyday life. All attendees have complained about accessibility problems due to the inadequacy or the absence of ramps in public places such as hospitals, historical buildings and their relatives' houses. And they emphasized that they do not prefer to leave their houses unless it is necessary, rather than to face and struggle accessibility problems in their daily lives.

It was asked whether they are able to use effectively the fixed ramps placed in public spaces and whether these ramps were in conformity with the dimensional standards. All eight attendees have pointed out they are not able to use these public ramps without any assistance because of ill-designed ramps not meeting the dimensional standards in terms of slope, width, nonskid surface.

It is generally stated by attendees that they have difficulty in using public transportation. Moreover, most of the participants complained that the bus ramps have no barrier on sides that causes danger of falling.

When participants were asked whether they had their own portable ramp, it was revealed that some of the participants surprisingly were not aware of the existence of portable-foldable ramps in the market.

It was revealed that all of the participants are dwelling on the ground floor and only three of the participants have a fixed ramp at the entrance of their apartment or the balcony of their own house. The remaining five participants mentioned about why they are not using a fixed ramp at their apartment. According to their responses, the main reasons are as following:

- The narrowness of the apartment entrance to locate a fixed ramp (blocking the entrance and stairs permanently)
- The lack of the necessary distance to provide the appropriate angle of inclination for a wheelchair user
- Being faced with some problems with their neighbors (for some functional and/or aesthetic reasons)

After exploring three main themes in the interview, it was intended to get more detailed suggestions from wheelchair users about how a good-designed deployable ramp should be. To this end, some videos of portable ramps in the market with three different types of deployment method (foldable, telescopic and rollable) were demonstrated to the participants. Thereafter, participants' opinions were asked for uncovering the most

wanted and desired functional features from a portable ramp. It was understood that all participants had a common view about the most desirable features are:

- Lightness
- Ease of deployment, transportation and installation
- Compactness

In addition, all participants who have seen these portable ramps for the first time, claim that they are going to acquire one because they have found the idea of having a portable and storable ramp very interesting, practical and useful.

According to attendees, rollable ramps are the most desired design with respect to their modularity that offers flexibility to extend the ramp length easily. Besides, they have found telescopic ramps are practical in terms of loading their wheelchair to their personal motorized vehicles such as van or car.

5.2.Findings of Observation During Product Trail

During the observation stage, semi-structured face-to-face interview question has been shaped. Besides, some interesting biases of wheelchair users have been uncovered. Most of the participants comment positively about lightness, compactness, portability, modularity, reconfigurability, ease of storage, anti-skidness, indoor-outdoor usage ability, deployability, customizability, and rapid solution for accessibility. Three of the potential participants were acting with suspicious towards the ramp and they did not want to participate the test. While the reason of this doubtful action has been asked, they answered as:

- The material used is unfamiliar for me. It is not look like metal.
- I have never heard about carbon fiber material. I am not sure whether it is durable or not.
- I have never used this kind of portable ramp before. I do not want to try it now.

Some of the relatives of participants wanted to round and then set up the ramp. It is observed that in general, they could easily perform the process and were satisfy about the lightness of the product.

Wheelchair users did not face any problem in terms of slipping or falling. Ramp width is quiet enough for every wheelchair which is owned by participants and suitable

to locate door entrance where the observation was conducted. Slope was suitable due to ramp is 2-meter-long that could be modified according to threshold length easily. Handles did not cause any problem in terms of not blocking the passage.

Table 5.2. Strength and weakness

Strength	**Weakness**
Light	Crunching Sound
Compact	Unfamiliar Material
Portable	Bias Towards a New Product
Modular	Unfamiliar Product
Reconfigurable	
Ease of Storage	
Anti-Slip	
Indoor-Outdoor Use	
Deployable	
Customizability	
Rapid Accessibility	

5.3.Findings of User Experiences

Users' opinions and suggestions about prototype were taken during field test in terms of ramp width, load-bearing capacity, anti-slip surface sufficiency and efficiency. Most of the participants commented positively about lightness, compactness, portability, modularity, reconfigurability, ease of storage, anti-slipness, indoor-outdoor usage ability, deployability, customizability, and rapid solution for accessibility. All the participants indicated that anti-slip surface of the ramp was much more effective than any other fixed public ramps. Four of the participants found the ramp quite wide due to their narrower wheelchairs and suggested that a narrower ramp may be more effective. All of the participants found the design practical to use in their daily life and claimed that they may purchase one. Two of the participants had their family members during field test and their opinions are also taken. Family members gave feedback about the general design, ease of use, weight and ease of storage and possible place of use. All feedbacks were positive in terms of satisfying users' expectations. One of the family members suggested that the ramp may not only be used for outdoor but also can be used for indoor such as shower stall.

During the field tests, users were asked to comment on the design in the most general sense. It was the first time seeing a deployable portable ramp for 7 of the participants. In general, all users have been approached positively on a ramp which provides ease of storage and transportation in order to overcome the entrance thresholds and declared that they would like to have one, if the products are affordable for them. Some of the participants have suggested that the product may available for every wheelchair user as like in the case of wheelchair donations made by philanthropists to associations and municipalities.

In particular, the parents of wheelchair users under the age of 18 said that they generally experience and overcome some difficulties like obstacles and thresholds by holding their children in their arms. However, they mentioned that this is not a permanent solution while their children are growing up day by day, it will not be possible to be carried by them. Moreover, this situation would create difficulties for themselves (spinal disc herniation and/or other health problems related with this) and may cause lack of self-confidence during children's adolescence periods. In this context, all of the participants have a positive approach to the idea of having a lightweight and portable ramp which is easy to carry and store.

It was asked whether the handle (provides ease of carrying) mounted on the approach plate causes any difficulties while using it. All of the participants stated that the handle did not constitute any obstacle and it was in a suitable place and position since it provided ease of transportation.

When the participants, who have seen or used similar portable ramps before, were asked to compare market products with the product that was designed and prototyped during the project, overlapping answers were received for the purpose of the project. Users mentioned that they have generally perceived the ramp as:

- lighter
- takes up less space while not in use
- provides ease of handling and carrying

compared to the market products.

When asked to comment on the efficiency and frequency of the anti-slip tapes, they stated that they provide better anti-skidness compared to most of the ramps in public use.

The users asked whether the ramp width (800 mm) provides a comfortable transition, they stated that it is quite wide even for a wider manual wheelchair and a narrower ramp can meet their needs.

5.4. Findings of Experimental Study

General profile of the participants can be seen from table 5.3. Of the 46 participants, 36 are male and 10 are female. Most of the participants are at the ages ranging in between 25-44, and the majority of participants are university graduated.

Table 5.3. Participants average profile

Variables	Frequency	Percentage
Gender		
Female	10	21.74%
Male	36	78.26%
Age		
24 or below	2	4.35%
25-34	19	41.30%
35-44	16	34.78%
45 or above	9	19.57%
Education Level		
Primary school High	5	10.87%
High school	13	28.26%
Collage	6	13.04%
University	18	39.13%
Master's Degree	4	8.70%
PhD	0	0.00%
Monthly Income		
0-1000 TL	1	2.17%
1001-2000 TL	12	26.09%
2001-3000 TL	9	19.57%
3001-4000 TL	12	26.09%
4001 TL and above	12	26.09%

5.4.1. Descriptive Analyses

Number of respondents, mean, standard deviation, minimum, and maximum values of the constructs were summarized in Table 5.4.

Table 5.4. The most preferred constructs according to descriptive analyses

No	Construct	Mean	Question
34	Extend	4.50	It is important to be extendable
29	Regulation	4.48	I think that the necessity of keeping this product in public places (banks, hospitals, government offices ...) will provide practical solutions for accessibility and accessibility.
20	Triability	4.41	It is important to give trial time to understand the properties of the product.
16	Personalization2	4.39	It is a good idea to see the change in price simultaneously while personalizing the product
46	Usefulness1	4.35	I think it is useful
15	Personalization1	4.33	I would like to customize some features to my own wishes.
14	Flexibility4	4.30	If necessary, I can extend and shorten it appropriately.
39	Cost	4.30	Purchase cost of the product is high (4.000 TL/meter)
18	Personalization4	4.28	I would like to determine the safety (barrier height, antiskipness, handrail etc.) of the product myself
17	Personalization3	4.28	I want to determine features (wideness-angle, width, weight) of it.
19	Personalization5	4.22	I would like to determine the basic functions of the product such as ergonomics (storage, portability, installation-uninstallation, assembly and interconnection, etc.)
42	EoL2	4.15	I can easily learn how to use
47	Usefulness2	4.04	It makes my daily life easier
13	Flexibility3	4.02	I want it to have the flexibility to add a number of functions that I consider necessary

The descriptive statistics reveal that most of the participants agree with the extend and regulation construct that indicates extendibility is important and keeping the ramp in the public places will provide practical solutions for accessibility. They generally think that personalization concept for such product is highly demanded. All these demand about personalization, cost, and flexibility construct are related with mass customization

concept which is parallel with the idea of proposed smart mass customization tool. Moreover, most of the participants think that the product is useful and triability is important before decision of purchasing. In addition, they think that it is easy to learn the product how to use (Table 5.5).

5.4.2. Reliability Test

Reliability test is used for measuring the internal consistency of the constructs contain more than one question items. Internal consistency is testes with Cronbach's Alpha coefficient which is selected 0.6 as threshold value. A construct can be considered "reliable" if Cronbach's Alpha coefficient is bigger than 0.6.

As can be seen from Table 5.5, Self_efficacy and PhysicalCon constructs do not show internal consistency, thus these constructs will be used as separate items in SPSS analysis. In addition, all of the intermediary constructs (Intention, Usefulness, EoU and Attitude) are highly reliable.

Table 5.5. Reliability Analysis

Construct	Number of question items	Cronbach's Alpha
Self_efficacy	2	0.342
PhysicalCon	2	-0.718
Flexibility	4	0.623
Personalization	5	0.731
Mobility	2	0.839
Transport	2	0.888
Security	2	0.647
EoL	2	0.686
EoU	3	0.851
Usefulness	5	0.906
Attitude	3	0.804
Intention	2	0.947

5.4.3. Results of ANOVA

ANOVA analysis is conducted according to demographic values (age and education). The significant results for ANOVA analysis based on age construct can be seen in Table 5.6.

The significant results for ANOVA analysis based on age construct can be seen in Table 5.7. Wheelchair users at the age of 25-34 are affected by the promotions and advertisements of such products more than people at the age of any other range. Another interesting result, users at the age of 45 and above claimed that they can easily learn how to use the product and do not face difficulty while using the ramp more than any other group of people. Moreover, wheelchair users at the age of 24 or below and 25-34 have similar attitude towards the using the ramp. People at the age of 25-34 claimed that the product provides them more freedom of movement.

Table 5.6. ANOVA Analyses by Mean Age

No	Construct	F	Sig.	24 or below (N=2)	25-34 (N=19)	35-44 (N=16)	45 and above (N=9)
24	External Influence	3.097	0.037	3.00	4.16	3.25	2.78
42	EoL2	2.518	0.071	4.50	3.68	4.25	4.89
53	Attitude3	1.903	0.144	4.00	4.00	3.06	3.78
43	EoU1	1.771	0.167	4.00	3.68	3.31	4.44
26	Mobility2	1.637	0.195	3.50	4.32	3.56	4.11

The most significant detail about ANOVA analyses by education level (Table 5.8) that wheelchair users, who have collage degree, are not relatively cautious in adopting new product, while primary school graduated people are approaching these kinds of products cautiously. In addition, wheelchair users with master's degree found the ramp much more required for ground conditions where they have to use a wheelchair more than any other group of people.

Table 5.7. ANOVA Analyses by Mean Education Level

No	Construct	F	Sig.	Primary school (N=5)	High school (N=13)	Collage (N=6)	University (N=18)	Master's Degree (N=4)
3	Innovativeness	3.618	0.064	3.80	3.08	2.33	2.78	2.50
10	PhysicalCon2	2.737	0.105	4.40	3.46	3.67	3.94	4.75

5.4.4. Result of Correlation Analyses

Correlation analysis shows the relationship between constructs. The correlation results of intermediary variables can be seen in Table 5.8. Full correlation analyses can be found in appendix.

Table 5.8. Correlation Results

Pearson Correlation				
	Ease of Use	Usefulness	Attitude	Intention
Ease of Use	1.000 ***	0.693 ***	0.651 ***	0.410 **
Usefulness	0.693 ***	1.000 ***	0.852 ***	0.505 ***
Attitude	0.651 ***	0.852 ***	1.000 ***	0.640 ***
Intention	0.410 **	0.505 ***	0.640 ***	1.000 ***

* : $p<0.05$
** : $p<0.01$
*** : $p<0.001$

5.4.5. Results of Regression Analyses

Regression Analysis is used to examine relationships between the constructs in the adoption taxonomy. Table 5.9 shows the summarizing results for regression analysis. According to regression analyses, results show that attitude is a direct determinant of users' intention toward the portable ramps with a coefficient of .640 ($p<0.001$). Attitude is directly affected by usefulness with a coefficient of .852 ($p<0.001$). However, there is not a direct effect of Ease of Use on Attitude. Moreover, Mobility, EoU and Compatibility are direct determinants of Usefulness perception. Mobility has also an effect on Ease of

Use perception. In addition, Transport, EoL and Mobility are direct determinants of Ease of Use perception.

Table 5.9. Results of regression analyses

Dependent variable	Independent veriable	Unstrandardized B	Std. Error	Standardized Beta	t	Sig.
Intention	(Constant)	-0.222	0.581		-0.381	0.705
	Attitude	0.826	0.150	0.640	5.524	0.000
Attitude	(Constant)	0.247	0.334		0.739	0.464
	Usefulness	0.891	0.082	0.852	10.809	0.000
Usefulness	(Constant)	0.736	0.288		2.554	0.014
	Mobility	0.416	0.090	0.483	4.634	0.000
	EoU	0.243	0.090	0.260	2.718	0.010
	Compatibility	0.201	0.083	0.266	2.435	0.019
Ease of Use	(Constant)	-0.034	0.580		-0.059	0.953
	Transport	0.368	0.102	0.453	3.623	0.001
	EoL	0.344	0.101	0.347	3.410	0.001
	Mobility	0.304	0.115	0.331	2.633	0.012

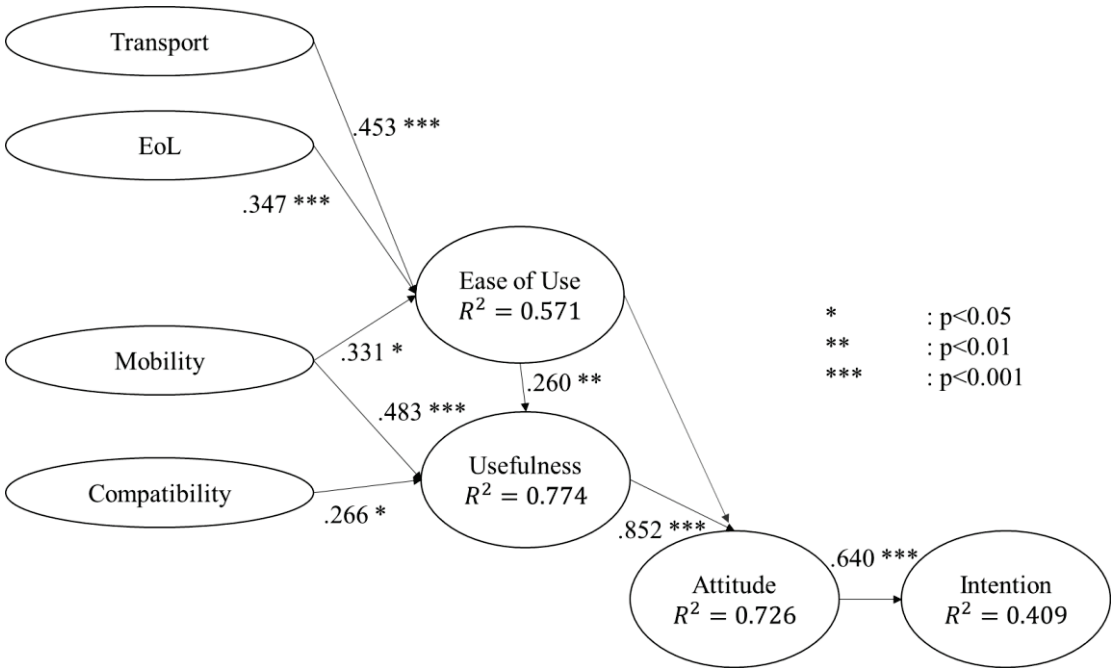


Figure 5.1. Results of portable ramps adoption framework

CHAPTER 6

MASS CUSTOMIZATION ASSISTANCE TOOL: DESIGN AND DEVELOPMENT

Mass customization level of the proposed model can be considered a customized fabrication while its approach is collaborative customization (see Fig 2.3 and Table 2.4). In other words, customized fabrication offers the customers a base product which will be modified according to customers' choices within the range of company's product family while customers' needs are understood and analyzed and used in manufacturing process directly.

Framework of the mass customization has been illustrated, and MI, CV and I parameters were elaborately explained in section 4.5. All design parameters are related with length customization, structural customization, storage customization, ease of use customization, extra apparatus and equipment need, and price customization.

6.1. Specifications of the Mass Customization Tool

Framework of the mass customization was illustrated, and MI, CV and I parameters were elaborately explained in section 4.5. In this chapter, user selections' options and their relationships with other parameters are shown. Consistency calculation and warning messages are illustrated as formulations as well. General information about main parts of the ramp was illustrated to inform user before customization process. And finally, a dynamically changing rolled ramps illustration shows compactness to visualize how final customized product will be look like.

6.1.1. User Selection

User selection consists of MI, CV and I selection options. MI has expanded selection options or directly manual inputs which are shown with green color, while grey-

colored restricted options (CV) are calculated in background automatically. Intermediary (I) options are activated or inactivated according to previous MI selection (Fig. 6.1).

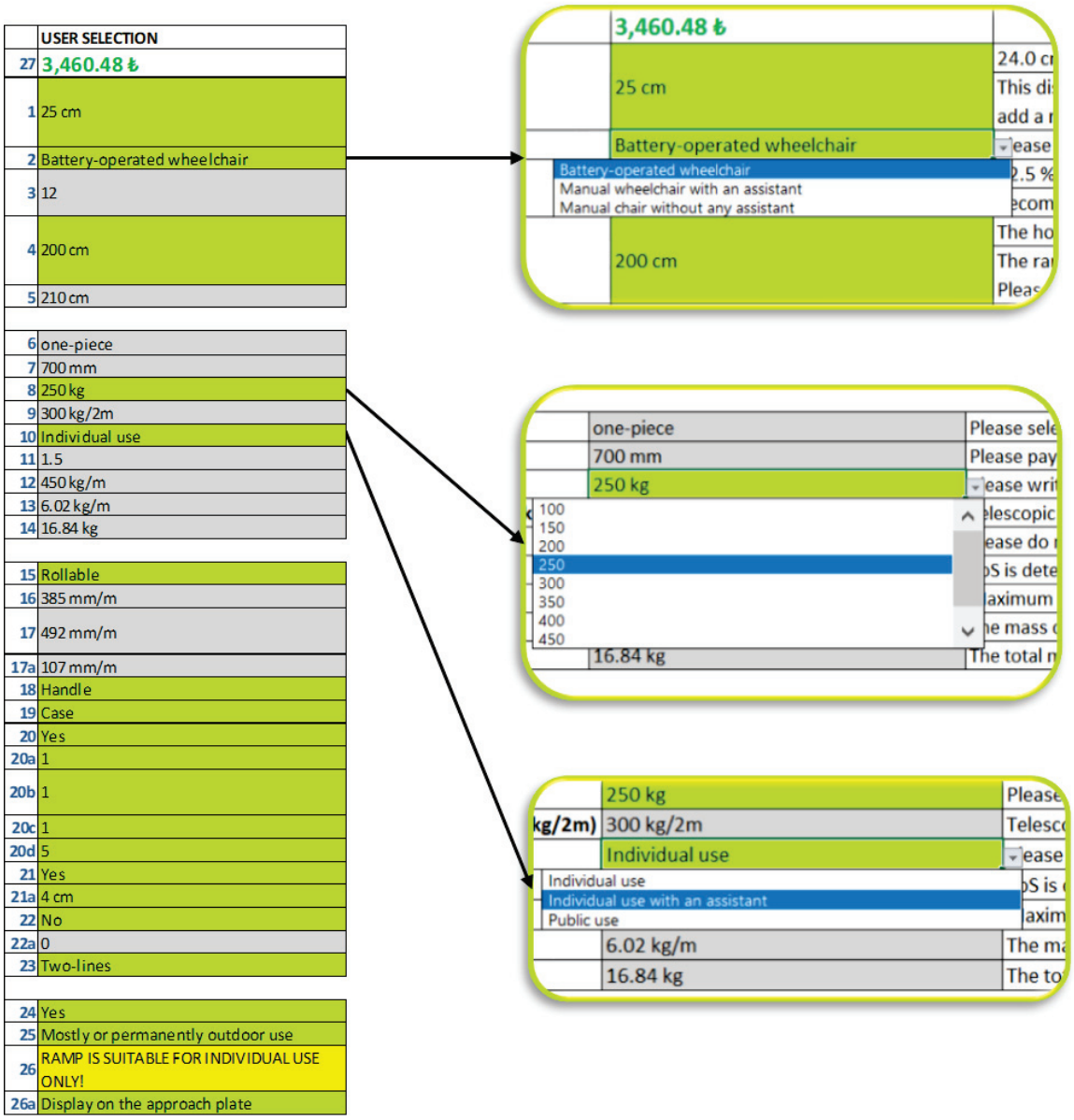


Figure 6.1. Expand selection options

6.1.2. Consistency Calculations and Warning Messages

All MI, CV and I parameters are parametrically related each other and offers thousands of different solutions to customers. Figure 6.2 illustrates computations to show consistency calculations and warning messages.

	USER SELECTION	COMPUTATIONS/APPROPRIATENESS
	3,526.98 ₺	Total price of the product is ₺3,526.98 according to your selections.
1	30 cm	24.0 cm maximum distance you can climb at an appropriate angle. This distance cannot be exceeded at an appropriate angle. It is recommended to add a rotation platform.
2	Battery-operated wheelchair	Please select the suitable option to determine the appropriate inclination angle.
3	12	Computed slope is 15. % which is not required rotation platform Recomended maximum slope is 12%
4	200 cm	The horizontal length required for climbing at an appropriate angle is 250 cm The ramp cannot be positioned at an appropriate angle for this horizontal distance.
5	252 cm	Suitable ramp length according to your selection.
6	one-piece	Please select width from the list
7	800 mm	Please pay attention to wheelchair width.
8	250 kg	Please write the maximum mass that the ramp will carry.
9	300 kg/2m	Telescopic feet are required for ramps longer than 2 meters.
10	Individual use	Please do not use your ramp outside the conditions you determined.
11	1.5	FoS is determined according to use condition.
12	450 kg/m	Maximum load bearing capacity with FoS
13	6.43 kg/m	The mass of a 1 meter long ramp.
14	21.6 kg	The total mass of the ramp.
15	Rollable	Deployment type
16	385 mm/m	Illustration A1 shows compactness of the 100-cm-long ramp in rolled position.
17	592 mm/m	Illustration A2 shows compactness of the 252-cm-long ramp in rolled position.
17a	207 mm/m	Illustration B1 shows comparison of the A1 and A2 in rolled position.
18	Handle & Wheel	It will be shipped with your ramp.
19	Case	It will be shipped with your ramp.
20	Yes	Please select at least 1 item from the list below.
20a	1	pair
20b	1	pair Min 1.0 telescopic ramp feet pair(s) is/are required.
20c	1	pair
20d	5	pair
21	Yes	Please select barrier height from the list below.
21a	4 cm	Modular side barrier will be shipped with your ramp.
22	No	Rotation Platform Required!
22a	0	Rotation platform will be shipped with your ramp
23	None	
24	Yes	Standard anti-skidness.
25	Mostly or permanently outdoor use	Suitable for outdoor use.
26	RAMP IS SUITABLE FOR INDICIDUAL USE ONLY!	Your warning meeage is suitable for displaying.
26a	Display on the approach plate	The message specified will be displayed in the selected location.

Figure 6.2. Consistency calculations and personalized warning messages

As can be seen from figure 6.2, consistency calculations and warning messages warn and lead to user during decision making process. For example, tool warns the user about horizontal distance which is not appropriate to satisfy suitable ramp slope without

a rotation plate (in this case, 12% ramp slope is the maximum slope for battery-operated wheelchairs). The tool also shows user the calculation of slope angle whether she/he does not prefer to use a rotation plate with the messages of "This distance cannot be exceeded at an appropriate angle. It is recommended to add a rotation platform" and "Computed slope is 15% which is not required rotation platform". In this way, decision is entirely up to user who may add a rotation platform to satisfy proper slope angle or may take the risk and prefers the 15% slope angle.

Calculations and warning messages also serve as a personalized user's manual in which can be used.

As can be seen from Fig. 6.3 and 6.4, two different scenarios have been illustrated to show how different selections effect the computations, warning massages and total price. Extra apparatus and mounting means were excluded from scenario to focus on parametric changes in between price and length, width, slope, mass and strength calculations. The first scenario represents individual use while the second scenario represents public use.

In the first scenario, "barrier to climb" has been selected 30 cm while wheelchair type is battery-operated, thus maximum slope angle automatically defined as 12%. Restricted horizontal distance has been selected shorter than required ramp length to observe changes in warning messages between two scenarios. Respectively in the first and second scenario, maximum loads have been selected as 250 kg and 350 kg while use conditions have been determined as "individual use" and "public" which has a direct effect on factor of safety. On the other hand, the second scenario were selected totally different on purpose to compare these two different cases.

6.1.3. General Information About Main Parts of the Ramp

See Figure 3.5., all assembly means are illustrated to inform users about general view of the product and to comprehend some technical terms and parts before starting the customization process. Also, it shows the base design in rolled position (Fig 4.5 and 4.6).

User Scenario-1

	PARAMETERS	USER SELECTION	COMPUTATIONS/APPROPRIATENESS
	Total Price (TL)	1,809.38 ₺	Total price of the product is ₺1,809.38 according to your selections.
1	Barrier to climb (cm)	30 cm	24.0 cm maximum distance you can climb at an appropriate angle.
			This distance cannot be exceeded at an appropriate angle. It is recommended to add a
2	Wheelchair type	Battery-operated wheelchair	Please select the suitable option to determine the appropriate inclination angle.
3	Slope (100*H/L) %	12	Computed slope is 15. % which is not required rotation platform
			Recomended maximum slope is 12%
4	Restricted horizontal distance (cm)	200 cm	The horizontal length required for climbing at an appropriate angle is 250 cm
			The ramp cannot be positioned at an appropriate angle for this horizontal distance.
5	Required Ramp Length (cm)	252 cm	Suitable ramp length according to your selection.
6	Ramp type	one-piece	Please select width from the list
7	Width (mm)	600 mm	Please pay attention to wheelchair width.
8	Max Load (kg)	250 kg	Please write the maximum mass that the ramp will carry.
9	Most Suitable Load bearing capacity with FoS (kg/2m)	300 kg/2m	Telescopic feet are required for ramps longer than 2 meters.
10	Use Condition	Individual use	Please do not use your ramp outside the conditions you determined.
11	Factor of Safety (FoS)	1.5	FoS is determined according to use condition.
12	Max (real) Load bearing capacity (kg/2m)	450 kg/m	Maximum load bearing capacity with FoS
13	Ramp Mass (kg/m)	5.6 kg/m	The mass of a 1 meter long ramp.
14	Total Ramp Mass (kg)	18.82 kg	The total mass of the ramp.

User Scenario-2

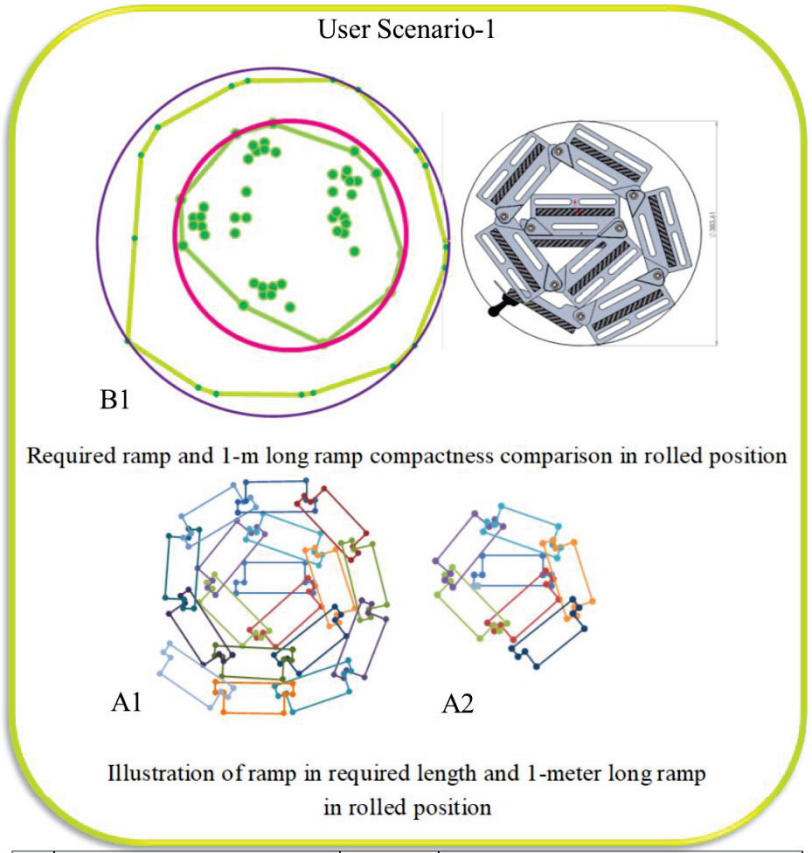
	PARAMETERS	USER SELECTION	COMPUTATIONS/APPROPRIATENESS
	Total Price (TL)	4,250.00 ₺	Total price of the product is ₺4,250.00 according to your selections.
1	Barrier to climb (cm)	15 cm	16.0 cm maximum distance you can climb at an appropriate angle.
			The specified distance can be easily climbed with an appropriate inclination angle.
2	Wheelchair type	Manual wheelchair with an assis	Please select the suitable option to determine the appropriate inclination angle.
3	Slope (100*H/L) %	8	Computed slope is 7.5 % which is not required rotation platform
			Recomended maximum slope is 8%.
4	Restricted horizontal distance (cm)	200 cm	The horizontal length required for climbing at an appropriate angle is 188 cm
			Restricted horizontal distance is appropriate for positioning the ramp
5	Required Ramp Length (cm)	188 cm	Suitable ramp length according to your selection.
6	Ramp type	one-piece	Please select width from the list
7	Width (mm)	800 mm	Please pay attention to wheelchair width.
8	Max Load (kg)	350 kg	Please write the maximum mass that the ramp will carry.
9	Most Suitable Load bearing capacity with FoS (kg/2m)	400 kg/2m	Telescopic feet are required for ramps longer than 2 meters.
10	Use Condition	Public use	Your ramp will be manufactured with a high safety factor.
11	Factor of Safety (FoS)	3	FoS is determined according to use condition.
12	Max (real) Load bearing capacity (kg/2m)	1200 kg/m	Maximum load bearing capacity with FoS
13	Ramp Mass (kg/m)	8.93 kg/m	The mass of a 1 meter long ramp.
14	Total Ramp Mass (kg)	11.2 kg	The total mass of the ramp.

Figure 6.3. User selection scenario 1 and 2

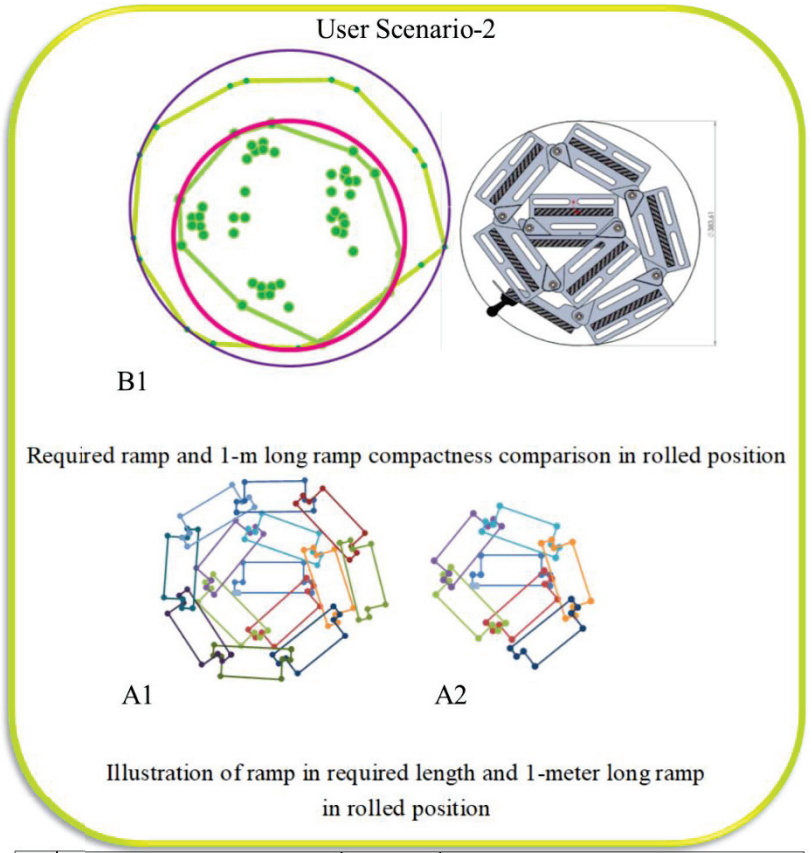
6.1.4. Dynamically Changing Rolled Ramp Illustrations

This section gives a visually foresight about customized design and its comparison with the base product is illustrated (Fig. 6.4). Even though, it is possible to change link geometry by changing design parameters, customization tool does not allow users such customization. The reason is that such strength calculations are complicated and required mechanical tests. However, it would be possible to make customization if a finite element analysis could be integrated in tool or an integration of library which contains mechanical properties of exact link shape and geometry for any specific material.

During experimentation with the tool, observed few parametric errors have been fixed and overall interface has been improved to be more user-friendly.



16	Compactness (diameter/1m ramp length - mm/m)	385 mm/m	Illustration A1 shows compactness of the 100-cm-long ramp in rolled position.
17	Total Compactness (diameter/m total ramp length - mm/m)	592 mm/m	Illustration A2 shows compactness of the 252-cm-long ramp in rolled position.
17a	Comparing compactness	207 mm/m	Illustration B1 shows comparison of the A1 and A2 in rolled position.



16	Compactness (diameter/1m ramp length - mm/m)	385 mm/m	Illustration A1 shows compactness of the 100-cm-long ramp in rolled position.
17	Total Compactness (diameter/m total ramp length - mm/m)	538 mm/m	Illustration A2 shows compactness of the 188-cm-long ramp in rolled position.
17a	Comparing compactness	153 mm/m	Illustration B1 shows comparison of the A1 and A2 in rolled position.

Figure 6.4. Dynamically changing rolled ramp illustration

CHAPTER 7

CONCLUSION

In this study, important design factors of portable ramps determined by wheelchair users have been researched. In addition, design factors that affect wheelchair users' adoption on portable ramps have been examined. During the study, it was found both predicted and unpredicted results which are compatible with theory of acceptance model.

7.1. Implications

Smart customization tool provides generating a personalized user manual during the customization process with the simultaneously changing warning messages. Besides it dynamically illustrates customized ramp in rolled position to visualize product for making easier decision-making process for potential customers.

Moreover, continuously developing additive manufacturing techniques will be providing customers to manufacture their own unique products in the near future where customer will become more conscious and informed.

It is highly possible to purchase a smart design tool rather than purchasing a real product in the future where every house may turn into a small factory.

Descriptive analyses show that, personalization concept for such product is highly demanded. All these demand about personalization, cost, extend and flexibility construct are related with mass customization concept which is parallel with the idea of proposed smart mass customization tool. Moreover, most of the participants think that the product is useful and triability is important before purchasing decision.

According to regression analyses, usefulness of portable rollable ramps was affected by mobility, ease of use and compatibility. Usefulness perception of potential customers can be increased by creating awareness with these constructs. It should have been emphasized that product provides mobility and ease of use while being compatible with the users' style of livings. Moreover, ease of use perception directly related with transport, ease of learn and mobility perceptions. The ramp should be introduced that it might be easy to learn and can be carried easily.

7.2. Limitation of Study

The most important limitation of this study is small sample size (46). It would be beneficial to improve the respondent size in order to generalize findings. Another limitation is research is conducted in Turkey which means generalization may vary because of the cultural differences. In addition, since the majority of potential users could not see touch or use the product itself, they did not have any chance to get a real experience.

7.3. Further Works

As a further work, the experimentation step can be repeated for proposed mass-customization tool to uncover the adoption of the tool. Moreover, experimentation step can be conducted with different group of potential ramp users like excavation workers, concert promoters, mothers with strollers, public building workers, heavy industry workers, etc.

Customization tool can be examined and experimented with a focus group, to develop the interface for making it much more user-friendly.

Customization tool can be developed and enhanced in terms of increasing ability of further customization towards personalization. These can be:

- Material selection with an integration of material mechanical properties library which is directly used in strength calculations
- However, link geometry has been optimized during preliminary studies to achieve better compactness, ramp link geometry can be redesigned by potential customers with an integrated user-friendly 3D design tool which dynamically illustrates compactness
- Continuously developing additive manufacturing techniques will be providing customers to manufacture their own unique products in the future.

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APPENDIX A

PRELIMINARY INTERVIEW STUDY

A.1. General Structure of the Semi Structured Face-to-Face Interview Questions

Four main theme and two or three sub themes are determined.

Table A.1. The main and sub theme of the interview

CONCEPT OF BEING A WHEELCHAIR USER	DAILY STRUGLES
	ACCESSIBILITY
	FAMILY AND ENTOURAGE
PUBLIC SPACES	SUFFICIENCY AND EFFICIENCY OF PUBLIC RAMP
	DEFICIENCIES OF PUBLIC RAMPS
	STANDARDIZATION OF PUBLIC RAMPS
TRANSPORTATION	PUBLIC TRANSPORTATION
	PERSONAL TRANSPORTATION
SUGGESTIONS	PERSONAL RAMPS
	PREFERENCES

A.2. Semi Structured Face-to-Face Interview Questions

A.2.1. Concept of Being a Wheelchair User

1. Can you visit friends or relatives easily, what are the places you visit frequently during the day? Are you experiencing problems with building accessibility in your visits to these places (historical, public places, private clinic, relative-friend)?

A.2.2. Public Spaces

1. Do you think that ramps in public spaces are sufficient to meet your needs? If you think it is insufficient, can you share your opinions and thoughts about these ramps? (slippery, too narrow, there is not enough lighting at night, no side barrier or insufficient barrier height, high slope, approach plate is not suitable etc.)
2. Do you think if the public space ramps are standardized in terms of dimensions in our country? And are you able to use these ramps without help and without encountering any difficulty?
3. Is it possible to tell whether the slopes of these ramps physically force you?

A.2.3. Transportation

1. Have you had any problem with the ramps on public transport (the risk of falling or falling off)? If you've faced a fall danger, was it during the boarding, or during the landing?
2. Was there a side barrier on the ramps in public transport and do you think if it should be?

A.2.4. Suggestion

1. Do you have a portable ramp? If so, how is the folding type (rollable, foldable, scissor-like mechanism, telescopic), and what are the characteristics you are

satisfied with or not? What is the most important feature you would expect from a portable ramp (lightness, modularity, compactness, easy portability, easy installation, …)?

2. If you don't have a portable ramp; (after viewing the videos of the products) which product would you prefer, why?

A.2.4.1. Video

1- https://www.youtube.com/watch?v=7O9XCgF6HlU; FOLDABLE

2- https://www.youtube.com/watch?v=gtxjJs0WriQ; TELESCOPIC

3-https://www.youtube.com/watch?v=ojzq0SpdsyA; ROLLABLE

A.3. New Question Emerged During Face-to-Face Interview

1. Are you a leaseholder or householder? (Ability to make permanent changes)
2. Is there any threshold at the entrance of the residence?
3. How do you exceed the threshold at the apartment entrance?
4. Do you have a fixed ramp at the entrance of your residence?
5. What is the reason of using a wheelchair?
6. Do you have a battery-powered wheelchair?
7. Would you consider purchasing a portable ramp?
8. Is there an elevator at your residence?

A.4. Transcripts of Semi Structured Face-to-Face Interview

A.4.1. Transcript 1

Yaş:27-spinal cord injury (trafik kazası)

Çalışıyor- eski bale sanatçısı şu an devlet opera balesinde basın danışmanı.

A) BAŞLANGIÇ GRUBU

1. Ben devlet memuruyum, her gün düzenli olarak işe gitmek zorundayim. Bir devlet dairesi olduğu düşünüldüğünde bir engellinin kolay hareket edebileceği bir bina olduğunu söyleyebilirim.

Ancak arkadaş ya da akraba ziyaretlerini kolaylıkla gerçekleştirebildiğimi söyleyemem. Sadece belli başlı sitelerin içi engelli hayatına uygun halde çok kısıtlı. Diğer türlü pek mümkün olmuyor.

Tarihi kamusal alanlarda inanılmaz zorlanıyoruz. 2012 valiliklerin yayınladığı bildiriye göre tüm kamusal alanlar tarihi mekanlar engellilerin ulaşımına uygun hale getirilmek zorundaydı. Valilik bu bildiriyi yayınladı ancak belli bir yaptırımı yoktu. Cezai işlem uygulaması bulunmadığı için kimse ciddiye almadı.

B) KAMUSAL ALAN GRUBU

1. Bundan 1 yıl önce sorsaydınız izmir için cevabım hayır olurdu. Ancak şu anda belediye bünyesine bir engelli mi aldı ne oldu bilmiyorum ancak. Kaldırım ve yollar yenilenmeye başladı. Bize ayrılacak olan 1m - 1.30 m gibi bir alandan memnun oluyoruz.

Rampalar düenlenmeye başlandı ancak engelli rampasını yanlış anlayıp engelli rampasını engelli yapanlar var. örneğin rampanın eğimi iyi kaydırmaz ama bittiği noktada su oluğu var vs. ya da genişliği 90 cm bir ramanın tam ortasında bir elektrik direği olabiliyor. Bazı durumlarda rampayı ulaşabilrsen rahat çıkabileceksin ama rampaya ulaşma imkanın yok böyle bir durum.

2. bunu üç ayrı başlıkta cevaplayabilirim.

-Aktif sandalye kullanıyorsanız kilonuz ideal kilodaysanız zorlanarak çıkabilirsiniz (benim gibi).

- Aktif sandalye ya da manuel sandalye kullanıyorsanız kilonuz ideal bir kilo değilse çıkmanız imkansız.

-akülü sandalye kullanıcısınız ve servikal düzeyde bir yaralanmaya sahip kullanıcıysanız yani ellerinizi de kullanamıyorsanız yardımsız çıkabilmeniz zaten imkansız.

3. Aslında bir ölçüsel standardı var olması gerekiyor. Olması gereken ebatlar malzemeler trabzan yüksekliği hepsi avrupa birliği uyum sürecinde 2012 yılında zannedersem çevre şehircilik bakanlığı tarafından yayınlandı ve kabul edildi ancak dikkat edilmiyor. Ne yalan söyleyeyim ben de engelli olmadan önce bunlara dikkat eden biri değildim. Kaldı ki bunların düzenlenmesi ve kontrolünü yapacak kişiyi engelli bir

bireyden seçmediğiniz sürece engelsiz bir kişi bunlara çok dikkat etmiyor, edemiyor maalesef.

C) ULAŞIM GRUBU

1. Toplu taşıma aracı kullanmıyorum tercih etmioyrum kendi aracım var özel olarak benim kullanımın için modifiye edildi. Ben bir trafik kazası sonucu omurilik zedelenmesi geçirdiğim için aracımın güvenli olmasına çok dikkat ettim. Ancak aracı aldığımda fabrika çıkışı nasılsa o şekilde alınıp sonradan modifiye ediyoruz vücut ölçülerim alınarak engelime uygun parçalar fabrikadan original olarak gönderildi ve serviste modifiye edildi daha sonar tse den bu araç trafiğe çıkabilir belgesi alındı.

Toplu taşıma aracı olarak sadece izban ve metro kullanıyorum. Çok zorluk yaşadığımı söyleyemem minimal düzeyde karşılaştığın oluyor elbette ancak şikayet edecek boyutta değil. Asansör kullanıyorum ancak asansörü ihtiyaç sahipleri haricinde kullananlar yüzünden hem meşgul hem de bozuk olma ihtimalleri çok yüksek oluyor. Vapuru kullanmak gibi bi ihtimalim yok malesef. Belli başlı otobüsleri de kullanabiliyoruz. Ancak ben tercih etmiyorum.

2.---

D) ÖNERİ GRUBU

1.apartmanımın girişine özel olarak rampa yaptırdım 7 adet basamak vardı. Ve apartmanımın bahçesi rampa yaptırmaya uygundu. Rampa taşınabilir değil sabit bir rampa giriş katında oturuyorum. Engelli olduktan sonra taşındım. Seyyar bir ramoaya sahip değilim.

E) VİDEOLAR

Foldable: Oldukça sağlam bir şeye benziyor. Kesinlikle beğenmedim engelsiz bir birey bile zorlanır.

Telescopic: Kilit mekanizması çok uğraştırıcı. Daha Pratik olabilir. Enini belirlenebiliyor çift parça olması o açıdan avantajlı olabilir. Her araçta kullanılamaz çünkü çoğu aracın tamponu yekpare değildir.

Rollable: Böyle bir rampa ilk defa görüyorum ve çok ağır bir akülü sandalye ile üzerine çıkmışlar cidden çok sağlam bir rampa olmalı bunu taşıyabildiği için. Tek bir alyen anahtarı ve somun anahtarıyla parça eklenip takılıyor. Daha Pratik hale getirilebilir. Basit bir hidrolik sistemle otomatik olarak açılması sağlanabilir mi? ekleme yapılabildiği için eğimi ayarlanabiliyor güzel bir şey.

Rollable ya da telescopic olanı kullanım yerine göre tercih edebilirdim. Bizler engelli olarak bazı şeylerin farkındayız istenilen her şeyin aynı anda olma ihtimali yok.

Ferrariye bineyim ama çok ucuz olsun gibi bir beklenti içinde değiliz. Rollable olan mükemmel bir tasarım bir engelli onu tek başına kuramaz farkındayım ancak belli bir yerde sabit olacaksa basit bir hidrolik sistemle otomatik olarak açılır kapanır hale getirilebileceğini düşünüyorum. Fiyat olarak değerlendirdiğimde ise telescopic olan daha uygun fiyatlıdır muhtemelen ve bir engellinin yardım almadan kurabileceğini düşünüyorum doğru bir materyalden yapıldığı takdirde. Aracımın bagajına hem tekerlekli sandalyemi hem de telescopic olanı sığdırabilirim. Ancak rollable olan bagajda çok yer kaplayabilir gibi görünüyor.

A.4.2. Transcript 2

Yaş: 38 (spinal cord injury –trafik kazası)

Çalışıyor-devlet memuru

A) BAŞLANGIÇ GRUBU

1. Hayır. Gün içinde işyerimi ziyaret ediyorum arkadaş akraba ziyareti yapamıyorum. Tarihi alanlar imkansız benim için, kamu kurumları da hepsi değil bazıları.

B) KAMUSAL ALAN GRUBU

1. Çok memnun değilim. Rampa yapmak için yapıyorlar. Engelsiz birinin bile çıkması zor olan rampalar yapıyolarlar. Üç kişinin yardımıyla bir rampa çıktığımı biliyorum ben. Mermerden rampa yapıır mı yapıyorlar. Hoş gözükmesi önemli değil. Rampa işlevini yerine getirmesi önemli güzel gözükmesi değil. Dar ve trabzansız yapıyorlar. Çok önemli trabzan. Iki kilo çimentoyla rampayı herkes yapar önemli olan engelli bireyin kendini çekebilecek olması trabzanlar sayesinde, eğimi çok önemli, rampa üzerinde girinti çıkıntı olmalı (sürtünmeli bir yüzey olmalı) modüler bir rampa düşünüyorsanız bence deniz suyuna daanıklı olması bence en önemlisi trabzan. Kuma bastamayacak bir tasarım olması.

Siz taşınabilir bir rampa tasarlamayı düşünüyorsunuz. Belediyeler tekerlekli sandalye veriyorlar. Bunlara kendi amblemlerini yapıştırıyolarlar. Rampa da versinler yine yapıştırsınlar medical firma reklam versin. Alışveriş merkezleri önündeki rampalar bunlar reklam alınmaya müsait mekanlar. Reklam aracı olarak kullanılabilir mesela. Ama trabzan mutlaka olsun. Max açı olan %35 lik açı trabzanla daha kolay aşılabilir (hastanın kendi kol gücüyle).

2.Standart var ama uygulayan yok. Avrupa birliği bir standart yayınlamış ancak avrupa birliği ülkelerindeki yollar senin rampaya gelene kadar yorulmamanı sağlıyor. Bizim yollarımız da bazen rampaya ulaşmak bile mümkün değil. Yarım metrede bir çukur ordan güçlükle kurtuldunuz önüne gelecek %35 lik bir rampayı tırmanacak güç kalmıyor kollarımızda tek hamlede çıkmak gerek kolay değildir rampa çıkmak. Herkes her açıyı çıkamaz. Trabzan bu açıdan çok önemli.

Sosyal hizmetler bakanlığında engelli masası var bir tane engelli çalıştığını gördünüz mü? Ben görmedim. Sıkıntı işte bu. Fizik tedavide eskiden öğrencilere tekerlekli sandalye kullandırılırdı empati kurabilmesi için yılda 1 defa en az. Empati bakarak olmaz. Yine de eskisinden daha iyi olmaya başladı.

Şöyle bir problem var mesela görme engelliler için yapılan sarı şeritler ortasında elektrik direğiyle bitiyor. Göstermelik iş yapıyorlar.

C) ULAŞIM GRUBU

1.2. toplu taşıma sorusu mu bunu geçiniz. Rampalı otobüslerimiz var da rampanın açılacağı yeri gördünüz mü? O açıyı 3-4 kişi yardımıyla çıkabiliyorum yanlarında barrier yok düşme tehlikesi var. akülü sandalyeyle bile çıkmak işkence oluyor. Eski otobüsler vardı bunlara asansör konulmuştu şöförler özellikle bozdular çünkü onlara işkence gibiydi özellikle bozduklarını bilinçli olarak bozduklarını biliyorum çünkü Pratik değildi uğraşmamak için bozdular sonra da kaldırıldı zaten.

D) ÖNERİ GRUBU

1.kendi apartmanımda bana ait bir rampa var sabit bir rampa. Kendim yaptırdım betondan. Komşularımla problem yaşamadım çünkü Zemin kata oturuyorum kendi balkonuma taktırdım. Apartmanda görselliği bozduğu için sorun çıkaranlar oldu ama çok umursamadım açıkçası onları.

2012 ab uyum yasaları çerçevesinde engelliler yasası var ancak devreye alınmadı yaptırımı yok sadece öneri şeklinde kaldı çünkü yürürlüğe girmiş olsaydı tüm kabu binalarındaki rampalar asansörler vs yönetmeliğe uygun olmak zorundaydı. Yapamadılar askıda kaldı. O yasa çıksa bir tek otobüs rampasız olamayacaktı. Örneğin hayatımdaki bir takım kısıtlamaları belgelersem istediğim yere dava açabilecektim yasa yürürlüğe girse ancak yaptırım yok şu anda.

E) VİDEOLAR

Foldable: çok uğraştırıcı sıkıntılı böyle olmaz. Daha seri ve daha küçük olmalı. Çok geniş yapmışlar gerek yok. Üzerindeki tırtıklar yeterli değil bence sürtünme yüzeyi daha fazla olmalı. Çok da hafif görünmüyor.

Telescopic: bu diğerine göre daha Pratik. Ama bu da yine yap-boz gibi toplayacaksın bu da zor düşününce. Çok sağlam bir yapıya benzemiyor. Orada bir düğme var klik gibi o sağlam olmazsa çok çabuk bozulur ve tekerlekli sandalye üzerindeyken kopabilir. Manuel sandalye kullanıcıları tek başına çıkamaz bunlar düşünülmemiş. Trabzan yok kendini de çekemez. Ayrıca bakın sandalye varken nasıl esniyor. Bu hiç iyi değil. Çökme yapması çıkmayı da zorlaştıran bi şey. Mesela sandalyem akülü 200-250 kg ben 100-120 kg bir insanım 370 kg etti toplamda daha da çok çökecektir ben kullanıyor olsaydım.

Rollable: Bunu sevdim bu güzel. Ama bence bunun maliyeti çok yüksektir. Daha sağlam bu belli. Yanlarına trabzan eklenebiliyor olması çok iyi. Çok iyi düşünülmüş bir ürün. Açının da parça eklenerek ayarlanabiliyor olması çok avantajlı bir durum. Ayrıca köprü gibi ark şeklinde olması o biraz önce bahsettiğim çökmeyi de önlüyor. Bir aksaklık gördüm, kaydırmazlığı sağlayacak bir şey göremedim. Kaydırmaz olması bizim için çok önemli. Maliyeti de önemli bir unsur. Süslü bir şey olmasına gerek yok. Baş ve son tırtıklı olsa o da yeterli çünkü ilk çıkarken sürtünme çok önemli. Arka ve ön tekerlek aynı sürtünmeye sahip olmalı.

A.4.3. Transcript 3

Yaş:18

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A) BAŞLANGIÇ GRUBU

1. Evet akraba ziyaretlerini gerçekleştirebiliyoruz. Akrabalarımızın apartmanları asansörlü ancak girişte basamak oluyor tabii onu da taşıyarak atlatıyoruz. Günlük hayatta çok sıkıntı yaşıyoruz diyemem.

B) KAMUSAL ALAN GRUBU

1. Kamusal binalara erişemiyoruz çoğu yerde engelliler için yollar oluyor ama basamak olan rampa olmayan yerlerde zorluk yaşıyoruz. Kısaca kamusal alanlarda ulaşımın kolay olduğunu düşünmüyorum bir engelliye uygun değil.

2. Evet kamusal alanlardaki rampalar düzgün olsa bile insanların duyarsız olması bu rampayı kullanmamaıza engel oluyor. Kaldırım kenarlarındaki rampalar örneğin araba park ediyorlar. Onun haricinde gözlemlediğim rampalar kaygan zemini ekerlekli sandalye için uygun değil. Genişlik konusunda şimdiye kadar bir sıkıntı yaşamadım. Demir zemin yapıyorlar bazen kayıyor. Geceleri özel olarak aydınlatılmış bir rampaya denk gelmedim. Kardeşim bedensel ve zihinsel engelli olduğu için yardımımıza ihtiyaç duyuyor. Akülü sandalye de kullanamıyor. Dolayısıyla aile bireyleri olarak biz ilgileniyoruz. Rampaların standardı olduğunu sanmıyorum şimdiye kadar gördüğüm tüm rampalar birbirinden farklıydı.

3. Dik ve kaygan zeminli rampalarda çok zorluk yaşıyorum çünkü bütün iş o an bana kalıyor.

C) ULAŞIM GRUBU

1. Otobüs, tren kullanıyoruz çok büyük sıkıntılar yaşamadık. Otobüsteki rampalar kaygan değil diyebilirim.

2. Korkuluk bulunmuyor. Şu ana kadar başımıza gelmedi ama bu durum sıkıntıya (kayma, devrilme) neden olacak durumlar doğurabilir tabii.

D) ÖNERİ GRUBU

1. Kendimize ait taşınabilir bir rampamız yok. Apartmanın giriş katında oturmamıza rağmen çok fazla basamak var. Kardeşimi tekerlekli sandalye ile çıkartamadığımız için tekerlekli sandalyeyi aşağıda bırakıp kardeşimi kucağımıza alıyoruz.

Bunun üzerine peki böyle bir taşınabilir rampanız olsaydı gerektiğinde açıp işiniz bittiğinde toplayabildiğiniz bir rampa işinize yarar mıydı? Sorusu yöneltildi.

Oğuzhan: Tabii ki yarar.

Peki hiç araştırdınız mı böyle bir rampa ya da var olduğunu biliyor muydunuz?

Kardeşi: hiç araştırmadık aslında öyle bir şey olduğunu pek bilmiyordum. Denk gelmedi hiç görmedim. Ancak dış cephe asansörü yaptırmayı düşündük ancak altımızda dükkan olduğu için belediye izin vermedi. Ama kardeşimi bazen babaanneme götürüyoruz o bakıyor. Balkonuna asansör yaptırdık dış cephe asansörü. Ancak bilemedik

aslında çok tehlikeli bir gün farketmeseydim kardeşim Alican asansörün altında kalacaktı. Son anda fark edip çektim kardeşimi.

2.YOK

E) VİDEOLAR

1. Bizim merdivenler çok dik. Bizim apartman için uygın değil rampa kısa olduğu için eğimi çok olur kucağımda taşısam daha iyi kardeşimi.

2. Teleskopik olan daha az yer kaplıyor gibi ancak yine de boyu sabit olduğu için benim işime yaramaz.

3. Bence en kullanışlı olan bu parça ekleniyorsa boyu da uzatılabiliyor demek tercih edecek olsam bunu tercih ederdim. Iki parça olanını değil tek parça olanını tercih ederim. Tek seferde açıp tek seferde toplamak daha kolay. Iki parçalı olduğunda iki kere aynı işi yapmak zor gelir bana.

A.4.4. Transcript 4

Yaş: 37 (Spina Bifida)

çalışmıyor

A) BAŞLANGIÇ GRUBU

1. Ettiğim de oluyor etmediğim de merdiven benim için engel ve herkesin apartmanında asansör olmuyor malesef. Gidebildiklerime gidebiliyorum asansör varsa ya da giriş katında oturuyorlarsa.

Benim apartmanımın girişinde de basamak var, ama benim şansım apartmanın zemin katı olması benim kullanabileceğim bir kapı açtırdık bahçeye onu kullanıyorum. Evimiz yokuşta akülü aracım yeni oldu. Akülü aracım yokken ailem yardım ediyordu ona rağmen zor oluyordu evime ulaşmak. Şimdi akülü aracım var biraz daha rahatım.

B) KAMUSAL ALAN GRUBU

1. artık söylene söylene alışveriş merkezleri, kamusal alanlar eskiye göre daha iyi hale getirildi. Sinema vs eskiye göre daha rahat ama tabi yine ulaşamadığım erişemediğim çok yer var. Bazı rampalar ise çok kaygan endişeleniyorum ve düşmekten korkuyorum. Yardımsız çıkmam imkansız hale geliyor. Trabzan olması çok önemli böyle rampalarda zemin kaygansa trabzandan destek alarak çıkıyorum. Bazı durumlarda ise hem rampa dik hem zemini kaygan böyle olduğunda aile bireylerimden biri arkamda diğeri önümde destek olarak ancak çıkarabiliyorlar beni. Trabzan olması çok önemli bir rampada.

Aydınlatma önemli rampaları ekstra aydınlatmak önemli nereye gideceğimi görebilmeliyim gece karanlıkta da. Ölçüsel standardı varsa bile uyulduğunu düşünmüyorum.

2. Devlet dairelerinde bazılarında rampalar var ama aküşü aracım yokken çıkamıyordum yardımsız. Hani bir laf var özürü kabahatinden büyük o rampayı hiç yapmamış olsalar daha iyi öyle dik rampayı çıkmamaızı nasıl bekliyorlar anlayamıyorum. Hadi çıktım diyelim nasıl ineceğim. Bir de bazıları o kadar dar oluyor ki tekerlekli sandalye kullanıcısı o rampayı kullanamaz zaten.

3. Rampa eğimleri manuel sandalyem varken beni her zaman zorluyordu. Akülü sandalye olduğunda yine çıkamadığım rampalar oluyor ancak manuele göre daha kolay çıkıyorum diyebilirim.

C) ULAŞIM GRUBU

1. Toplu taşıma sık kullanıyorum. Eskiye göre daha iyi rampalar açılıyor binebiliyoruz. Ancak onların da dik olduğunu düşünüyorum.

2. Yanlarda bariyer yok malesef toplu taşıma araçlarındaki rampalarda. Düşme tehlikesi şimdiye kadar atlatmadım.

D) ÖNERİ GRUBU

1. Kendime ait taşınabilir bir rampam yok. Evimin önünde kaldırımın rampası yoktu çıkamıyordum yardımsız. Belediyeden rica ettim sağolsunlar yaptılar. Ama insanlar araçlarıyla önüne park edebiliyor tabii. Duyarsızlık yapıyorlar. Kaldırımlar yollar eskiye göre daha iyi diyebilirim yine de çok eksik var.

2.

E) VİDEOLAR

1. Foldable: Pratik bir şeye benziyor günlük hayatta ufak sorunlara çözüm olabilir.

2. Telescopic: Bu daha Pratik diğerini ben tek başıma açıp kuramam ama bakınca bunu belki kurabilirim. Açılması daha pratik.

3. Rollable: bu daha da pratik görünüyor. Tek parça olmasını tercih ederim rampanın ne kadar az iş o kadar iyi. Boyunun ayarlanabiliyor olması en büyük avantajı. Katlanabilir bir rampa almayı düşünürsem teleskopik olanı ya da rulo olanı tercih ederdim kullanım yerine bağlı olarak.

A.4.4. Transcript 5

Yaş: 23 (spina bifida)

Öğrenci (AOF)

A) BAŞLANGIÇ GRUBU

1. Yeni akülü araca geçtim. Oyüzden alışma sürecim daha da sıkıntılı geçiyor bir kaç kez aracı çarptım. Araç daha geniş eskisinden asansöre binerken geçemedim dar geldi bu nedenle aracın kenarındaki frenler kırıldı. Akrabaların evinde asasör olsa bile o bile benim için dar olabiliyor demek istediğim. Eni kurtardı diyelim bu sefer boyu sıkıntı yaratıyor ayaklıkları çıkarmak zorunda kalıyorum. Arabaya bineceksem aküyü sökmek zorundayım ancak o şekilde katlanabiliyor çünkü. Genelde toplu taşıma kullanmaya alıştırmaya çalışıyorum kendimi. Artık daha sık kullanıyorum toplu taşımayı ama tabi sıkıntı yaşıyorum.

B) KAMUSAL ALAN GRUBU

1. Tarihi ve kamusal alanlar da sıkıntılar yaşıyorum tabii ki. Eskiye göre engellileri biraz daha düşünerek bir şeyler yapmaya çalışıyorlar ama hala ulaşamadığımız yerler var tabii ki. Kaldırımlardaki rampalar eskiye göre bizim için daha ulaşılabilir hale getirdi şehir içini ancak önüne park ediyor insanlar. Metrolarda giriş çıkışlarda zeminden dolayı çok kayıyorum örneğin tekerlek kaydırıyor duvara çarptım bir kere.

2. Yeşilyurtta (İzmir) bir lise de sınava girecektim. Rampa vardı ama o kadar dikti ki geri doğru devrilmek üzereydim şansıma arkamda biri vardı düşmekten kurtardı beni. Korkuluk vardı ama dikliği o kadar fazlaydı ki geri doğru devrilmeme sebep oldu.

3. Yardım almadan rampa eğimi uygunsa akülü arıcımla kolaylıkla çıkabiliyorum. Aküsüz aracım yokken dışarı çıkamıyordum bile. Cesaret edemiyordum.

C) ULAŞIM GRUBU

1. Vapura uzun süredir binmedim. Otobüslerde ise şoför ile alakalı duyarlı biriyse yardımcı oluyor değilse olmuyor rampayı açma konusunda. Kötü bir durum tabii. Insiyatifine kalmış yardımcı olmak.

2. Bariyer bulunmuyordu hiç görmedim bariyer olan bir rampa toplu taşıma araçlarında.

D) ÖNERİ GRUBU

1. Kendime ait taşınabilir rampam yok. Evin içinde sandalyemi bırakıyorum. Dizlerimin üzerinde işlerimi halletmeye çalışıyorum kendimi hareketsizliğe alıştırmak

istemediğim için. Apartmanın girişinde basamak var. rampa yok ama son zamanlarda konuşuyoruz bir rampa yaptıralım diye ailemle çünkü girişteki 3-4 basamak bile zorluyor en az iki kişinin yardımı gerekiyor o basamakları atlatabilmem için. Komşularım da bu durumdan rahatsız olacak insanlar değiller.

2. Bilgim yok

E) VİDEOLAR

1. Foldable: ailem benim de binebileceğim tarzda (van tarzı) bir araç almayı düşünüyor. Araca binmem konusunda iyi olabilir böyle bir rampa.

2. Telescopic: iki parçalı yapmışlar bunu mesela daha iyi bence. Daha az yer kaplıyor üstelik diğeri ile kıyaslayacak olursam.

3. Rollable: teleskopik olanla ikisini kıyaslayacak olursam teleskopik olanı seçerdim. Kurmak daha kolay öyle görünüyor videodan.

A.4.4. Transcript 6

Yaş:12 (Cerebral Palsy) – annesi ile görüşüldü

Öğrenci

A) BAŞLANGIÇ GRUBU

1. Çoğunlukla hayır. Çoğu akraraba-arkadaş evlerinde malesef rampa yok. Genelde melike'yi tekerlekli sandalyesinden indirip kucakta taşımak zorunda kalıyoruz. Eski yapılarda asla rampa yok, nereye gidersek gidelim yok. Kızımı kayıt ettirdiğim okuldan almak ve başka okula yazdırmak zorunda kaldım. Okulda bile yok. Tarihi binalarda hiç görmedim ama yapılamaz değil istenirse yapılır uğraşılmıyor, umursanmıyor. Dışarıya koyacakları bir rampa o binanın görüntüsünü bozacak diye korkuyorlar. Buna inanmıyorum bıraksınlar daha çok insan ziyaret edebilsin. Kızımın doktorunu ziyaret ettiğimizde bile biz yukarı çıkamıyoruz. Doctor kızımın yanına aşağı iniyor. Binalar bu kadar ulaşılmaz ve erişilmez bizler için. Melike'yi aşağıda görüyor.

B) KAMUSAL ALAN GRUBU

1. Kamusal alanlarda rampaları yetersiz ve beklenti ve ihtiyaçları karşılamıyor. Kamu binalarına çok gitmiyoruz ancak gittiğimiz ve çok sık ziyaret etmek zorunda olduğumuz kamusal binalar hastaneler. Biz rapor alabilmek için 4-5 yılda bir almamız gereken bir rapor bu Tepecik devlet hastanesine gitmek durumundayız. Şu an benim çocuğum kucapa alınabilir bir çocuk ama kucapa alınamayan bir sürü engelli insan var.

ve tepecik hastanesinin %90 ında rampa yok gözlemlerime göre. Ve çocuk bölümleri genelde hep üst katlara verilmiş herkes çocuğunu kucağında taşımak zorunda kalıyor. Bu kucakta taşınan insanlar genç ergen insanlar artık. Düşündüğünüzde çocuğum 37 kilo taşıyabiliyorum ama seneye ne olacak kaç kilo olacak taşıyabilecek miyim? Hastanelerde bile rampa yoksa erişmek ulaşmak bu kadar zorken başka kamusal binalarından bunu beklemiyorum. Ama çocuğumu hastaneye götürmek zorundayım devlet benden bu raporu istiyorsa bana ulaşılabilirliği de sağlamalı. Doktorlara söylüyoruz şikayet edin diyorlar. Kime edeceğim. Engelli hakkı diyorlar. Engelli hakkını kendileri gasp ediyolar gçrmezden gelerek. Çocuğum henüz 12 yaşında olduğu için çoğu zorluğu yaşamıyorum aslında asıl sorunlar büyüyünce başlayacak.

2. Rampalar varsa bile çok dik, kaygan, genişliği yetersiz, telefon ışığıyla aydınlatıyoruz. Hep düşünüyorum rampa kenarına bir aydınlatma yapmak ne kadar zor olabilir. Biz çocuğumuzun yanındayız yardımcı oluyoruz ama bir engelli yardımsız çıkabilmeli bu rampaları. Eğimin bir standardı var normal insan çıkamıyor.

3. Bazı rampalarda eşim yıkarı çıkıyor çekiyor ben aşağıdan itiyoum ancak o şekilde çıkarabiliyoruz. Bir engellinin yardımsız çıkması imkansız bu rampaları. Alışveriş merkezlerindeki yürüyen rampalar da o şekilde kaygan fren tutmuyorsa kayıp düşmek çok kolay.

C) ULAŞIM GRUBU

1. toplu taşıma kullanamıyoruz. Izban metro sadece o da asansör olduğu için. Belediye otobüsüne binemiyoruz. Şanslıyız kendi aracımız var. ancak çoğu engellinin aracı olmuyor.

2. otobüs rampalarının geniş olması çok iyi. Genelde akülü aracı olanlar rahat kullanabiliyor o rampayı da. Bariyer yok yanlarında ancak geniş olması bu durumda önem kazanıyor işte. Otobüsler kamusal binalardan daha iyi olduğunu düşünüyorum. En azından bir proje yapılmış uğraşılmış.

D) ÖNERİ GRUBU

1. kendimize ait rampamız yok. Müstakil evde yaşıyoruz. Ekonomik açıdan şanslıyız ki evimizi çocuğumuza göre düzenleyebiliyoruz. Melike'nin rahat kullanabileceği gibi düşünüyoruz her şeyi.

2. hiç incelemedim açıkçası. Evimiz iki katlı olduğu için bir süre asansörlerle ilgili araştırma yaptık. Onun haricinde aracımız da melikeye uygun büyüklükte tercih ettik. Örneğin tekerlekli sandalyesini araca rahat koymak için vs araştırdık. Daha çok eşim araştırıyor böyle şeyleri aslına bakarsanız. Bilgisiz değiliz ancak dediğim gibi melike

henüz küçük ve zayıf bir kız o yüzden çok ihtiyaç duymadık ama duyacağımız zaman da gelecektir diye düşünüyorumm.

E) VİDEOLAR

1. Foldable: iyi düşünülmüş bir tasarım olduğunu düşünmüyorum. Tekerlekli sandalye kullanan bir birey bunu kendi kurabilmeli. Bu sebeple iyi bir çözüm olduğunu düşünmüyorum.

2. Telescopic: Bu rampanın da aynı şekilde uğraştırıcı ve kullanışsız olduğunu düşünüyorum.

3. Rollable: Tasarım açısından en çok bunu beğendim diyebilirim. Ancak videodaki gibi elektronik bir sistemle kendi açılıyor olması gerekir. Bu sayede engelli bir birey yardımsız da açabilir.

A.4.4. Transcript 7

Yaş:16 (Spina Bifida)

Öğrenci

A) BAŞLANGIÇ GRUBU

1. Yok geçen seneye kadar tekerlekli sandalye kullanıyordum. Fizik tedavi sonrası değnekle yürümeye başladım zor da olsa. Ancak çok fazla zorluk yaşıyordum. Örneğin bir yere ziyarete gideceğmiz zaman babam beni sırtına alıyordu. Annem de tekelekli sandalye mi katlayıp taşımak zorunda kalıyordu.

B) KAMUSAL ALAN GRUBU

1. Kamusal alanlarda rampa görmedim hiç. Tarihi binalarda görmedim öyle bir şey. Tepecik hastanesine gidiyorum en sık orda da rampa var ama yeterli değil. Arabayı da genelde babam itiyor. Sürekli saga sola takılıyorurdum. Düşme tehlikesi atlattım bir kaç kez babam tuttu.

2. Rampalar çok dik ben nasıl çıkayım oradan? Gece karanlıkta da öyle aydınlatması olmuyor ki ekstra önümüzü görelim.

3. Zorlamaz mı tabii ki zorluyor. Ailemden yardım alıyorum işte o yüzden hep. Tek başıma yapamıyorum çoğu şeyi.

C) ULAŞIM GRUBU

1. Otobüste rampa var diyorlar ancak benim oturduğum mühite rampalı otobüs göndermiyorlar herhalde. Ben hiç görmedim. Otobüs beni görünce bazen durmuyor zaten

arabam var zaten binemem diye. İzbanda rampa var olmasına da kaygan yapmışlar çıkmak çok zor.

2. Hiç binmedim rampalı otobüse engelli kartım olmasına rağmen bana denk gelmedi öyle bir otobüs. Sanırım bizim muhite eski otobüs veriyorlar o nedenle gelen otobüsün de yerden yüksekliği çok fazla.

D) ÖNERİ GRUBU

1. kendi evimin girişinde bir tane basamak var. Diğer basamakları emekleyerek çıkıyorum. Bir basamak sonra arabayı apartman girişinde bırakmak zorundayım zaten çünkü dar zaten giriş onunla devam edemiyorum.

2. Yok görmedim hiç araştırmadım açıkçası.

E) VİDEOLAR

1. Foldable: Bu çok ağır bir rampa bununla uğraşılmaz. Ben zaten bunu kuramam babam da uğraşmaz sinirli bir adam babam.

2. Telescopic: Bunu kurmak daha kolay gibi geldi.

3. Rollable: Bu çok harikaymış. Hafif duruyor üstelik tek parça olması da iyi. İki parça demek iki kere uğraşmak demek. Bir de düğmeye basınca kendi açılsa süper olur.

A.4.4. Transcript 8

Yaş:17 (Quadriplegik Cerebral Palsy) – Annesi ile görüşüldü

-

A) BAŞLANGIÇ GRUBU

1. Mümkün değil. Nereye çıkıyoruz da akrabanın evini ziyaret ediyoruz. Bizim için oğlumla başka bir evi ziyaret etmek imkansız gibi bir şey. Rampa yok olsa da öyle bir rampa yapmışlar ki dik ne araba sığabiliyor ne de arkadan ittirebiliyorsun, kayıyor vs. zaten eski binalarda hiç rampa görmedim. Yeni binalarda da yer yer var yeni başladı. Ama dedğim gibi o rampayı hiç yapmasalar daha iyi öyle bir rampa. Bazen merdivenden çıkarmak bana daha kolay geliyor tutunarak tırabzana çekiyorum. Bu yüzden de çoğu zaman bir yere gitmiyoruz, gidemiyoruz. Menderes'te oturuyorum bizim o taraflarda binalar 3 katlı maksimum ve tamamı asaansörsüz. Kısacası gitmek istesek de gidemiyoruz.

B) KAMUSAL ALAN GRUBU

1. Kamusal alanlar dediğinizde sadece behçet uz ve tepecik devlet hastanesi var benim için oralara gidiyoruz en çok. Asansör hariç bi şey yok yani rampa yok basamak varsa yine zarla zorla çıkarıyoruz bir şekilde. Ancak asansör dediğim zaman bütün sorunlar çözüldü olmuyor. Orası hastane herkes hasta herkes asansör kullanmak istiyor dakikalrca asansör kuyruğu bekliyoruz. Başka seçeneğimiz yok çünkü.

2. Metro istasyonları, izban çıkışlarında var rampalar ancak çok kaygan. Esbaş durağını sıklıkla kullanıyorum örneğin öyle kaygan rampa yapılmaz. Fayans gibi bir malzemeden yapmışlar.

3. Mesela bir gün ismail gibi CP olan bir arkadaşı var evlerine gidelim dedik özel rampa yaptırmışlar girişe ama çocukların tekerlekli sandalyesi bizimkinden daha dar rampayı da ona göre yaptırmışlar. Ama bizim için dardı mesela sığamadık, ismail'i çıkaramadım oradan. Ölçüsel standardı yoktu rampanın.

C) ULAŞIM GRUBU

1. Otobüs kullanıyorz. Ve yeni otobüsler artık rampalı şoförler de sağolsunlar görüp durup yardımcı oluyorlar. Eski ptpbüslere binemiyorduk.

2. Rampanın kenarında koruma bordürü yoktu. Ama şimdiye kadar öyle bir tehlike atlatmadık.

D) ÖNERİ GRUBU

1. Zemin kata oturuyoruz. Tabi girişte 4 basamak var trabzandan tutarak çeke çeke zor da olsa çıkarmaya çalışıyorum ismail'in arabasını. Bina 20 yıllık bina ve kirada otutuyorum istesem de sabit rampa yaptıramıyorm.

E) VİDEOLAR

1. Foldable: Apartman önüne böyle bir şey konulabilir işte. Ihtiyaç olunca kurup kaldırılabilcek. Ilk kez böyle rampa görüyorum. Ağır olmasını önemsemedm açıkçası soruna çözüyor, işe yarıyorsa bu gözardı edilebilir.

2. Telescopic: bu iki parçalıymış o nedenle pek kullanışlı gelmedi bana.

3. Rollable: katlanabilir olanı ya da bunu tercih ederdim alacak olsam. Ama buna parça eklenebiliyor bir de sanki toplaynca daha az yer kaplıyor gibi. Fiyat da önemli tabii benim için.

APPENDIX B

EXPERIMENTAL STUDY DOCUMENTS

B.1. Main Screens of Experimental Study

Figure B.1. Experimental study's main screen

Figure B.2. Experimental study's main screen (Scrolled down)

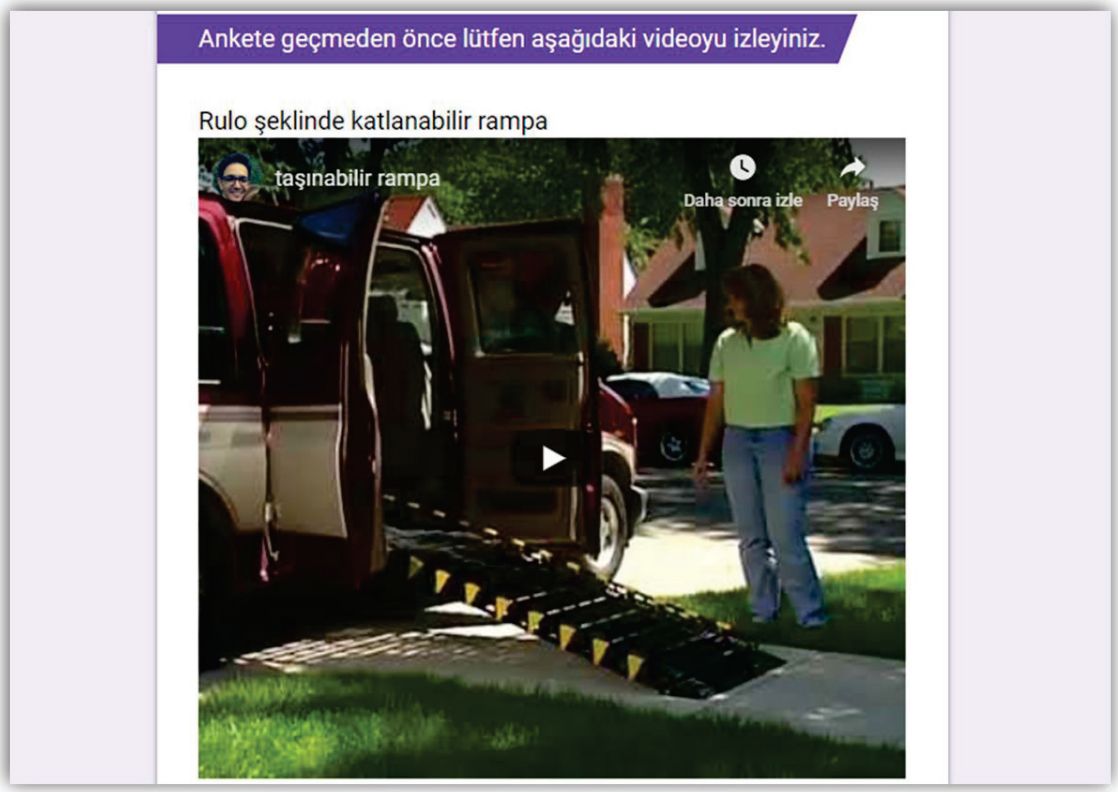

Figure B.3. Experimental study's main screen (Scrolled down)

B.2. Experimental Study Questions

Table B.1. Questions of experimental study (Türkçe)

No	Constructs	Items
1	Assistant	tekerlekli sandalye kullanırken size yardımcı olan birisi var mı?
2	Experience	kaç senedir tekerlekli sandalye kullanıyorsunuz
3	Innovativeness	yeni çıkan ürünleri benimsemede temkinli yaklaşırım
4	Self-efficacy1	tek başıma rahatlıkla kullanabilirim
5	Self-efficacy2	bu tür ürünleri kullanabileceğimden emin değilim
6	Weight Problem	piyasada fiziksel özelliklerime uygun (kilo, boy…) tekerlekli sandalye bulabiliyorum.
7	Time to Arrive	kısa zaman harcayarak gitmem gereken yerler var
8	Concern Health	dış mekanlarda tekerlekli sandalye kullanır iken endişe duyuyorum
9	Physical Condition1	kamusal alanlardaki rampaların kullanımının rahat olduğunu düşünüyorum
10	Physical Condition2	tekerlekli sandalye kullanmak durumunda olduğum yerlerdeki zemin şartları için bu platform gereklidir
11	Flexibility1	satın alma sırasında kişiselleştirmeye müsait, esnek bir yapısı olduğunu düşünüyorum
12	Flexibility2	her türlü zeminde kullanılabilecek bir düzene sahip
13	Flexibility3	gerekli gördüğüm bir takım işlevleri ekleme esnekliğine sahip olmasını isterim
14	Flexibility4	gerektiğinde kullanım yerine uygun olarak uzatıp kısaltabilirim.
15	Personalization1	bazı özelliklerini kendi bekletilerim doğrultusunda özelleştirmek isterim
16	Personalization2	ürünü kişiselleştirirken fiyattaki değişimi eş zamanlı olarak görmek iyi bir fikir
17	Personalization3	ürününün genişlik-açı, en, ağırlık gibi boyutlarını kendim belirlemek isterim
18	Personalization4	ürünün emniyet (bariyer yüksekliği, kaydırmazlık, trabzan vb) özelliğini kendim belirlemek isterim
19	Personalization5	ürünün ergonomi (depolama, taşıma, açma-kapama, montaj ve birbirine ekleme vb) gibi temel fonksiyonlarını kendim belirlemek isterim
20	Triability	ürünün özelliklerini anlamama yetecek kadar süre deneme amaçlı kullanabilmem önemlidir
21	Image	bu ürünü kullanarak benzer durumdaki arkadaşlarım arasında daha farklı bir imaja sahip olacağımı düşünüyorum
22	Compatibility	benim tarzıma, yaşayışıma uygundur

(Cont. on next page)

Table B.1. (Cont.)

23	Internal Influence	yakınlarımın bu konudaki görüşlerini önemserim
24	External Influence	bu tür ürünlerin tanıtım yazı ya da reklamları beni etkiler
25	Mobility1	bu ürün sayesinde istediğim yere gidebilirim
26	Mobility2	bu ürün bana daha fazla hareket özgürlüğü sağlar
27	Transport1	istediğim yere taşıyabilirim
28	Transport2	taşımasının kolay ve pratik olduğunu düşünüyorum
29	Regulation	bu ürünü kamusal alanlarda bulundurulması zorunluluğunun ulaşılabilirlik ve erişilebilirlik için pratik çözümler sunacağını düşünüyorum (banka, hastane, devlet daireleri...)
30	Support	hızlı ve kolayca teknik destek alabilirim
31	Security1	kullanım esnasında tehlike yaşayabilirim
32	Security2	kullanımını güvenli buluyorum
33	Width	genişliğini yeterli buluyorum
34	Extend	uzayabilir olması önemlidir
35	Light	hafif olduğunu düşünüyorum
36	Firm	sağlam olduğunu düşünüyorum
37	Stable	dengeli olduğunu düşünüyorum
38	Ergonomic	ergonomik buluyorum
39	Cost	ürünün satınalma maliyeti yüksektir (1 metresi 4.000 tl)
40	Cost Afford	bu ürünü satın almaya mali gücüm yeter
41	Ease of Learn1	kullanmayı öğrenmem zaman alır
42	Ease of Learn2	kullanımını kolayca öğrenebilirim
43	Ease of Use1	kullanımda zorluk yaşamam
44	Ease of Use2	kolay katlanır olduğunu düşünüyorum
45	Ease of Use3	kurulumunu kolay ve pratik buluyorum
46	Usefulness1	yararlı olduğunu düşünüyorum
47	Usefulness2	günlük hayatımı kolaylaştırır
48	Usefulness3	sosyal hayatıma yardımcı olur
49	Usefulness4	engelleri kolayca aşmamı sağlar
50	Usefulness5	üründen memnun kalabilirim
51	Attitude1	kullanmak bence iyi fikir
52	Attitude2	başkalarına tavsiye ederim
53	Attitude3	kullanmayı düşünürüm
54	Intention1	almaya niyetim var
55	Intention2	yakın zamanda edinmeyi planlıyorum
56	Kansei Words	İzlemiş olduğunuz video ve fotoğraftan yola çıkarak aşağıdaki kelimelerden hangilerinin bu ürünü temsil ettiğini belirtin (yaklaşık 3-5 kelime seçiniz)

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Table B.1. (Cont.)

57		dönüştürülebilen
58		faydalı
59		gelişmiş
60		güvenilir
61		hayati
62		modern
63		portatif
64		pratik
65		rahat
66		ulaşılabilir
67		yenilikçi
68		sağlam
69	Animal	eğer bu uygulama için bir logo yapıyor olsaydınız hangi hayvanı temsili olarak kullanmayı tercih ederdiniz?
70	Car	bu uygulamayı, hangi araba marka-model ile benzer yakın bulursunuz?
71	Improvement	bu ürünün daha kullanışlı olması için ne önerirsiniz?
72	Comment	eklemek istediğiniz bir şey var mıdır?

APPENDIX C

RESULT OF ANALYSES

C.1. Findings of Analyses

Table C.1. Correlation analyses

Assistant	Pearson Correlation	0.15	0.01	-0.09	-0.24
	Sig. (2-tailed)	0.326	0.972	0.574	0.105
Experience	Pearson Correlation	0.02	0.09	-0.02	-0.24
	Sig. (2-tailed)	0.906	0.552	0.913	0.110
Innovativeness	Pearson Correlation	-0.03	0.03	0.01	0.18
	Sig. (2-tailed)	0.831	0.838	0.955	0.245
Self_efficacy1	Pearson Correlation	0.33	0.30	0.43	0.66
	Sig. (2-tailed)	0.027	0.040	0.003	0.000
Self_efficacy2	Pearson Correlation	0.13	0.16	0.14	0.15
	Sig. (2-tailed)	0.379	0.304	0.354	0.307
Weight_Prob	Pearson Correlation	0.30	0.36	0.30	0.14
	Sig. (2-tailed)	0.043	0.013	0.040	0.370
Time2Arrive	Pearson Correlation	0.12	0.25	0.20	0.22
	Sig. (2-tailed)	0.443	0.101	0.194	0.138
Concern_Health	Pearson Correlation	-0.08	0.00	0.21	-0.01
	Sig. (2-tailed)	0.580	0.997	0.170	0.964
PhysicalCon1	Pearson Correlation	0.23	0.04	-0.07	0.06
	Sig. (2-tailed)	0.122	0.798	0.663	0.708
PhysicalCon2	Pearson Correlation	0.05	0.21	0.41	0.38
	Sig. (2-tailed)	0.754	0.171	0.005	0.009
Flexibility1	Pearson Correlation	0.37	0.22	0.34	0.27
	Sig. (2-tailed)	0.013	0.147	0.023	0.075

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Table C.1. (Cont.)

Flexibility2	Pearson Correlation	0.23	0.37	0.36	0.21
	Sig. (2-tailed)	0.128	0.010	0.015	0.164
Flexibility3	Pearson Correlation	0.29	0.30	0.34	0.28
	Sig. (2-tailed)	0.051	0.044	0.020	0.057
Flexibility4	Pearson Correlation	0.66	0.39	0.42	0.11
	Sig. (2-tailed)	0.000	0.008	0.004	0.477
Personalization1	Pearson Correlation	0.43	0.30	0.43	0.16
	Sig. (2-tailed)	0.003	0.042	0.003	0.300
Personalization2	Pearson Correlation	0.00	0.00	0.16	0.28
	Sig. (2-tailed)	0.996	0.990	0.294	0.063
Personalization3	Pearson Correlation	-0.09	-0.05	0.05	0.25
	Sig. (2-tailed)	0.565	0.737	0.743	0.099
Personalization4	Pearson Correlation	0.12	0.12	0.20	0.11
	Sig. (2-tailed)	0.432	0.420	0.177	0.488
Personalization5	Pearson Correlation	0.13	0.29	0.23	0.19
	Sig. (2-tailed)	0.396	0.047	0.119	0.203
Triability	Pearson Correlation	0.18	0.09	0.00	-0.13
	Sig. (2-tailed)	0.232	0.565	0.988	0.391
Image	Pearson Correlation	0.20	0.32	0.21	0.28
	Sig. (2-tailed)	0.194	0.031	0.161	0.060
Compatability	Pearson Correlation	0.61	0.76	0.73	0.53
	Sig. (2-tailed)	0.000	0.000	0.000	0.000
InternalInfluence	Pearson Correlation	0.24	0.28	0.26	0.08
	Sig. (2-tailed)	0.107	0.062	0.080	0.616
ExternalInfluence	Pearson Correlation	0.23	0.21	0.42	0.32
	Sig. (2-tailed)	0.123	0.171	0.004	0.032
Mobility1	Pearson Correlation	0.55	0.80	0.81	0.53
	Sig. (2-tailed)	0.000	0.000	0.000	0.000
Mobility2	Pearson Correlation	0.49	0.70	0.70	0.50
	Sig. (2-tailed)	0.000	0.000	0.000	0.000

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Table C.1. (Cont.)

Transport1	Pearson Correlation	0.61	0.64	0.70	0.68
	Sig. (2-tailed)	0.000	0.000	0.000	0.000
Transport2	Pearson Correlation	0.59	0.50	0.62	0.63
	Sig. (2-tailed)	0.000	0.000	0.000	0.000
Regulation	Pearson Correlation	0.31	0.18	0.30	0.16
	Sig. (2-tailed)	0.038	0.228	0.045	0.289
Support	Pearson Correlation	0.31	0.30	0.29	0.40
	Sig. (2-tailed)	0.037	0.043	0.055	0.006
Security1	Pearson Correlation	0.17	0.29	0.27	0.16
	Sig. (2-tailed)	0.263	0.054	0.067	0.293
Security2	Pearson Correlation	0.34	0.47	0.59	0.39
	Sig. (2-tailed)	0.022	0.001	0.000	0.008
Width	Pearson Correlation	0.26	0.35	0.46	0.47
	Sig. (2-tailed)	0.082	0.017	0.001	0.001
Extend	Pearson Correlation	0.21	0.24	0.38	0.17
	Sig. (2-tailed)	0.158	0.104	0.009	0.256
Light	Pearson Correlation	0.48	0.31	0.41	0.39
	Sig. (2-tailed)	0.001	0.039	0.004	0.008
Firm	Pearson Correlation	0.31	0.29	0.49	0.38
	Sig. (2-tailed)	0.037	0.048	0.001	0.009
Stable	Pearson Correlation	0.33	0.34	0.51	0.27
	Sig. (2-tailed)	0.027	0.019	0.000	0.073
Ergonomic	Pearson Correlation	0.57	0.47	0.60	0.46
	Sig. (2-tailed)	0.000	0.001	0.000	0.001
Cost	Pearson Correlation	0.05	0.09	-0.02	-0.24
	Sig. (2-tailed)	0.757	0.561	0.882	0.108
CostAfford	Pearson Correlation	0.25	0.20	0.32	0.50
	Sig. (2-tailed)	0.096	0.187	0.032	0.000
EoL1	Pearson Correlation	0.13	-0.03	-0.04	-0.22
	Sig. (2-tailed)	0.400	0.824	0.780	0.151

(Cont. on next page)

Table C.1. (Cont.)

EoL2	Pearson Correlation	0.37	0.05	0.07	-0.13
	Sig. (2-tailed)	0.012	0.752	0.670	0.407
Flexibility	Pearson Correlation	0.55	0.46	0.53	0.32
	Sig. (2-tailed)	0.000	0.001	0.000	0.032
Personalization	Pearson Correlation	0.17	0.20	0.31	0.28
	Sig. (2-tailed)	0.264	0.188	0.039	0.059
Mobility	Pearson Correlation	0.56	0.81	0.81	0.56
	Sig. (2-tailed)	0.000	0.000	0.000	0.000
Transport	Pearson Correlation	0.63	0.60	0.69	0.69
	Sig. (2-tailed)	0.000	0.000	0.000	0.000
Security	Pearson Correlation	0.29	0.43	0.49	0.31
	Sig. (2-tailed)	0.052	0.003	0.001	0.037
EoL	Pearson Correlation	0.29	0.01	0.02	-0.19
	Sig. (2-tailed)	0.052	0.950	0.923	0.198
EoU1	Pearson Correlation	0.87	0.74	0.65	0.38
	Sig. (2-tailed)	0.000	0.000	0.000	0.009
EoU2	Pearson Correlation	0.88	0.49	0.50	0.37
	Sig. (2-tailed)	0.000	0.001	0.000	0.012
EoU3	Pearson Correlation	0.89	0.58	0.55	0.33
	Sig. (2-tailed)	0.000	0.000	0.000	0.023
Usefulness1	Pearson Correlation	0.70	0.64	0.53	0.20
	Sig. (2-tailed)	0.000	0.000	0.000	0.176
Usefulness2	Pearson Correlation	0.66	0.93	0.80	0.50
	Sig. (2-tailed)	0.000	0.000	0.000	0.000
Usefulness3	Pearson Correlation	0.60	0.89	0.80	0.52
	Sig. (2-tailed)	0.000	0.000	0.000	0.000
Usefulness4	Pearson Correlation	0.52	0.90	0.72	0.40
	Sig. (2-tailed)	0.000	0.000	0.000	0.005
Usefulness5	Pearson Correlation	0.55	0.88	0.75	0.47
	Sig. (2-tailed)	0.000	0.000	0.000	0.001

(Cont. on next page)

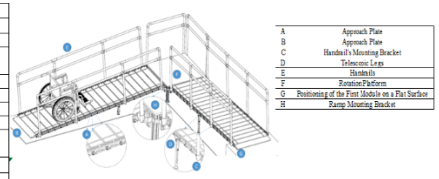
Table C.1. (Cont.)

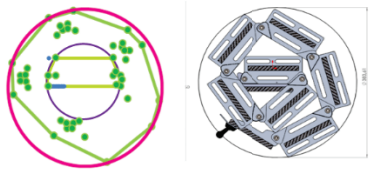
Attitude1	Pearson Correlation	0.63	0.86	0.87	0.52
	Sig. (2-tailed)	0.000	0.000	0.000	0.000
Attitude2	Pearson Correlation	0.44	0.57	0.77	0.40
	Sig. (2-tailed)	0.002	0.000	0.000	0.006
Attitude3	Pearson Correlation	0.58	0.74	0.90	0.69
	Sig. (2-tailed)	0.000	0.000	0.000	0.000
Intention1	Pearson Correlation	0.38	0.49	0.62	0.98
	Sig. (2-tailed)	0.010	0.001	0.000	0.000
Intention2	Pearson Correlation	0.42	0.49	0.63	0.97
	Sig. (2-tailed)	0.003	0.001	0.000	0.000
EoU	Pearson Correlation	1.00	0.69	0.65	0.41
	Sig. (2-tailed)	0.000	0.000	0.000	0.005
Usefulness	Pearson Correlation	0.69	1.00	0.85	0.51
	Sig. (2-tailed)	0.000	0.000	0.000	0.000
Attitude	Pearson Correlation	0.65	0.85	1.00	0.64
	Sig. (2-tailed)	0.000	0.000	0.000	0.000

APPENDIX D

MASS CUSTOMIZATION TOOL

	PARAMETERS	USER SELECTION	COMPUTATIONS/APPROPRIATENESS
	Total Price (TL)	0.00 ₺	Total price of the product is ₺0.00 according to your selections.
1	Barrier to climb (cm)	0 cm	24.0 cm maximum distance you can climb at an appropriate angle. The specified distance can be easily climbed with an appropriate inclination angle.
2	Wheelchair type	Battery-operated wheelchair	Please select the suitable option to determine the appropriate inclination angle.
3	Slope (100*H/L) %	12	Computed slope is . % which is not required rotation platform Recomended maximum slope is 12%
4	Restricted horizontal distance (cm)	200 cm	The horizontal length required for climbing at an appropriate angle is 0 cm Restricted horizontal distance is appropriate for positioning the ramp
5	Required Ramp Length (cm)	0 cm	Suitable ramp length according to your selection.
6	Ramp type	one-piece	Please select width from the list
7	Width (mm)	800 mm	Please pay attention to wheelchair width.
8	Max Load (kg)	250 kg	Please write the maximum mass that the ramp will carry.
9	Most Suitable Load bearing capacity with FoS (kg/2m)	300 kg/2m	Telescopic feet are required for ramps longer than 2 meters.
10	Use Condition	Individual use	Please do not use your ramp outside the conditions you determined.
11	Factor of Safety (FoS)	1.5	FoS is determined according to use condition.
12	Max (real) Load bearing capacity (kg/2m)	450 kg/m	Maximum load bearing capacity with FoS
13	Ramp Mass (kg/m)	#SAYI/0!	The mass of a 1 meter long ramp.
14	Total Ramp Mass (kg)	. kg	The total mass of the ramp.
15	Deployability	Rollable	Deployment type
16	Compactness (diameter/1m ramp length - mm/m)	385 mm/m	Illustration A1 shows compactness of the 100-cm-long ramp in rolled position.
17	Total Compactness (diameter/m total ramp length - mm/m)	185 mm/m	Illustration A2 shows compactness of the 0-cm-long ramp in rolled position.
17a	Comparing compactness	-201 mm/m	Illustration B1 shows comparison of the A1 and A2 in rolled position.
18	Type of handling (handle, wheels, none)	None	
19	Type of storage	None	
20	Extra aparatus needed?	No	Please pay attention to the warnings.
20a	Mounted Bracket (pair)	1	Your selection will be neglected
20b	Telescopic Legs (pair)	1	Your selection will be neglected Telescopic feet are not required for ramps shorter than 2 meters.
20c	Approach Plate (pair)	1	Your selection will be neglected.
20d	Release Pim (pair)	5	Your selection will be neglected.
21	Side Barrier (extra barrier needed?)	No	
21a	Side Barrier (cm)	4 cm	Please deselect.
22	Rotation platform needed?	No	Rotation Platform Not Required.
22a	Rotation platform (qty)	0	Rotation platform will be shipped with your ramp
23	Handrail needed?	None	
24	Anti-Skidness	No	Caution, risk of skidding
25	UV Resistance	Residential use	Do not expose the product to direct sunlight for a longtime.
26	Warnings (No More Than 300 Characters)		Your warning meeage is suitable for displaying.
26a	Warning Message Placement	None	The message specified will be displayed in the selected location.



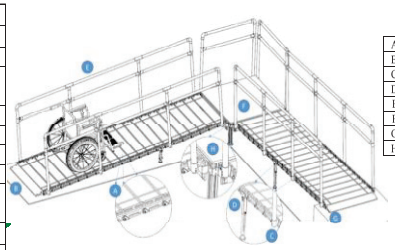


Required ramp and 1-m long ramp compactness comparison in rolled position

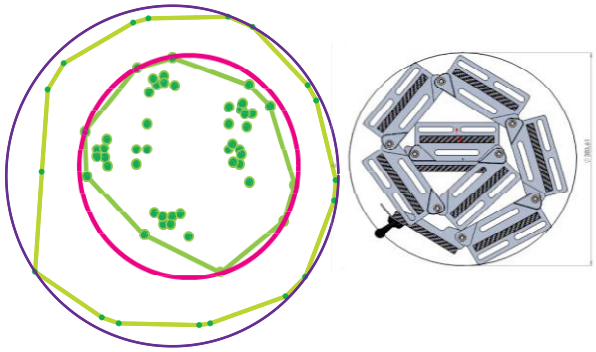
Illustration of ramp in required length and 1-meter long ramp in rolled position

Figure D.1. General view of the mass customization tool

	PARAMETERS	USER SELECTION	COMPUTATIONS/APPROPRIATENESS
	Total Price (TL)	1,935.94 ₺	Total price of the product is ₺1,935.94 according to your selections.
1	Barrier to climb (cm)	30 cm	24.0 cm maximum distance you can climb at an appropriate angle. This distance cannot be exceeded at an appropriate angle. It is recommended to add a rotation platform.
2	Wheelchair type	Battery-operated wheelchair	Please select the suitable option to determine the appropriate inclination angle.
3	Slope (100*H/L) %	12	Computed slope is 15. % which is not required rotation platform Recomended maximum slope is 12%
4	Restricted horizontal distance (cm)	200 cm	The horizontal length required for climbing at an appropriate angle is 250 cm The ramp cannot be positioned at an appropriate angle for this horizontal distance. Please add a rotation platform.
5	Required Ramp Length (cm)	252 cm	Suitable ramp length according to your selection.
6	Ramp type	one-piece	Please select width from the list
7	Width (mm)	700 mm	Please pay attention to wheelchair width.
8	Max Load (kg)	250 kg	Please write the maximum mass that the ramp will carry.
9	Most Suitable Load bearing capacity with FoS (kg/2m)	300 kg/2m	Telescopic feet are required for ramps longer than 2 meters.
10	Use Condition	Individual use	Please do not use your ramp outside the conditions you determined.
11	Factor of Safety (FoS)	1.5	FoS is determined according to use condition.
12	Max (real) Load bearing capacity (kg/2m)	450 kg/m	Maximum load bearing capacity with FoS
13	Ramp Mass (kg/m)	6.02 kg/m	The mass of a 1 meter long ramp.
14	Total Ramp Mass (kg)	20.21 kg	The total mass of the ramp.
15	Deployability	Rollable	Deployment type
16	Compactness (diameter/1m ramp length - mm/m)	385 mm/m	Illustration A1 shows compactness of the 100-cm-long ramp in rolled position.
17	Total Compactness (diameter/m total ramp length - mm/m)	592 mm/m	Illustration A2 shows compactness of the 252-cm-long ramp in rolled position.
17a	Comparing compactness	207 mm/m	Illustration B1 shows comparison of the A1 and A2 in rolled position.
18	Type of handling (handle, wheels, none)	None	
19	Type of storage	None	
20	Extra aparatus needed?	No	Please pay attention to the warnings.
20a	Mounted Bracket (pair)	1	Your selection will be neglected
20b	Telescopic Legs (pair)	1	Your selection will be neglected Min 1.0 telescopic ramp feet pair(s) is/are required.
20c	Approach Plate (pair)	1	Your selection will be neglected.
20d	Release Pim (pair)	5	Your selection will be neglected.
21	Side Barrier (extra barrier needed?)	No	
21a	Side Barrier (cm)	4 cm	Please deselect.
22	Rotation platform needed?	No	Rotation Platform Required!
22a	Rotation platform (qty)	0	Rotation platform will be shipped with your ramp
23	Handrail needed?	None	
24	Anti-Skidness	No	Caution, risk of skidding
25	UV Resistance	Residential use	Do not expose the product to direct sunlight for a longtime.
26	Warnings (No More Than 300 Characters)		Your warning meeage is suitable for displaying.
26a	Warning Message Placement	None	The message specified will be displayed in the selected location.



A	Approach Plate
B	Approach Plate
C	Handrail's Mounting Bracket
D	Telescopic Legs
E	Handrails
F	Rotation Platform
G	Positioning of the First Module on a Flat Surface
H	Ramp Mounting Bracket



Required ramp and 1-m long ramp compactness comparison in rolled position

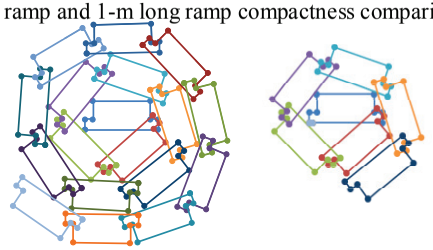
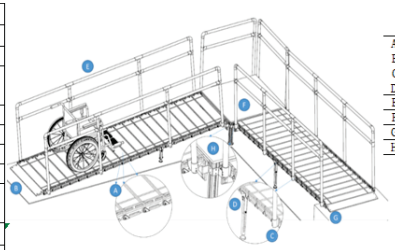


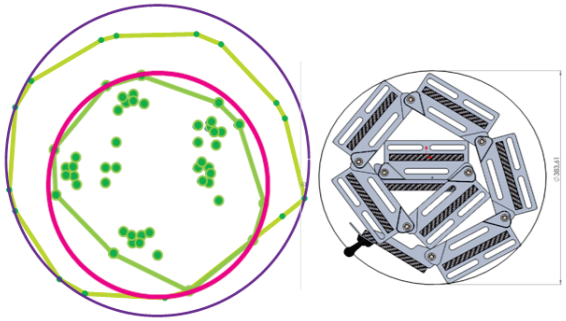
Illustration of ramp in required length and 1-meter long ramp in rolled position

Figure D.2. General view of the mass customization tool after making the first selection

	PARAMETERS	USER SELECTION	COMPUTATIONS/APPROPRIATENESS
	Total Price (TL)	2,596.83 ₺	Total price of the product is ₺2,596.83 according to your selections.
1	Barrier to climb (cm)	30 cm	24.0 cm maximum distance you can climb at an appropriate angle. This distance cannot be exceeded at an appropriate angle. It is recommended to add a rotation platform.
2	Wheelchair type	Battery-operated wheelchair	Please select the suitable option to determine the appropriate inclination angle.
3	Slope (100*H/L) %	12	Computed slope is 15. % which is not required rotation platform Recomended maximum slope is 12%
4	Restricted horizontal distance (cm)	200 cm	The horizontal length required for climbing at an appropriate angle is 250 cm The ramp cannot be positioned at an appropriate angle for this horizontal distance. Please add a rotation platform.
5	Required Ramp Length (cm)	252 cm	Suitable ramp length according to your selection.
6	Ramp type	one-piece	Please select width from the list
7	Width (mm)	700 mm	Please pay attention to wheelchair width.
8	Max Load (kg)	250 kg	Please write the maximum mass that the ramp will carry.
9	Most Suitable Load bearing capacity with FoS (kg/2m)	300 kg/2m	Telescopic feet are required for ramps longer than 2 meters.
10	Use Condition	Individual use	Please do not use your ramp outside the conditions you determined.
11	Factor of Safety (FoS)	1.5	FoS is determined according to use condition.
12	Max (real) Load bearing capacity (kg/2m)	450 kg/m	Maximum load bearing capacity with FoS
13	Ramp Mass (kg/m)	6.02 kg/m	The mass of a 1 meter long ramp.
14	Total Ramp Mass (kg)	20.21 kg	The total mass of the ramp.
15	Deployability	Rollable	Deployment type
16	Compactness (diameter/1m ramp length - mm/m)	385 mm/m	Illustration A1 shows compactness of the 100-cm-long ramp in rolled position.
17	Total Compactness (diameter/m total ramp length - mm/m)	538 mm/m	Illustration A2 shows compactness of the 252-cm-long ramp in rolled position.
17a	Comparing compactness	153 mm/m	Illustration B1 shows comparison of the A1 and A2 in rolled position.
18	Type of handling (handle, wheels, none)	Handle	It will be shipped with your ramp.
19	Type of storage	Case & Belt	It will be shipped with your ramp.
20	Extra aparatus needed?	Yes	Please select at least 1 item from the list below.
20a	Mounted Bracket (pair)	1	pair
20b	Telescopic Legs (pair)	1	pair Min 1.0 telescopic ramp feet pair(s) is/are required.
20c	Approach Plate (pair)	1	pair
20d	Release Pim (pair)	5	pair
21	Side Barrier (extra barrier needed?)	No	
21a	Side Barrier (cm)	4 cm	Please deselect.
22	Rotation platform needed?	No	Rotation Platform Required!
22a	Rotation platform (qty)	0	Rotation platform will be shipped with your ramp
23	Handrail needed?	None	
24	Anti-Skidness	Yes	Standard anti-skidness.
25	UV Resistance	Residential use	Do not expose the product to direct sunlight for a longtime.
26	Warnings (No More Than 300 Characters)	RAMP IS SUITABLE FOR INDIVIDUAL USE ONLY!	Your warning meeage is suitable for displaying.
26a	Warning Message Placement	Display on the approach plate	The message specified will be displayed in the selected location.



A	Approach Plate
B	Approach Plate
C	Handrail's Mounting Bracket
D	Telescopic Legs
E	Handrails
F	Rotation Platform
G	Positioning of the First Module on a Flat Surface
H	Ramp Mounting Bracket



Required ramp and 1-m long ramp compactness comparison in rolled position

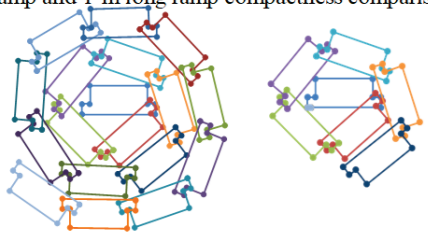


Illustration of ramp in required length and 1-meter long ramp in rolled position

Figure D.3. General view of the mass customization tool after customization

D.1 User Selection Formulas

Table D.1. User selection formulas

No	USER SELECTION
27	**=SUM(Total_Price_TL)**
3	=IF(Wheelchair_Type="Battery-operated wheelchair", "12", IF(Wheelchair_Type="Manual wheelchair with an assistant", "8", "6"))
5	=SQRT((Barrier_to_climb*100/Slope_)^2+Barrier_to_climb^2)
9	=(ROUNDUP(Max_Load_kg/100,0))*100
11	=(IF(Use_Condition="Individual use","1.5", IF(Use_Condition="Individual use with an assistant", "2","3")))
12	=Most_Suitable_Load_Bearing_Capacity_with_FOS*FoS_
13	=(100*Total_Ramp_Mass__kg/Required_Ramp_Length__cm)*FoS_/2
14	=Ramp_Type="two-pieces" (2*((Unit_Carbon_Fiber_Plate_Mass_g__mm*200*Required_Link_QTY)+(Unit_Link_Mass_gr__qty*2*Required_Link_QTY))/(1000*FoS_/2)*(Most_Suitable_Load_Bearing_Capacity_with_FOS/300)) Unit_Carbon_Fiber_Plate_Mass_g__mm*Width_mm
17	=ROUND('CONVEX HULL'!J25,1)
17 a	=Total_Compactness_mm-Compactness__mm
22 a	=IF(Rotation_Platform_Needed="Yes",ROUNDDOWN(Required_Horizontal_Distance_cm/Restricted_Horizontal_Distance_cm,),0)

D.2. Computations and Appropriateness Formulas

Table D.2. Computations and appropriateness formulas

No	COMPUTATIONS/APPROPRIATENESS
27	=COST_
1	= IF(OR(ISBLANK(Restricted_Horizontal_Distance_cm), ISBLANK(Slope_)), "-", Slope_*Restricted_Horizontal_Distance_cm/100)
	=IF(Barrier_to_climb>Max_Dist_Can_be_climbed, "This distance cannot be exceeded at an appropriate angle. It is recommended to add a rotation platform.", "The specified distance can be easily climbed with an appropriate inclination angle.")
2	Please select the suitable option to determine the appropriate inclination angle.
3	=100*Barrier_to_climb/Restricted_Horizontal_Distance_cm
	=IF(Wheelchair_Type="Battery-operated wheelchair", "Recomended maximum slope is 12%", IF(Wheelchair_Type="Manual wheelchair with an assistant", "Recomended maximum slope is 8%.", "Recomended maximum slope is 6%"))

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Table D.2. (Cont.)

4	=Barrier_to_climb*100/Slope_
	=Restricted_Horizontal_Distance_cm<Required_Horizontal_Distance_cm "The ramp cannot be positioned at an appropriate angle for this horizontal distance. Please add a rotation platform." "Restricted horizontal distance is appropriate for positioning the
5	Suitable ramp length according to your selection.
6	=IF(Ramp_Type="two-pieces","Your ramp pair will be produced in 200 mm width as standard.","Please select width from the list")
7	=IF(Width_mm= "200 mm", "Ramp suitable for two-pieces use.", "Please pay attention to wheelchair width.")
8	Please write the maximum mass that the ramp will carry.
9	Telescopic feet are required for ramps longer than 2 meters.
10	=IF(Use_Condition="Public use", "Your ramp will be manufactured with a high safety factor.", "Please do not use your ramp outside the conditions you determined.")
11	FoS is determined according to use condition.
12	Maximum load bearing capacity with FoS
13	The mass of a 1 meter long ramp.
14	The total mass of the ramp.
15	Deployment type
16	Illustration A1 shows compactness of the 100-cm-long ramp in rolled position.
17	=Required_Ramp_Length__cm
17a	Illustration B1 shows comparison of the A1 and A2 in rolled position.
18	=IF(Type_Of_Handling="None", "", "It will be shipped with your ramp.")
19	=IF(Type_of_Storage="None", "", "It will be shipped with your ramp.")
20	=IF(Extra_Aparatus_Needed="Yes", "Please select at least 1 item from the list below.", "Please pay attention to the warnings.")
20a	=IF(Extra_Aparatus_Needed="Yes", "pair", "Your selection will be neglected")
20b	=IF(Extra_Aparatus_Needed="Yes", "pair", "Your selection will be neglected")
	=IF(Required_Horizontal_Distance_cm<200,"Telescopic feet are not required for ramps shorter than 2 meters.",ROUNDDOWN(J10/200,0))
20c	=IF(Extra_Aparatus_Needed="Yes", "pair", "Your selection will be neglected.")
20d	=IF(Extra_Aparatus_Needed="Yes", "pair", "Your selection will be neglected.")
21	=IF(Extra_Side_Barrier="Yes","Please select barrier height from the list below."," ")
21a	=IF(Extra_Side_Barrier="Yes","Modular side barrier will be shipped with your ramp.","Please deselect.")
22	=IF(Restricted_Horizontal_Distance_cm<Required_Horizontal_Distance_cm,"Rotation Platform Required!", "Rotation Platform Not Required.")
22a	=IF(Rotation_platform_QTY="0", "Not required", "Rotation platform will be shipped with your ramp")
23	=IF(Handrail_Needed<>"None","Handrail dimensions will be calculated according to the ramp length."," ")

(Cont. on next page)

Table D.2. (Cont.)

24	=IF(Anti_Skidness="Yes","Standard anti-skidness.","Caution, risk of skidding")
25	=IF(UV_RESISTANCY="Mostly or permanently outdoor use","Suitable for outdoor use.","Do not expose the product to direct sunlight for a longtime.")
26	=IF(LEN(Warnings__)<=300,"Your warning meeage is suitable for displaying.","Your message is in more than 300 characters. Not suitable")
26a	The message specified will be displayed in the selected location.

D.3. Price Formulas

Table D.3. Price Formula

No	UNIT PRICE
5	=IF(Max_Load_Bearing_Capacity_kg=600, Required_Link_QTY*2*Unit_Price_Ramp_Length_TL, Required_Link_QTY*2*Unit_Price_Ramp_Length_TL*(Max_Load_Bearing_Capacity_kg/600))
7	=IF(Width_mm=800, C13,C13*Width_mm/800) =IF(Max_Load_Bearing_Capacity_kg=600, Unit_Price_Ramp_Width_TL*Required_Link_QTY,Unit_Price_Ramp_Width_TL*Required_Link_QTY*(Max_Load_Bearing_Capacity_kg/600))
10	=IF(Barrier_to_climb>0, IF(FoS_=1.5,"0",Unit_Price_Ramp_FOS_TL*FoS_),0)
18	=IF(Type_Of_Handling="None",Unit_Price_Ramp_Handle_Wheel_TL*0,IF(Type_Of_Handling="Handle & Wheel",Unit_Price_Ramp_Handle_Wheel_TL*1.5,IF(Type_Of_Handling="Wheel",Unit_Price_Ramp_Handle_Wheel_TL*1,Unit_Price_Ramp_Handle_Wheel_TL*0.5)))
19	=IF(Type_of_Storage="None",Unit_Price_Ramp_Type_of_storage_TL*0,IF(Type_of_Storage="Case & Belt",Unit_Price_Ramp_Type_of_storage_TL*1.5,IF(Type_of_Storage="Case",Unit_Price_Ramp_Type_of_storage_TL*1,Unit_Price_Ramp_Type_of_storage_TL*0.5)))
20a	=IF(Extra_Aparatus_Needed="Yes",Unit_Price_Ramp_Mounted_Bracket_Pair_TL*Mounted_Bracket_Pair,0)
20b	=IF(Extra_Aparatus_Needed="Yes",Telescopic_Legs_Pair*Unit_Price_Ramp_Telescopic_legs_Pair_TL,0)
20c	=IF(Extra_Aparatus_Needed="Yes",Approach_Plate_Pair*Unit_Price_Ramp_Approach_Plate_Pair_TL,0)
20d	=IF(Extra_Aparatus_Needed="Yes",Release_PIM_Pair*Unit_Price_Ramp_Release_Pin_Pair_TL,0)
21a	=IF(Extra_Side_Barrier="Yes",Unit_Price_Ramp_Side_Barrier_TL*Side_Barrier_cm*Required_Ramp_Length__cm*2,"0")
22a	=Unit_Price_Ramp_Rotation_Platform_TL*Rotation_platform_QTY

(Cont. on next page)

Table D.3. (Cont.)

23	=IF(Handrail_Needed="None",Unit_Price_Ramp_Handrail_TL*0,IF(Handrail_Needed="Two-lines",Unit_Price_Ramp_Handrail_TL*2*Required_Ramp_Length__cm/100,Unit_Price_Ramp_Handrail_TL*1*Required_Ramp_Length__cm/100))
25	=IF(L41="Mostly or permanently outdoor use",Unit_Price_UV_Resistancy_TL*Required_Horizontal_Distance_cm/100)
26	=IF(Warnings__="",0,Unit_Price_Warning_Message_TL)
26a	=IF(Warning_Message_Placement="Display on the approach plate",Unit_Price_Warning_Message_Placement_TL,Unit_Price_Warning_Message_Placement_TL*2)