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Design based exploration of medical system adoption: Case of wheelchair ramps

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ABSTRACT

This study focuses on the 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, and provide a temporary solution to increase accessibility in their daily lives. In this research, a rollable ramp was examined as this prototype was developed in a prior funded research and thesis study. Our aim in this study is to explore the critical factors of satisfaction of users' and potential users' of portable ramps. To maximize the usability of portable ramp in various outdoor/indoor spaces and physical structures, an efficient permutation of flexible/adjustable components is offered. The research includes flexibility and customization and many external factors effective for adoption of portable ramp. In this context, three research methods were applied; semi structured-face-to-face interviews, observation, and experimental study. The constructs of the survey were extracted from literature and patent reviews then refined during observation and interviews. Wheelchair users answered a web-based survey with multiple constructs. The survey uncovered that personalization, flexibility, extension capability, and cost is critical. As well, users prefer the chance to try the model before purchasing. The effort needed to carry and learn how to use the ramp seems to be one of the key factors. It is also found that the user's life style and product match has an effect on adoption. At the end of the study, a smart mass customization design tool will be developed, which potential users or sales representatives are able to easily interact with in order to customize the portable ramp.

1. Introduction

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

This study is the continuation of the work by the authors on a smart mass customization design tool for portable ramps [42]. Wheelchair users try to reach a wide range and a large number of destinations in their daily lives, such as banks, stores, religious buildings, workplaces, 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. [1]. There are many kinds and different brands of portable ramps in the world market. The comparison of these types and features has been discussed in detail [42].

The objective of this paper is to understand the nature of interaction between product design and the potential users to contribute to the designers to come up with a better design to serve wheelchair and ramp users. Therefore specific research questions are:

- What are the critical factors of the ramp that affects users' satisfaction.?
- Are built-in flexibility and customization options effective in the adoption process.?

Qualitative studies followed by quantitative analyses helped us to develop hypotheses and test them to answer the research questions in

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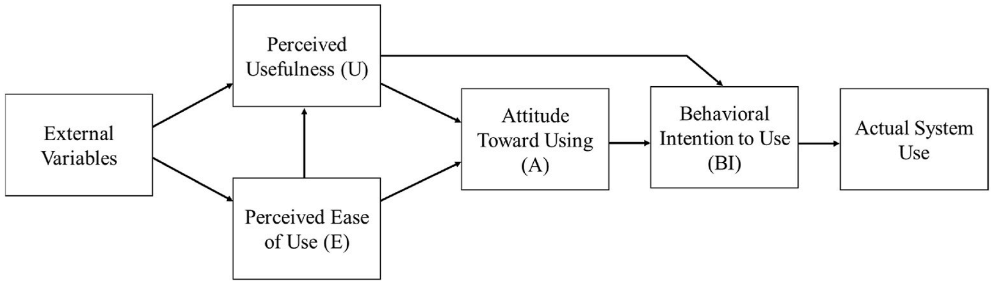

Fig. 1. First modified version of Technology Acceptance Model (TAM) [35].

the following sections.

2. Literature review

In the realm of technology and management of technology there has been some research around wheelchairs related technology. Brown et al. [2] discusses design, implementation, and testing for an adaptable optimal controller which can be used in electric wheelchairs combining adaptable controller theory with pattern recognition techniques presented as a microprocessor system embedded on an electric wheelchair [2]. The design of computer based wheelchair controller motor system was studied in order to show the advantage of benefiting from innovative computer systems in wheelchair designs [3]. Langbein et al. [4] study the calibration of an ergometer for wheelchairs which could be incorporated into the wheelchair ergometer as a economic and reliable method of power generation [4]. This research was done through a series of calibration experiments in order to pinpoint the characteristic of the device related to operation.

The previous studies had studied battery state of charge indicator in order to prevent stranding and to provide more cost-effective wheelchair operation [5]. Almost a decade before Aylor et al. studied the cost-effectiveness and operation of the wheelchair batteries, Jaffe developed an ultrasonic head position interface for wheelchair control with features like obstacle detection, wall-following, and cruise control modes [6]. The role of better engineered wheelchair in the betterment of community participation was published in 2006 [7]. The mentioned study focuses on summarizing research and developments underway with goals of safety enhancement and design optimization while stressing that significant career and business opportunity of serving the public good in a meaningful and tangible ways exist in this field of research.

There are some studies that solely study on portable ramps. Sweeney et al. [8] concludes that it is not possible to recommend a specific ramp for a specific disability or type of wheelchair and stressing that this recommendation must be based on some factors such as the type of the wheelchair and user's social requirements [8]. A more recent study focuses on wheelchair ramp navigation in frozen conditions by considering elements such as type of ascent and descent strategy, number and severity of obstructions, and average velocity among others [9]. As it can be seen most these researchers have focused on the wheelchairs themselves and less attention has been paid to the access ramps for these wheelchairs and the smart design that can be associated to them. Wheelchair users experience many situations that has an impact on the stability and performance of their wheelchair. Stability is affected by user characteristics and abilities, environmental features and conditions, and wheelchair modification and accessories.

Moreover, many of these studies are decades old. There also seems to be a gap around exploration of wheelchair users' expectations from portable ramps and their adoption factors when designing a ramp. More importantly, as mentioned by Sweeney and Lemaire decades apart, different situations and conditions may need a different kind of ramp to cater to that specific scenario. A smart mass customization tool for designing portable ramps may be able to address some of these problems.There are already different types of portable ramps wity myriad of features which have been discussed in detail [42].

In terms of adoption of new designs and technologies in fields of healthcare and public health, while many studies focus on the adoption of health information technology, and discuss the health organizations' heavier focus on financial functionalities and transactions compared to the improvement of service quality and safety [10–12], topics such as safety enhancement and design optimization should still be pursued and studied. There has been some research around healthcare adoption related to improvement of service quality and safety, especially in topics connected to information technology. Brooks et al. [13] studied patient safety related information technologies in urban and rural hospitals while looking at important organizational factors that are effective in the adoption of these technologies [13]. More examples of research in this field have focused on the adoption and implementation of topics such as radio frequency identification devices, general promotion of appropriate diffusion of technology in medicine, telemedicine, mobile nursing information systems, and privacy protection [14–21].

An adoption related topic that has not been studied as much is around the access and safety of wheelchair users. Wheelchair users access number of destinations throughout the routine days, such as health facilities, banks, schools, stores, places of worship, workplaces, and residential building. In doing so, wheelchair users may encounter many different barriers like curbs, lack of ramps or ramps that are too steep, among others [1]. There are currently 2.7 million wheelchair users in the united states [22] and 65 million globally [23] making independence in mobility one of the most important determinants of quality of life for individuals with disabilities [24]. These numbers are expected to higher in the US which is the most significant regional market for powered and manual mobility related products as the baby boomer generation aging and increase in the lifespans [25]. This regional and global increase proves that investments and research and developments improvement of quality and access of wheeled mobility is as relevant as important as ever. It is also important to note the importance of the participation of end-users in how a design take place [26]. As maybe the biggest user of wheelchair ramps, wheelchair users, would provide as excellent opportunity for creation of user centered smart design tool which has the potential to act as a bolster to their accessibility in their daily lives.

Welage & Liu [27] examined wheelchair accessibility in public buildings and discuss the role of professional in this practice area stressing the importance of the role of professionals in terms of wheelchair accessibility advocacy and assisting wheelchair users to participate fully in all areas of the community. The characteristics of study evaluations of the mentioned research was location, sample of buildings, design, instruments. Another study tried to determine the extent to which curb ramps in an urban area met a set of wheelchair accessibility guidelines [28]. Plos et al. [29] presented an approach called EMFASIS as an integrated strategy for removing stigmatization issues from Assistive Technology as an urgent way to become aware of the powerful lever for integration offered by industrial design. Soewardi et al. [30] develops a multifunctional and ergonomic wheelchair design based on user requirements based on user centered design to specify and improve

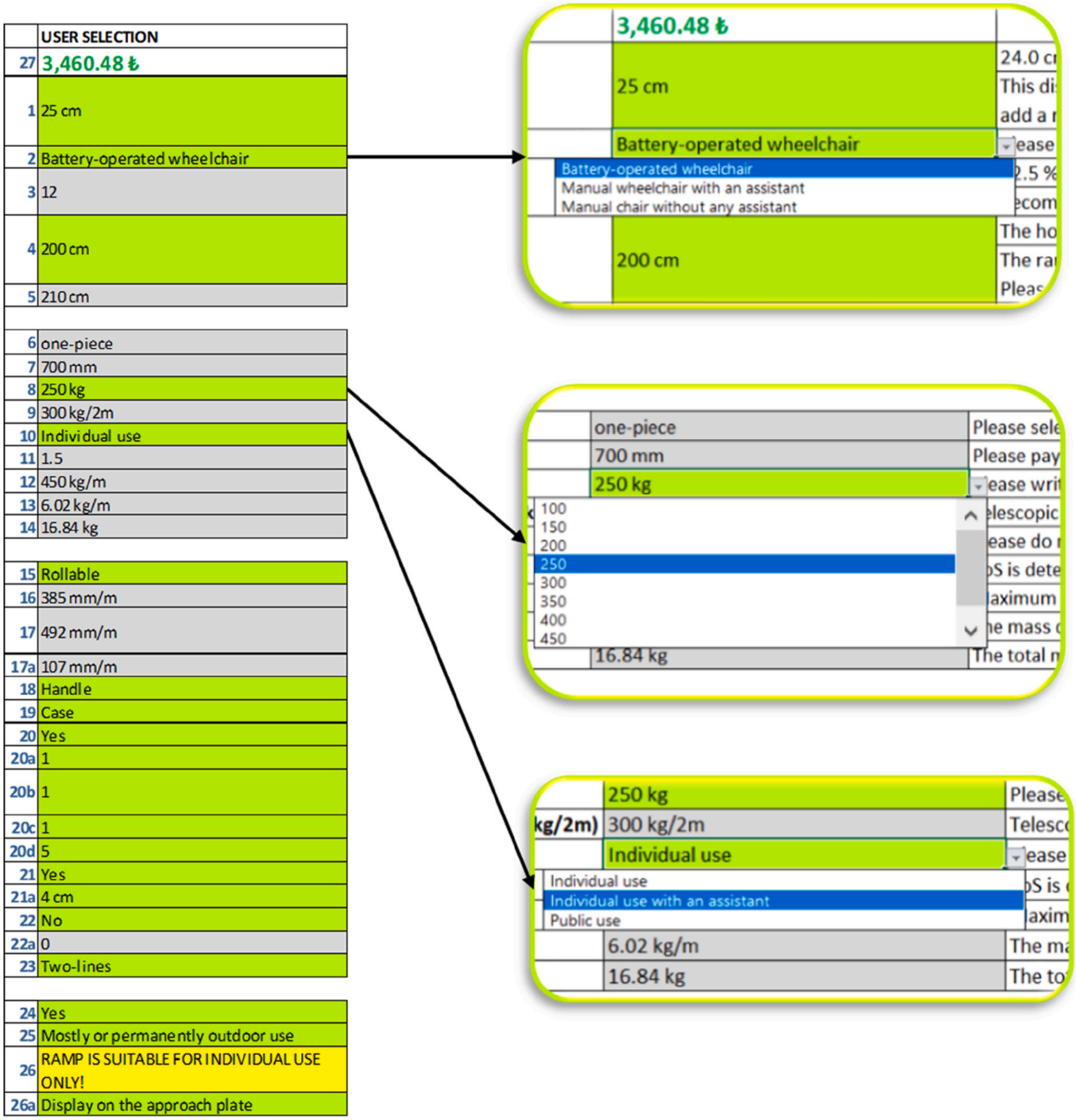

Fig. 2. Expand selection options.

wheelchair design parameter. There are more wheelchair related research with focus on user centered innovation in the literature such as [31,32].Carlson et al. [33] also describes a system that allows a power wheelchair user to drive through a virtual architectural environment allowing better visualization of that environment by architects and designers and the ability for them to test the environment for handicapped accessibility, and evaluation of that environment's design standards. Moreover, there has been some research around the design of wheelchair-accessible motion-based games. This research was aiming to encourage older adults to develop a positive relationship with their wheelchair by gamification of users' wheelchairs [34].

Technology Acceptance Model (TAM) is one of the most popular models of acceptance theory (Fig. 1), which is used to predict user behavior towards a new technology while uncovering their perception of usefulness, ease-of-use, attitude toward using, and intention to use [35]. TAM has been applied to various innovative technology products to estimate the possible reaction of the users and adoption possibility [36–40]. Davis and Venkatesh proposed the final version of TAM in which attitude construct was eliminated after they realized that perceived usefulness and ease of use (EoU) were found to have a direct influence on intention [41].

In this research, a previously designed rollable ramp was examined as a prototype. Semi structured-face-to-face interviews, observation, and experimental study were applied as parts of this study. The constructs of the survey were extracted from literature and patent reviews then refined during interviews and observation studies [42]. Wheelchair users responded to a web-based survey with many constructs (Fig. 2). The findings of this user centered study explores the wheelchair users' experience of portable ramps and their adoption factors. By using technology acceptance model, key adoption criteria and parameters are pinpointed. The information obtained from this methodology would be valuable asset in designing effective ramps for wheelchair users.

Table 1
Methodology of the study [42].

	Study	Time Period	Analysis and Output
1	Preliminary studies	July 2015–May 2018	Building a full functional prototype within a TUBİTAK funded project and ME graduate thesis.
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, in-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 measuring instrument with 35 construct and 72 questions, 46 respondents
6	Mass customization assistance tool	April 2019–July 2019	Design and develop a customization tool based on the findings of requirement exploration survey

3. Methodology

The research consisted multiple interrelated stages where each usually produced an input for the following step. Below are the details of the stages (Table 1).

The purpose of the experimental study was to uncover the factors that affect wheelchair users' adoption of 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 consisted of a photograph and a video of the product, and the questionnaire consisting of 72 questions (Appendix Table). Collected data from participants was used for regression and descriptive analysis. All of the answers were scaled 1 to 5 in which 1 represented strongly disagree, 3 was neither agrees nor disagrees, and 5 was strongly agree. Participants selected 1 to 5 to specify the level of the agreement to the questions.

The framework of the mass customization has been illustrated. All design parameters were related to length customization, structural customization, storage customization, ease of use customization, extra apparatus and equipment need, and price customization (Table 2).

All parameters are parametrically related to each other, and offer many different solutions to customers. Fig. 3 illustrates results of computations to show consistency calculations and warning messages. As can be seen from Fig. 3, consistency calculations and warning messages lead the user during the decision-making process. For example, the tool warns the user about the 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). If the user prefers to not use a rotation plate, the tool shows the calculation of slope angle to the user 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, the decision is entirely up to the user who may add a rotation platform to satisfy the 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.

As can be seen from Fig. 4, two different scenarios are illustrated to show how different selections effect the computations, warning messages, and total price. Extra apparatus and mounting means were excluded from the 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.

Table 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/2 m)	Computed Value
10	Use condition	Manual Input
11	Factor of Safety (FoS)	Computed Value
12	Max (real) load bearing capacity (kg/2 m)	Computed Value
13	Ramp mass (kg/m)	Computed Value
14	Total ramp mass (kg)	Computed Value
15	Deployability	Manual Input
16	Compactness (diameter/1 m 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

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

The questionnaire was conducted with a web-based data collection instrument. The questionnaire consisted 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. The survey presented a photograph of the proposed design and a YouTube video about a portable rollable ramp that is

	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.

Fig. 3. Consistency calculations and personalized warning messages.

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.

Fig. 4. User selection scenario 1 and 2.

presently on the market. The name and link to the video is provided here titled: Taşınabilir rampa: https://www.youtube.com/watch?v=DmojKH3__o[1]

Participants were expected to answer the questions while considering the photography and the video. All of the answers were scaled 1 to 5 in which 1 represents strongly disagree, 3 means neither agrees nor disagrees, and 5 equals strongly agree. The demographic information for the questionnaire is shown in Table 3 and the variables explored are provided in the Appendix.

[1] https://www.youtube.com/watch?v=DmojKH3__o.

4. Results and discussion

The general profile of the participants can be seen in Table 3. Of the 46 participants, 36 were male, and 10 were female. Most of the participants were ages ranging between 25 and 44, and the majority of participants were university graduates. The descriptive statistics revealed that most of the participants agreed with the extension and regulation construct that indicated that extendibility is important, and that putting the ramp in the public places would provide practical solutions for accessibility. They generally thought that the personalization concept for such a product would be in high demand. These demands for personalization, cost, and flexibility construct are related to the mass

Table 3
Demographic profile.

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

Table 4
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

Table 5
The most effective 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/m)
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

customization concept, and is parallel with the idea of the proposed smart mass customization tool. Moreover, most of the participants thought that the product was useful, but that it was important to try the product before making the decision to purchase. A reliability test was used to measure the internal consistency of the constructs contained in more than one question item. Internal consistency was tested with Cronbach's Alpha coefficient, and 0.6 was selected as the threshold value. A construct can be considered "reliable" if Cronbach's Alpha coefficient is bigger than 0.6. As can be seen from Table 4, Self_efficacy and PhysicalCon constructs do not show internal consistency, thus these constructs were used as separate items in SPSS analysis. In addition, all of the intermediary constructs (Intention, Usefulness, EoU, and Attitude) were highly reliable.

Table 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

During the exploration survey phase, the descriptive statistics revealed that most of the participants agreed with the extension and regulation constructs. This indicated that the ability to extend the ramp is important, and that keeping the ramp in the public places will provide practical solutions for accessibility. They generally thought that the ability to personalize the product would create high demand. The demand for personalization, affordability, and flexibility relates to the mass customization concept, andis parallel with the idea of the proposed smart mass customization tool. Moreover, most of the participants thought that the product was useful, but that the ability to try the product before purchasing was important.In addition, they thought that the product was easy to learn (EoL).The most effective constructs according to descriptive analyses are summarized in Table 5.

A reliability test (Table 4) was used for measuring the internal consistency of the constructs that contained more than one question item. Internal consistency was tested with Cronbach's Alpha coefficient, and 0.6 was selected as the threshold value. A construct is considered "reliable" if Cronbach's Alpha coefficient is bigger than 0.6. As can be seen Table 4., Self-efficacy and PhysicalCon constructs did not show internal consistency, thus these constructs were used as separate items in SPSS analysis. In addition, all of the intermediary constructs (Intention, Usefulness, EoU, and Attitude) were highly reliable.

The significant results for ANOVA analysis based on age construct can be seen in Table 6. Wheelchair users between the ages of 25–34 were affected by promotions and advertisements of such products more than people of any other age. Another interesting result was that users aged 45 and above claimed that they easily learned how to use the product, and had no difficulty using the ramp compared to other groups of people. Moreover, wheelchair users of relatively lower ages had a similar attitude towards using the ramp. People aged 25–34 claimed that the product provided them with more freedom of movement. The most significant detail about the ANOVA analysis by education level (Table 7) was that college-educated wheelchair users were comfortable with adopting the new product, while people who only attended primary school approached these kinds of products with caution. In addition, wheelchair users with master's degrees found the ramp was a requirement for navigating ground conditions more than any other group of people.

Regression Analysis (Table 8) is used to examine relationships between the constructs in the adoption taxonomy. Four major constructs including ease of transportation (Transport), ease of learning (EoL), mobility gain (Mobility), and suitability for lifestyle and way of living (Compatibility) had significant impact on the adoption constructs of Ease of Use, Usefulness, Attitude and Intention.

Table 8 shows the summarizing results for regression analysis. Regression Analysis was used to examine relationships between the constructs in the adoption taxonomy. According to regression analysis, results showed that attitude was a direct determinant of users' intention

Table 7
ANOVA analyses by mean education level.

No	Construct	F	Sig.	Primary school (N = 5)	High school (N = 13)	College (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

Table 8
Results of regression analyses.

Dependent	Independent	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

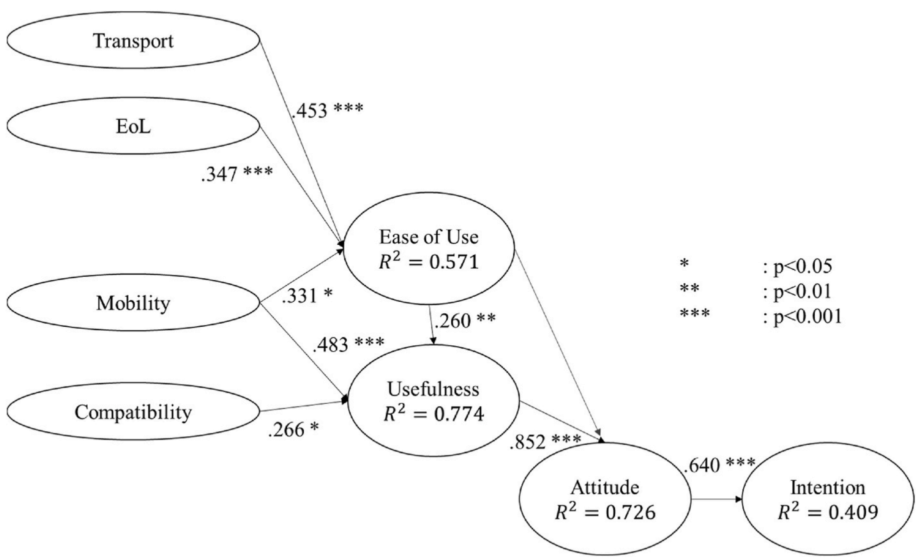

Fig. 5. Results of portable ramps adoption framework.

toward the portable ramps with a coefficient of 0.640 ($p < 0.001$). Attitude was directly affected by usefulness with a coefficient of 0.852 ($p < 0.001$). However, there was not a direct effect of Ease of Use on Attitude. Moreover, Mobility, EoU and Compatibility were direct determinants of Usefulness perception. In addition, Transport, EoL, and Mobility were direct determinants of Ease of Use perception. Results of the portable ramps adoption framework are shown in Fig. 5.

As Fig. 5 clearly shows user are really keen on being mobile and doing that easily.

5. Conclusions

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

The smart customization tool generates a personalized user manual during the customization process with simultaneously changing warning messages. To make the decision-making process easier for potential customers, it also dynamically illustrates a customized ramp in rolled position. Moreover, emerging technologies such as additive manufacturing techniques may enable the tool to provide customers with the ability to manufacture their own unique products in the near future as customers become more conscious and informed about products on the market.

The descriptive analysis showed that the personalization concept for such a product is in high demand. Demands for personalization, affordability, ramp extendability, and flexibility construct are related to the mass customization concept, which is parallel with the idea of the proposed smart mass customization tool. Potential users could have access to the customization tool so that they can attempt to configure the product, while at the same time they could see the affect of these changes on the final price. The user could immediately configure the length, width, climbing slope, number of pieces, maximum load, safety coefficient, handling style, storage options, accessories of handrail, warning messages, anti-skidness property, side bars, UV protection and other features depending on their personal preferences.

This flexible capability of the tool allows for the creation of a product that best represents the user preferences under an assumed budget constraint. The user is no longer limited by what a manufacturer offers, and they go beyond initial and single design settings. With this approach, the user is involved with the entire design process. This tool, in turn rises the user's overall satisfaction.

Moreover, most of the participants thought that the product was useful, but that the ability to try the product before purchasing is important … Salespeople may provide trial products so that users can test the impact of a prototype of a particular design, which provides a first hand experience.

According to analysis, usefulness perception of portable rollable ramps was affected by mobility, ease of use, and compatibility. Usefulness perception of potential customers can be amplified by creating awareness with these constructs. It should be emphasized that the product provides mobility and ease of use while being compatible with the users' life style. Moreover, ease of use perception was directly related to transport, ease of learning, and mobility perceptions. The ramp should be introduced as easy to learn and light and easy to carry.

The most important limitation of this study was the small sample size (46). It would be beneficial to improve the respondent size in order to generalize the findings. Another limitation was that the research was 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 the chance to get a real experience.

Future studies can expand this work and address some of the limitations such as lack of specific with respect to the types of wheelchairs and disabilities.

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APPENDIX

VARIABLES

Construct	Question	Scale	S-Type
Assistant	Is there someone who can help you when using a wheelchair?	5	Scale
Experience	how many years have you been using a wheelchair?	5	Scale
Innovativeness	I am cautious in adopting new products.	5	Scale
Self_efficacy	I can easily use it alone.	5	Scale
Self_efficacy	I'm not sure I can use such products.	5	Scale
Weight_Prob	I can find a wheelchair suitable for my physical characteristics (weight, height …).	5	Scale
Time2Arrive	There are places to go by spending a short time.	5	Scale
Concern_Health	I am concerned when using wheelchairs outdoors.	5	Scale
PhysicalCon	I think the ramps in public places are comfortable to use.	5	Scale
PhysicalCon	This product is required for floor conditions where I have to use a wheelchair.	5	Scale
Flexibility	I think it has a flexible structure that allows for personalization at the time of purchase	5	Scale
Flexibility	It can be used in any kind of ground	5	Scale
Flexibility	I want it to have the flexibility to add a number of functions that I consider necessary	5	Scale
Flexibility	If necessary, I can extend and shorten it appropriately.	5	Scale
Personalization	I would like to customize some features to my own wishes.	5	Scale
Personalization	It is a good idea to see the change in price simultaneously while personalizing the product	5	Scale
Personalization	I want to determine features (wideness-angle, width, weight) of it.	5	Scale
Personalization	I would like to determine the safety (barrier height, antiskipness, handrail etc.) of the product myself	5	Scale
Personalization	I would like to determine the basic functions of the product such as ergonomics (storage, portability, installation-uninstallation, assembly and interconnection, etc.)	5	Scale
Triability	it is important to give trial time to understand the properties of the product.	5	Scale
Image	With using this product, I think I will have a different style among my friends who use it.	5	Scale
Compatability	It is suitable for my style and way of living	5	Scale
InternalInfluence	I care about my relatives' opinions on this topic	5	Scale
ExternalInfluence	The promotions and advertisements of such products affect me	5	Scale
Mobility	With the help of this product I can go anywhere I want	5	Scale
Mobility	This product provides me more freedom of movement	5	Scale
Transport	I can carry it anywhere	5	Scale
Transport	I think it is easy and practical to carry	5	Scale
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.	5	Scale
Support	I can get technical support quickly and easily	5	Scale
Security	I may come up danger during use.	5	Scale
Security	I find it safe to use.	5	Scale
Width	I find its width enough	5	Scale
Extend	It is important to be extendable	5	Scale
Light	I think it is light	5	Scale
Firm	I think it is strong	5	Scale
Stable	I think it is stable	5	Scale
Ergonomic	I think it is ergonomic	5	Scale
Cost	Purchase cost of the product is high (4.000 TL/m)	5	Scale
CostAfford	It is affordable product	5	Scale
EoL	It takes time to learn to use	5	Scale
EoL	I can easily learn how to use	5	Scale
EoU	I do not face difficulty while using.	5	Scale
EoU	I think it is easy foldable	5	Scale
EoU	I find it easy and practical to install	5	Scale
Usefulness	I think it is useful	5	Scale

(*continued on next page*)

(*continued*)

VARIABLES			
Construct	Question	Scale	S-Type
Usefulness	It makes my daily life easier	5	Scale
Usefulness	It helps my social life	5	Scale
Usefulness	It allows me to easily overcome from obstacle	5	Scale
Usefulness	I can be satisfied with this product	5	Scale
Attitude	It is a good idea to use	5	Scale
Attitude	I recommend to other people	5	Scale
Attitude	I intend to use it	5	Scale
Intention	I intend to buy	5	Scale
Intention	I am planning to buy it soon	5	Scale

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