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Universal Safety Design (USD) and Sustainability: Comparison of Guidelines between Universal Design (UD) and USD

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Featured Application: Universal Design is a design concept that allows the elderly or disabled to use living facilities or products. Universal Safety Design guidelines have extensibility in fairness, flexible work, and sustainability perspectives.

Abstract: Universal Design (UD) has contributed to enhancing the quality of life through design for all. This study aims to compare the users' subjective scores for UD guidelines and Universal Safety Design (USD) guidelines. A questionnaire survey was performed to get information on the 165 users' subjective scores for design guidelines implementing UD or USD. Results show that USD guidelines have extensibility in fairness, flexible work, and sustainability perspectives. UD guidelines show a low correlation coefficient with sustainability guideline of USD. In the results of the regression analysis, the guidelines of USD reflect the design concept of UD. Additionally, USD guidelines increase the design concept of sustainability. USD guidelines are expected to contribute to creating comfortable and safe environments for the disabled, the elderly, foreigners, and socially vulnerable groups. Additionally, it is expected to address discrimination at work.

Keywords: sustainable design; safety and health; diversity; inclusion; sustainability

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1. Introduction

Universal Design (UD) is the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design [1]. The word 'universal' means 'everybody' or 'towards the individual.' It is the concept of providing user-friendly products to various classes of users without discrimination [2,3]. UD's perspective has evolved from the roots of the disability rights movement to an aging population, health and well-being, and social participation [4]. The scope of UD's application ranges from planners and designers to facility managers and facilities, especially in the buildings, shopping malls, public facilities, health sector, rehabilitation, and groups dealing with all kinds of disabilities [4–9]. That is, UD is devoted to enhance the quality of life through design for all for making a better society for everyone, regardless of age, gender, culture, abilities or disabilities [5].

UD extends to the concept of consideration and inclusion of socially vulnerable groups in the human rights perspective [3,10]. In South Korea, user or production workers' characteristics are gradually diversifying due to the increase of the elderly, women, and foreigners [11,12]. Thus, it is necessary to consider diversity in terms of physical ability, class, and institution [13,14]. Accommodating all people including workers at workplace requires an extension of the paradigm [2,15–18].

The world is being reshaped under the influence of globalization and new technologies. New employment patterns and working conditions present a challenge to the protection and promotion of occupational safety and health (OSH) of workers [19]. New hazardous agents and physical, chemical, biological factors in addition to occupational accidents still threaten the health of workers [20].

Sustainable development is based on social equity, environmental sustainability, and economic viability [21]. While many organizations have made enormous efforts to reduce their environmental impact, not many have endeavored to minimize the impact on their workers. Decent work has become the UN's 2030 Agenda for Sustainable Development [22]. The concept of decent work covered the working conditions in which work is performed, in addition to respecting the fundamental norms of work [23].

The elimination of discrimination at work has become a major challenge of the 2030 Agenda for Sustainable Development [22]. European Institute for Design and Disability (EIDD) adopted the 'EIDD Design for All,' which is a design for human diversity, social inclusion, and equality [5]. Inclusive work climates have been linked to employee outcomes of well-being, high-quality work relations, and job satisfaction [24].

Safe and healthy working conditions are the primary indicator for 'decent work' [23]. Additionally, OSH is essential for a sustainable society that enables workers to enjoy a healthy and productive life during and after working [20]. The WHO meeting, which was held in 1994, adopted a proposal for 'universal OSH' [25]. A universal OSH presents minimum basic standards of OSH for all workers.

Kim and Jeong [15] proposed a 'universal safety' concept as a design concept to extend UD. The 'universal safety' refers to a design concept in which anyone can use products or workplaces safely, regardless of the employment contract and weakness of physical or cognitive function [15].

Kim and Jeong [3] established the 'universal safety design (USD)' concept and the USD guidelines. They proposed 46 guidelines based on six principles. It is a systematic consideration not only for workers or users but also for the individual, organization, and environment to ensure a basic standard level of health and safety [3].

Baek and Jeong [26] surveyed the usefulness of USD guidelines in implementing the UD concept. They showed that USD guidelines reflected the UD concept. This study follows up Baek and Jeong's study [26]. This study analyzes the importance of design guidelines for implementing the US and USD concept and investigates the relationships between the two guidelines.

1.1. Literature Review and Terminology

This section summarizes the terminology of the articles found by keywords in the 'Web of Science' database. The keywords used in database search are 'universal design', 'sustainability', 'diversity', 'inclusion', 'accessibility', 'physical support', 'universal health', and 'universal safety'.

1.1.1. Physical Support

Product designers should guarantee comfort and safety for users regardless of age, size, gender, abilities, or disabilities [5]. Physical support design involves low physical effort and appropriate size and space [1]. Low physical effort means ensuring efficient and comfortable use with minimal fatigue or effort [1,3,6–9]. In contrast, appropriate size design is provided for approach, reach, manipulation, and use, regardless of the user's body size, posture, or mobility [1,3,6–9].

1.1.2. Flexibility

It should be free to use, regardless of the preferences or environment of the person who uses the product or wishes to work [3]. Design for flexibility includes flexible designs and flexible working. Flexible design means accommodating various tastes and abilities [1]. Flexible working means providing workers with flexibility in the form of work [3,27].

1.1.3. Accessibility

Everyone should be able to use products in a way that is easy to understand [3]. Design for accessibility includes designs for simplicity and perceptibility [3]. Simplicity means that everyone can easily understand, regardless of the user's experience, literacy, or

concentration level [28]. Perceptibility means that everyone can effectively perceive the necessary information, regardless of the user's sensing ability or usage environment [28].

1.1.4. Ensuring Safety and Health

It should be designed so that users can quickly respond to mistakes or errors and ensure safety even in emergencies. Especially for repeated use, products or equipment should be easy to operate, and consumables should be replaced comfortably and safely [3].

For ensuring safety and health, designs should include an error-proof design and a safety and health assurance policy. Error-proof design means minimizing the risk and negative consequences of accidental or unintended actions [6–9,29]. Additionally, a safety and health assurance policy means ensuring the basic level of health and safety standards for all workers regardless of employment status [3].

1.1.5. Diversity and Inclusion

Diversity refers to differences between users, including observable demographic diversity and unobservable cognitive diversity [30,31]. Conversely, inclusion is based on the perceptions of fairness and belonging. Thus, inclusion means increasing equality and participation of all employees [32].

The inclusive design includes equitable use and fairness of design policy. Equitable use design is helpful and marketable for people of various abilities. Fairness of design policy means ensuring fairness and equality without discrimination [1].

1.1.6. Sustainability

Sustainability is the ability to maintain or support an activity or process over the long term [17,33].

Designs for sustainability include socio-ethical sustainability and work sustainability. Socio-ethical sustainability means that the design should ensure building and improving consensus as social values change. Work sustainability means that the design should provide comfort and safety for long-term work or usage.

1.2. UD and USD Guidelines

UD has seven principles and 29 guidelines [1]. The UD seven principles include equitable use, appropriate size and space, flexible design, simplicity, perceptibility, error-proof design, and low physical effort.

Kim and Jeong [3] proposed a USD concept, and Baek and Jeong [26] confirmed the usefulness of six principles and 46 USD guidelines. The USD concept was developed based on the limitations of UD and supported users and workers to work efficiently, comfortably, and safely. The USD six principles include physical support, flexibility, accessibility, ensuring safety and health, diversity and inclusion, and sustainability.

2. Materials and Methods

2.1. Data Collection

In this study, a questionnaire survey was used to get information on the user's subjective feelings towards the UD or USD concept. Table 1 shows 46 design guidelines and research variables of USD [3]. U1 to U7 refers to UD guidelines, and S1 to S6 refers to USD guidelines.

The questionnaire consisted of UD and USD questionnaires. First, respondents were asked to evaluate the UD questionnaire on a 7-point scale. The UD questionnaire asks the following questions. 'How important do you think about the following guideline for people with disabilities to use products without discrimination?' Respondents have to rate each guideline on a 7-point scale. The 7-point scale is expressed as '1 = very low, 2 = low, 3 = little low, 4 = moderate, 5 = little high, 6 = high, 7 = very high.' The 27 questions were asked randomly.

Table 1. Guidelines of USD and research variables.

USD Guidelines	Variables	
	UD *	**USD ****
S1. Physical support		
S1.1 Low physical effort		
1. Allow the user to maintain a neutral body position.	U6	S1
2. Use reasonable operating forces even for people with weak strength.	U6	S1
3. Reduce the number of steps required to complete tasks.	U6	S1
4. Minimize the range of motion and travel distances.	U6	S1
S1.2 Appropriate size and space		
1. Provide a clear line of sight to important elements for any seated or standing user.	U7	S1
2. Make reach to all components comfortable for any seated or standing user.	U7	S1
3. Accommodate variations in hand and grip size.	U7	S1
4. Provide adequate space for the use of devices or personal assistance.	U7	S1
S2. Flexibility		
S2.1 Flexible design		
1. Provide choices in methods of use.	U2	S2
2. Accommodate right- or left-handed access and use.	U2	S2
3. Facilitate the user's accuracy and precision.	U2	S2
4. Provide adaptability to the user's pace.	U2	S2
S2.2 Flexible working		
1. Adopt a flexible working concepts to accommodate diverse workforce.		S2
2. Adopt strategies and policies focusing on implementing flexible working.		S2
3. Consider the needs of different groups of workers and improve work-life balance.		S2
S3. Accessibility		
S3.1 Simplicity		
1. Eliminate unnecessary complexity	U3	S3
2. Be consistent with user expectations and intuition.	U3	S3
3. Accommodate a wide range of literacy and language skills.	U3	S3
4. Arrange information consistent with its importance.	U3	S3
5. Provide effective prompting and feedback during and after task completion.		S3
6. Make observations of the relevant parts of the system possible.	U3	S3
S3.2 Perceptibility		
1. Use different modes for redundant presentation of essential information.	U4	S3
2. Provide adequate contrast between essential information and its surroundings.	U4	S3
3. Give each action an immediate and obvious effect.	U4	S3
4. Provide affordance and compatibility with a variety of techniques.	U4	S3
S4. Ensuring safety and health		
S4.1 Error-proof design		
1. Arrange elements to minimize hazards and errors.	U5	S4
2. Provide fool-proof or fail-safe features.	U5	S4
3. Provide warnings of hazards and errors.	U5	S4
4. Discourage unconscious action in tasks that require vigilance.	U5	S4
5. Include reversible actions and safety nets to minimize the consequence of errors.		S4
S4.2 Safety and health assurance policy		
1. Consider policies to ensure safety and health, including socially vulnerable groups.		S4
2. Predict and prevent occupational incidents and illnesses.		S4
3. Consider mental stress for emotional workers or service providers.		S4
S5. Diversity and inclusion		
S5.1 Equitable use		
1. Provide the same means of use for all users.	U1	S5
2. Avoid segregating or stigmatizing any users.	U1	S5
3. Make provisions for privacy, security, and safety equally available to all users.	U1	S5
4. Make the design appealing to all users.	U1	S5
S5.2 Fairness of design policy		
1. Accommodate all production workers and consumers from a design policy point of view.		S5
2. Ensure non-discrimination in cultural and institutional aspects.		S5
3. Ensure equal policies for comfort and safety to foreigners and temporary workers.		S5

Table 1. *Cont.*

USD Guidelines	Variables	
	UD *	USD **
S6. Sustainability		
S6.1 Socio-ethical sustainability		
1. Encourage and support decision-making and planning processes relevant to long-term implications.		S6
2. Provide shareability and socializing abilities for continuous improvement through user feedback.		S6
3. Consider the long-term productive capability, quality, and capacity of natural ecosystems.		S6
S6.2 Work sustainability		
1. Consider not only the visible hazards but also the risks of cumulative exposure or repetitive use.		S6
2. Anticipate and prevent cumulative risks and health impacts following long-term use or work.		S6
3. Consider mental workloads and stress in the new forms of creative or service works.		S6

* Universal design guideline, ** Universal safety design guideline.

Second, respondents were asked to evaluate the USD questionnaire in the same way. The questionnaire asked, 'How important do you think about the following guideline to implement the USD concept? The USD concept allows to allow the elderly or the disabled to use products like healthy people, and to ensures health and safety for workers, regardless of foreign or temporary workers.' Respondents have a five-minute break between the UD and USD questionnaires.

In this study, we surveyed university or graduate students majoring in human factors or industrial design. A total of 165 respondents were made up of 110 males and 55 females. The mean age was 25.6 years old (standard deviation = 6.413).

2.2. Data Analysis

Figure 1 represents the research variables defined in this study. The dependent variables were expressed as subjective importance of UD or USD guidelines. Independent variables consisted of seven principles of UD (U1 to U7) and six principles of USD (S1 to S6), and 12 detailed USD principles (S1.1 to S6.2).

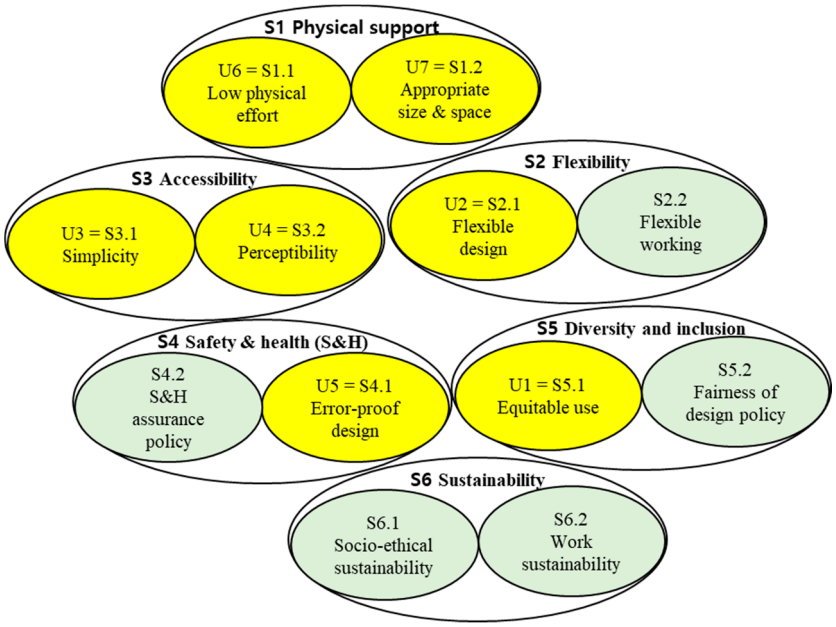

Figure 1. Guidelines of UD (U1 to U7, yellow) and USD (S1 to S6, yellow and green).

First, this study analyzes the importance of design guidelines for implementing the US and USD concepts. Second, factor analysis was conducted to identify guidelines with high explanatory power when implementing UD or USD. Finally, we investigate correlation and regression analysis to determine the relationships between UD and USD guidelines. For the statistical analysis, SPSS 18.0 was used, and the significance level was 0.01.

3. Results

3.1. Mean Comparison Test on UD Guidelines

Table 2 and Figure 2 show the results of mean comparison tests for the subjective scores between UD and USD according to seven areas of the UD guidelines. In Table 2 and Figure 2, the mean scores of USD are higher than UD scores in equivalent use (U1), flexible design (U2), simplicity (U3), perceptibility (U4), and error-proof design (U5) at a significance level of 0.01. In Table 2, the increase in subjective scores (% = USD scores / UD scores) was highest at simplicity (U3), followed by perceptibility (U4) and equal use (U1). On the other hand, there was no difference in low physical effort (U6) and appropriate size and space (U7) at a significance level of 0.01.

Table 2. Mean comparison tests between UD and USD scores according to UD guidelines.

UD Guideline	UD Scores (A)		USD Scores (B)		Mean Test *p*-Value *	(%) = B/A
	Mean	SD	Mean	SD		
U1. Equitable use	5.170	0.924	5.472	0.816	0.002 *	105.8%
U2. Flexible design	4.992	0.775	5.175	0.742	0.029 *	103.7%
U3. Simplicity	5.158	0.829	5.539	0.709	0.001 *	107.4%
U4. Perceptibility	5.167	0.788	5.496	0.754	0.001 *	106.4%
U5. Error-proof design	5.623	0.769	5.795	0.772	0.043 *	103.1%
U6. Low physical effort	5.407	0.846	5.489	0.831	0.376	101.5%
U7. Appropriate size and space	5.153	0.810	5.292	0.749	0.109	102.7%
Total mean	5.233	0.618	5.448	0.607	0.002 *	104.1%

* Significant at significance level 0.01, SD = Standard deviation.

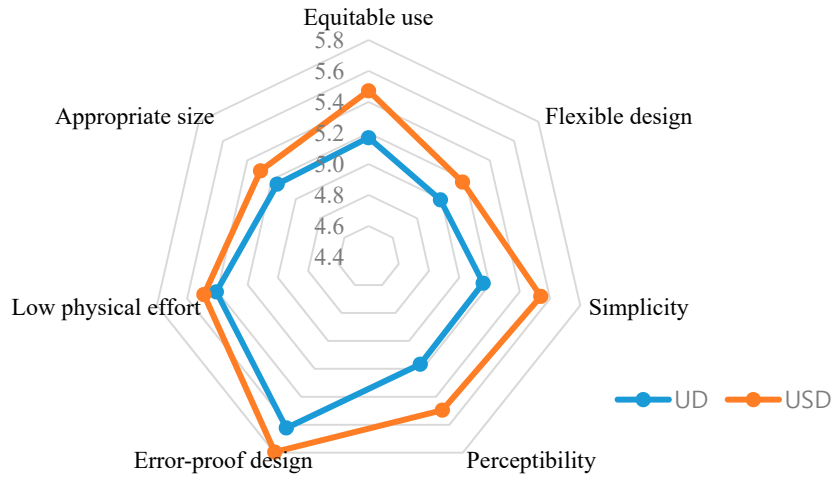

Figure 2. Mean scores of UD and USD according to UD guidelines.

Overall, average UD scores in the USD concept are 104.1% higher than average UD scores in the UD concept. In short, USD guidelines reflect the UD concept.

3.2. Mean Comparison Test on USD Guidelines

Table 3 and Figure 3 show the results of mean comparison tests for the subjective scores between UD and USD according to six areas of the USD guidelines.

Table 3. Mean comparison tests between UD and USD scores according to USD guidelines.

USD Guideline	UD Scores (A)		USD Scores (B)		Mean Test *p*-Value *	(%) = B/A
	Mean	SD	Mean	SD		
S1. Physical support	5.256	0.737	5.412	0.781	0.063	103.0%
S2. Flexibility	5.062	0.752	5.160	0.715	0.226	101.9%
S3. Accessibility	5.152	0.735	5.506	0.669	0.001 *	106.9%
S4. Ensuring safety and health	5.448	0.734	5.679	0.728	0.004 *	104.2%
S5. Diversity and inclusion	5.157	0.791	5.456	0.786	0.001 *	105.8%
S6. Sustainability	5.028	0.892	5.493	0.831	0.001 *	109.2%
Total mean	5.184	0.629	5.443	0.622	0.001 *	105.0%

* Significant at significance level 0.01, SD = Standard deviation.

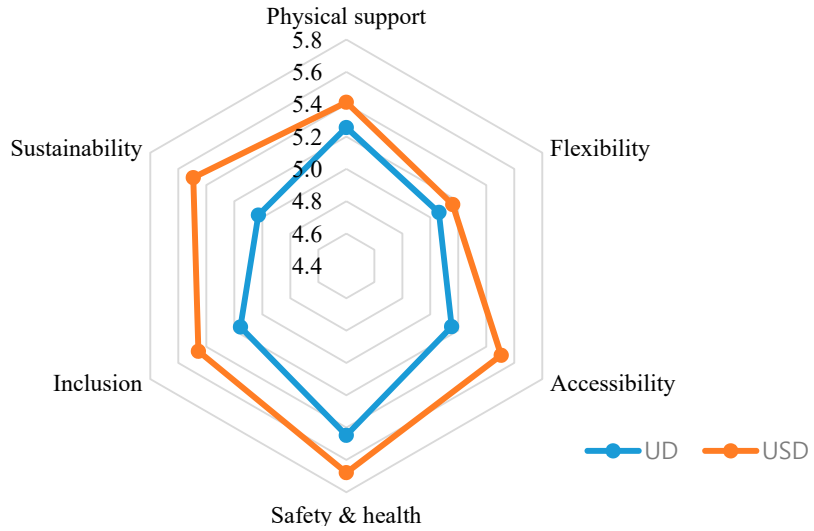

Figure 3. Mean scores of UD and USD according to USD guidelines.

In Table 3 and Figure 3, mean scores of USD are higher than UD scores in accessibility (S3), ensuring safety and health (S4), diversity and inclusion (S5), and sustainability (S6) at a significance level of 0.01. The increase in subjective score, (% = USD scores / UD scores), was highest in sustainability (S6), followed by accessibility (S3), and diversity and inclusion (S5). On the other hand, there was no difference in physical support (S1) and flexibility (S2) at a significance level of 0.01. Overall, average USD scores in the USD concept are 105.0% higher than average USD scores in the UD concept.

3.3. Factor Analysis on UD and USD Guidelines

Table 4 shows the results of factor analysis using the principal component method on the subjective scores of the UD guidelines. In Table 4, the results of factor analysis were summarized as one principal component for UD. The highest explanatory guideline for UD was simplicity (U3), followed by appropriate proper size and space (U7), error-proof design (U5), equivalent use (U1), low physical effort (U6), and flexible design (U2).

Table 5 shows the results of factor analysis on the subjective scores of the USD guidelines. In Table 5, the results were summarized as one principal component for USD. The highest explanatory guideline for USD was ensuring safety and health (S4), followed by diversity and inclusion (S5), accessibility (S3), flexibility (S2), sustainability (S6), and physical support (S1).

Table 4. Results of factor analysis on UD guidelines.

Observed Variables	Factor
U3 Simplicity	0.813
U7 Appropriate size and space	0.808
U5 Error-proof design	0.746
U1 Equitable use	0.744
U6 Low physical effort	0.737
U2 Flexible design	0.716
U4 Perceptibility	0.695
Explained total variance = 56.6%	
Kaiser–Meyer–Olkin test = 0.860	
Bartlett test χ^2 = 486.9, $p < 0.001$	

Table 5. Results of factor analysis on USD guidelines.

Factor Analysis by USD Guidelines		Factor Analysis by Detailed USD Guidelines	
Observed Variables	**Factor**	**Observed Variables**	**Factor**
S4. Ensuring safety and health	0.871	S3.1 Simplicity	0.837
S5. Diversity and inclusion	0.857	S5.1 Equitable use	0.810
S3. Accessibility	0.843	S4.1 Error-proof design	0.806
S2. Flexibility	0.816	S6.2 Work sustainability	0.795
S6. Sustainability	0.808	S1.2 Appropriate size and space	0.769
S1. Physical support	0.782	S4.2 Safety and health assurance	0.748
		S2.2 Flexible working	0.740
		S5.2 Fairness of design policy	0.740
		S3.2 Perceptibility	0.689
		S6.1 Socio-ethical sustainability	0.682
		S1.1 Low physical effort	0.677
		S2.1 Flexible design	0.661
Explained total variance = 68.9%		Explained total variance = 56.0%	
Kaiser–Meyer–Olkin test = 0.903		Kaiser–Meyer–Olkin test = 0.922	
Bartlett test χ^2 = 593.4, $p < 0.001$		Bartlett test χ^2 = 1167.0, $p < 0.001$	

Table 5 also shows the results of factor analysis on the subjective scores of the detailed USD guidelines. In Table 5, the results of factor analysis show one principal component. The highest explanatory guideline for the detailed USD was simplicity (S3.1), followed by equitable use (S5.1), error-proof design (S4.1), work sustainability (S6.2), appropriate size and space (S1.2), and safety and health assurance policy (S4.2).

3.4. Correlation Coefficients and Regression Analysis

Table 6 shows the correlation coefficients between USD guidelines and the mean of UD. According to the correlation coefficient between the USD guidelines, physical support (S1) was the highest relationship with accessibility (0.635). The flexibility (S2) was the highest correlation coefficient with diversity and inclusion (0.637), while accessibility (S3) was the highest relationship with ensuring safety and health (0.690). Ensuring safety and health (S4) was the highest relationship with sustainability (0.697), and diversity and inclusion (S5) was the highest relationship with accessibility (0.654).

Table 6. Correlation coefficients between USD and UD guidelines.

USD Guidelines	USD					Mean of UD
	S2	S3	S4	S5	S6	
S1 Physical support	0.577 *	0.635 *	0.615 *	0.627 *	0.552 *	0.843 *
S2 Flexibility		0.594 *	0.597 *	0.637 *	0.561 *	0.746 *
S3 Accessibility			0.690 *	0.654 *	0.591 *	0.876 *
S4 Safety and health				0.639 *	0.697 *	0.812 *
S5 Inclusion					0.598 *	0.789 *
S6 Sustainability						0.693 *

* Significant at significance level 0.01.

In Table 6, the USD guideline with the highest correlation coefficient for the mean of UD is accessibility (0.876), followed by physical support (0.843), and ensuring safety and health (0.812). On the other hand, sustainability, a concept that was absent from the UD guidelines, showed a low correlation coefficient with UD (0.693). It represents that UD guidelines are less explanatory in sustainability.

Table 7 shows the results of the regression analysis of USD guidelines on the mean of UD. The stepwise regression equation predicting UD's mean using four variables of physical support, flexibility, accessibility, and safety and health was high explanatory power (R^2 = 0.952). The explanatory power (R^2 = 0.959) was also high for the five variables of physical support, flexibility, accessibility, safety and health, and inclusion. That is, USD guidelines fully explain the UD concept. Additionally, Table 7 shows that the UD was primarily influenced by accessibility, followed by flexibility.

Table 7. Regression analysis of USD guidelines on the mean of UD.

USD Guidelines	UD (y) = f(x_1, x_2, x_3, x_4)		UD (y) = f(x_1, x_2, x_3, x_4, x_5)	
	B	p	B	p
(Constant)	0.161	0.087	0.155	0.076
Physical support (x_1)	0.240	0.001 *	0.218	0.001 *
Flexibility (x_2)	0.184	0.001 *	0.155	0.001 *
Accessibility (x_3)	0.362	0.001 *	0.345	0.001 *
Safety and health (x_4)	0.184	0.001 *	0.152	0.001 *
Inclusion (x_5)			0.101	0.001 *
Regression model	$y = 0.161 + 0.240x_1 + 0.184x_2 + 0.362x_3 + 0.184x_4$		$y = 0.155 + 0.218x_1 + 0.155x_2 + 0.345x_3 + 0.152x_4 + 0.101x_5$	
Statistics for model	F = 815.3, $p < 0.001$ *		F = 762.1, $p < 0.001$ *	
R^2	0.952		0.959	

* Significant at significance level 0.01.

3.5. Regression Analysis of UD and USD on Sustainability

Table 8 shows the results of the regression analysis of UD or USD on sustainability.

Table 8. Regression analysis of UD and sustainability on the mean of USD.

Variable	Sustainability (m) = f(x_1)		Sustainability (m) = f(x_2)	
	B	p	B	p
(Constant)	0.330	0.439	−0.490	0.134
UD (x_1)	0.948	0.001 *		
USD (x_2)			1.099	0.001 *
Regression model	$m = 0.330 + 0.948x_1$		$y = -0.490 + 1.099x_2$	
Statistics for model	F = 149.5, $p < 0.001$ *		F = 341.2, $p < 0.001$ *	
R^2	0.478		0.675	

* Significant at significance level 0.01.

The regression equation of UD on sustainability shows a low explanatory power (R^2 = 0.478). On the other hand, the regression equation of USD on sustainability shows a relatively high explanatory power (R^2 = 0.675). It presents that USD guidelines increase the design concept of sustainability.

4. Discussion

This study provides the explanatory guidelines when implementing UD to resolve discrimination among the disabled or the elderly. In implementing UD, the explanatory guidelines were simplicity (U3) and appropriate proper size and space (U7).

The philosophy of UD has contributed to product design so that even the elderly and the disabled can use the product safely and comfortably [2,4–9]. In this study, the design concept applying the USD guideline [3] was found to increase consumer's satisfaction in implementing the UD concept. This result is consistent with the result of Back and Jeong [26].

Aging and globalization raised the need to extend the paradigm to ensure safety for people with diverse characteristics [3]. In this study, the sustainability score showed a low linear relationship with UD. USD can help design decent work and working conditions in sustainable development from the worker's perspective. USD provides guidelines for socio-ethical sustainability and work sustainability for sustainable design [3]. It can pave the way for creating an environment in which everyone, including socially vulnerable groups, can live with safety and comfort. USD can be applied to reduce incidents and ensure productivity in production workers by helping them to work efficiently, comfortably, and safely. This study showed that the explanatory guidelines in implementing USD were simplicity, equitable use, error-proof design, work sustainability, and appropriate size and space.

In this study, we also examined the usefulness of USD guidelines. This study showed that the USD guidelines reflect UD's concept. The USD guidelines also showed the extensibility of fairness of design policy, flexible working, and sustainability. Additionally, adding sustainability guidelines in the UD increases the user's subjective scores for USD.

This study is meaningful in that the USD's guidelines are extensible to create an environment that is safe and convenient for everyone to live and work. The USD guidelines predict and prevent future risks and current risks for users and workers. It is also likely to improve working conditions, not only to promote working activities for the elderly but also to contribute to employment opportunities.

5. Conclusions and Limitations of the Study

There are several limitations to this study. First, the questionnaire does not include the disabled, foreigners, various age groups, or user groups. Therefore, a study considering various factors is expected. Second, this study evaluated the user's subjective feelings. However, this study did not completely solve the problem of respondent bias in the questionnaire and questionnaire procedure. Therefore, further research is expected that reflects more systematic research methods. Third, it can be interpreted that the UD guidelines target users, and USD guidelines are for workers. Therefore, it may be pointed out that the UD and USD guidelines should be selected not only by the area of the design target but also by the goals of the design. The authors expect to modify the USD guidelines according to the design target. Fourth, O Shea et al. [8] categorized four UD evaluation methods with checklist evaluations, value-driven evaluations, holistic evaluations, and invisible evaluations. It is also expected to validate the USD guidelines by various evaluation methods.

Despite these limitations, the present research contributes to the existing knowledge of design guidelines. The results of this study are expected to be used as the basic guidelines to improve the worker's discrimination among working environments. The present study is also likely to guide in enhancing comfort and safe environments or products. Bridging discrimination in the workplace is crucial for inclusive and sustainable growth [26–28]. This

study indicates that efforts to address discrimination are also necessary for sustainability in designing the everyday use of products.

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