DOI: 10.6977/IJoSI.202309_7(7).0001
S. Shahrin, K. Rahman1, etc./Int. J. Systematic Innovation, 7(7),1-11(2023)

A UDP-TRIZ method as a universal design approach for product design

Suhaimi Shahrin[1,2], K.A.A.A. Rahman[1*], K.M. Kamarudin and R. Che Me[1]
[1] Faculty of Design and Architecture, Universiti Putra Malaysia, Malaysia
[2] Faculty of Mechanical Engineering & Technology, Universiti Malaysia Perlis, Malaysia
* Corresponding author E-mail: drkhairulazlin@upm.edu.my
(Received 23 December 2022; Final version received 29 May 2023; Accepted 31 May 2023.)

Abstract

To encourage the participation of individuals with diverse abilities in the community, universal design has been adopted as the foundation for creating user-friendly designs that include people of all ages, the disabled, and the elderly. However, the approach to universal design lacks a systematic and directed strategy for designers to ensure that their designs fit universal design requirements. Most manuals and guidelines focus on the built environment, and there is no specific guidance for product design. This situation is seen as an opportunity to introduce an approach for designers to approach universal designs effectively. Therefore, this research proposes an intervention tool for universal design. Universal design principles and TRIZ 40 creative principles are synergised and used in the design process to benefit one another mutually. A UDP - TRIZ methodology framework is introduced to a group of designers engaged in a series of design activities to create a product with a universal design for visually impaired persons in mind. This study demonstrates that this strategy can assist designers in understanding user-related problems, identifying innovations, justifying designs in terms of universal design requirements, and fostering the creative process.

Keywords: Product Design, Universal Design Principles, TRIZ.

1. Introduction

The Convention on the Rights of Persons with Disabilities and its Optional Protocol (A/RES/61/106) were enacted at the United Nations Headquarters in New York on December 13, 2006, and made available for signature on March 30, 2007. 82 parties signed the Convention, 44 parties signed the Optional Protocol, and one party ratified the Convention. On the opening day of a UN Convention, the number of signatories has never been higher. It is also the first comprehensive human rights treaty of the twenty-first century. The Convention went into effect on May 5, 2008.

Following the acceptance of this Convention, the respondent country must submit an appropriate law to protect the rights of individuals with disabilities. For instance, the Malaysian government passed the Persons with Disabilities Act 2008 in 2008. This law's primary purpose is to increase the well-being and involvement of people with disabilities in the community without excluding them. As a result of new laws and policies relevant to social inclusion and the prevention of discrimination, the design industry has been under pressure to build valuable and accessible products, services, and environments.

Erdtman et al. (2021) said in their study that universal design has its roots in architecture and design. American architect Ronald Mace coined the term "universal design" in 1985. Since then, the phrase 'universal design' has been extensively used as a design approach and concept in architecture and product design, with the intention of considering the needs of a diverse population. The term universal design originated in the United States and is known as Design for All in Europe and Inclusive Design in the United Kingdom (Clarkson & Coleman, 2015). In order to increase population diversity, the term "universal design" has evolved. Some critics dispute the use of the word "universal" and assert that no single design solution meets all user requirements. Nevertheless, Steinfeld & Maisel, (2012) defend the "universal" terminology in "universal design." The phrase "universal" should not be understood as a "single solution" but instead as a design objective integrating diverse people.

In a publication by Heylighen, (2014), the author states that UD has been criticised for aiming to obtain an

unachievable goal, as no design would be great for everyone. In response, modern conceptions of universal design do not allude to a single "perfect" solution but show UD as a process of continual quality improvement. Universal design is a prevalent practice within the built environment. A manual and guidelines were created using the universal design principle (UDP) proposed by Mace (1985) of North Carolina State University. Each manual and policy for universal design are exclusive and apply only to the country that gazettes it. Table 1 summarises the universal design manual and guidelines for Southeast Asia countries:

Table 1. Governance of universal design in ASEAN country

Malaysia	i. MS 1183:2015 – Specification for Fire Precautions in the Design and Construction of Buildings ii. MS 1184:2014 – Code of Practice on Access for Disabled Persons to Public Buildings iii. MS 1331:2003 – Code of Practice for Access of Disabled Persons Outside Buildings iv. MS 1184: 2014 Universal Design And Accessibility In The Built Environment - Code Of Practice v. GP015 – A *Garis Panduan Perancangan Rekabentuk Sejagat* (Universal Design) vi. Panduan Rekabentuk Sejagat (Universal Design) Kemudahan Rekreasi Taman Awam
Indonesia	Permen PUPR No. 14 / PRT / M / 2017 Concerning the Ease Requirements for Building Buildings
Thailand	Ministerial regulation on Facility in Building for Persons with Disability and Elderly B.E. 2548
Singapore	i. Guide to Universal Design index (UDi) 2022 ii. Universal Design Guide for Public Places 2016 iii. Universal Design Guide 2007 iv. Universal Design Guidelines (Commercial Buildings) 2006
Vietnam	i. Standard of Construction 01:2001 (Standard of construction assures the accessibility for people with disabilities) ii. Standard of Construction 265: 2002(roads and pavements- basic constructing principles for people with disabilities to approach)
Philippines	i. Batas Pambansa Bilang 344 Accessibility Law ii. Republic Act No. 7277 Magna Carta for the Disabled Persons and the likes
Cambodia	The guideline on Water, Sanitation, and Hygiene (WASH) for Persons with Disabilities and Older people
Brunei	DADG:2018 – Different Abilities Design Guidelines

The great majority of standards created in the field of built environment focus on the governance of facilities that are accessible to individuals with disabilities. There is no evidence of product design or transport design guidelines or manuals. This trend is significant because human interaction regularly involves products and transportation in addition to space and the environment. The seven universal design principles (UDP) are the foundation for all policies and guidelines. Steinfeld & Maisel, (2012) propose that UD, based on seven principles and eight objectives, is the ideal resource for designers to provide conceptual insight for tackling the issue and offering solutions that suit different sorts of users. In Table 2, Steinfeld & Maisel, (2012) present seven UD principles.

Table 2. Universal Design Principle (UDP)

UDP1	Equitable Use
UDP2	Flexibility In Use
UDP3	Simple & Intuitive
UDP4	Perceptible Information
UDP5	Tolerance for Error
UDP6	Low Physical Effort
UDP7	Size & Space for Approach & Use

Universal design guidelines are developed to ensure that products, environments, and systems are accessible and usable by people of all ages and abilities, including those with disabilities. The goal of universal design is to create inclusive spaces and products that eliminate barriers and accommodate diverse needs so that everyone can participate equally in society.

Universal design guidelines are developed to address the fact that many environments, products, and systems were designed with only certain types of users in mind, such as able-bodied individuals. This can create

barriers for people with disabilities, seniors, and others who have different needs or limitations. For example, stairs can be a barrier for people who use wheelchairs, and small text on a website can be difficult for people with visual impairments to read.

By developing universal design guidelines, designers and architects can create products and spaces that are more accessible and accommodating to a wider range of users. Universal design principles can be applied to everything from building design and transportation systems to technology and consumer products. Ultimately, the development of universal design guidelines is important because it helps to create a more inclusive and equitable society where everyone can participate fully and comfortably. By eliminating barriers and accommodating diverse needs, we can create a world that works better for everyone. Detail guidelines for each UDP are shown in Table 3

Table 3. UDP Guidelines

Principle	Guideline
UDP1 Equitable Use	1a. All potential users could use this product in essentially the same way, regardless of differences in their abilities.
	1b. Potential users could use this product without feeling segregated or stigmatized because of differences in personal capabilities.
	1c. Potential users of this product have access to all features of privacy, security, and safety, regardless of personal capabilities.
	1d. This product appeals to all potential users.
UDP2 Flexibility in Use	2a. Every potential user can find at least one way to use this product effectively.
	2b. This product can be used with either the right or left hand alone.
	2c. This product facilitates (or does not require) user accuracy and precision.
	2d. This product can be used at whatever pace (quickly or slowly) the user prefers.
UDP3 Simple and Intuitive Use	3a. This product is as simple and straightforward as it can be.
	3b. An untrained person could use this product without instructions.
	3c. Any potential user can understand the language used in this product.
	3d. The most important features of this product are the most obvious.
	3e. This product provides feedback to the user.
UDP4 Perceptible Information	4a. This product can be used without hearing.
	4b. This product can be used without sight.
	4c. The features of this product can be clearly described in words (e.g., in instruction manuals or on telephone helplines).
	4d. This product can be used by persons who use assistive devices (e.g., eyeglasses, hearing aids, sign language, or service animals).
UDP5 Tolerance for Error	5a. Product features are arranged according to their importance.
	5b. This product draws the user's attention to errors or hazards.
	5c. If the user makes a mistake with this product, it won't cause damage or injure the user.
	5d. This product prompts the user to pay attention during critical tasks.
UDP6 Low Physical Effort	6a. This product can be used comfortably (e.g., without awkward movements or postures).
	6b. This product can be used by someone who is weak or tired.
	6c. This product can be used without repeating any motion enough to cause fatigue or pain.
	6d. This product can be used without having to rest afterward.
UDP7 Size and Space for Approach and Use	7a. It is easy for a person of any size to see all the important elements of this product from any position (e.g., standing or seated).
	7b. It is easy for a person of any size to reach all the important elements of this product from any position (e.g., standing or seated).
	7c. This product can be used by a person with hands of any size.
	7d. There is enough space to use this product with devices or assistance (e.g., wheelchair, oxygen tank, or service animal).

2. Literature Review

Although the term UD is widely used in research, legislation, guidelines, and manuals, there is still variation in its understanding and use. Moore et al. (2022) and Van Der Linden et al. (2016) think that the low adoption of design for UD and application of UDP to solve a user(s) and customer(s) problem occurs because designers approach UD and UDP design with a particular mindset. How the design problems are processed and come to generate products that diverse populations can utilise based on their age, gender, and skills influence the distinct mentalities of designers.

Van Der Linden et al. (2016) claimed that there is insufficient information for architects to employ in their design practice. The information should be presented to allow designers to utilise it during the design process. To coordinate how designers comprehend design difficulties, it is necessary to supply relevant information so that designers may generate designs that fulfill the needs of users.

Product designers struggle to comprehend the difficulties faced by users with diverse abilities and interpret the UDP so that it can be used as a design solution tool. The vast majority of designers state that the UDP is unclear and that it is difficult to evaluate whether the design they have presented is appropriate for the problem they are attempting to solve (Shahrin et al., 2020). According to Yang et al., (2010), a comprehensive product development process is required to ensure that UD activities are correctly integrated into the product and that flexible and imaginative product concept development is thoroughly explored, resulting in genuinely beneficial outcomes for users.

The primary objective of universal design is to create products that individuals with diverse abilities can utilise. However, it generally encountered various constraints throughout product design and development to achieve UD objectives, resulting in less inventive design (Yang et al., 2010)Numerous articles demonstrated attempts to use TRIZ in multiple fields to perform the study's objectives. Typically, TRIZ integrated technical parameters and analysis tools into the process. (Abramov, 2017; Amer, Ong et al., 2019; Brad & Brad, 2015; Pelt & Hey, 2011; C M Yang et al., 2010; Chun Ming Yang et al., 2012)

The only evidence of the applicability of TRIZ to the UD method is a 2010 study by Yang et al., (2010). This study offered a TRIZ-based method for designing innovative products that includes UD principles. The author provided a newly created technique that begins with a description of a problem during the product's design and development, followed by an evaluation of the product's UD performance using the Product Performance Program tool. A 3-step inventive problem-solving procedure was then formulated as the problem statement. The contradiction Matrix of TRIZ was employed to identify proper inventive principles that could serve as resolutions, leading to improved or new product concepts used to determine acceptable ideas that could provide solutions and result in further or enhanced product concepts.

However, this study reveals a limitation: product designers must be trained in the TRIZ 3-step innovative problem-solving strategy to employ this methodology. It is not normal for trained product designers to use TRIZ as a problem-solving technique. Whilst formal training is required for the method, the proposed approach, including TRIZ, could reinforce the UD principles and generate more concrete and innovative solutions. On the other hand, this study also revealed how UD and TRIZ principles could work together to develop more original and creative solutions that fit UD objectives without compromising.

As a result, this study proposes an application of intervention tools for product designers that synergised UDP with TRIZ 40 inventive principles to improve the creative design process by utilising inventive principles suited for design solutions. This tool provides the designer with a quicker and easier method to identify UDP issue(s), or problem(s) and suitable TRIZ 40 inventive principles corresponding to the UDP and choose a practical generic solution to provide by TRIZ 40 inventive principles to propose a design solution.

The synergy between UDP and TRIZ was developed by a focus group discussion among TRIZ experts. The experts have concluded the synergy between UDP and TRIZ (Shahrin et al., 2020). This synergy is proposed to primarily be used when UD intervention in the design process is required. This synergy between UDP and TRIZ creative concepts will assist designers in generating ideas, validating design solutions, and developing universal design validation tools. This tool could provide designers with a much clearer understanding of challenges and their corresponding solutions in the form of TRIZ's 40 innovative principles, which have been mapped to match with the UDP. The synergy of UDP and TRIZ inventive principles is shown in Table 4.

Table 4. UDP-TRIZ table

Principle	Guideline	TRIZ 40 inventive principles
UDP1 Equitable Use	1a	6, 26, 33, 40
	1b	6
	1c	6, 5, 11
	1d	6, 5, 30
UDP2 Flexibility in Use	2a	6, 4, 7
	2b	6, 13, 17
	2c	6, 4, 7
	2d	6, 7, 15
UDP3 Simple and Intuitive Use	3a	3, 6
	3b	25, 6
	3c	25, 6
	3d	3, 6
	3e	23, 32
UDP4	4a	6, 18, 19, 32
Perceptible Information	4b	6, 18, 19, 32
	4c	6
	4d	6, 24, 26, 35, 36
UDP5 Tolerance for Error	5a	2
	5b	10, 16
	5c	2, 6, 9, 11, 22, 34
	5d	2, 9, 10, 23
UDP6 Low Physical Effort	6a	6, 4, 12, 15, 24, 28, 29, 39
	6b	6, 4, 8
	6c	8, 12, 14, 20, 27
	6d	20
UDP7 Size and Space for Approach and Use	7a	6, 1, 7
	7b	6, 37
	7c	6, 7
	7d	6, 24, 39

3. Methodology

The primary objective of universal design is to create a product that individuals with diverse abilities can utilise. Nonetheless, it generally encountered many constraints throughout product design and development to achieve UD objectives, resulting in less inventive design (Yang, 2010).

The synergy between UDP and TRIZ was introduced to resolve this issue. The designer will be able to recognise relevant UDPs to be enhanced and discover appropriate innovative principles associated with each UDP. Based on the offered inventive notions, this tool could assist the designer in identifying the most suitable option to use in a design. Additionally, the designer will have a significantly more precise notion from which inventive principles they can generate ideas. UDP-TRIZ can also be used to validate the submitted idea in pursuit of the UDP guidelines' goals and objectives.

To ensure the credibility of this study, all participants involved are product design practitioners. Three (3) junior designers and three (3) experienced designers were selected to perform in a design process, creating a universal design product. A case study of the design problem was provided, and the designers were required to develop a design solution for the case study's product. A framework of the proposed UDP-TRIZ method is illustrated below.

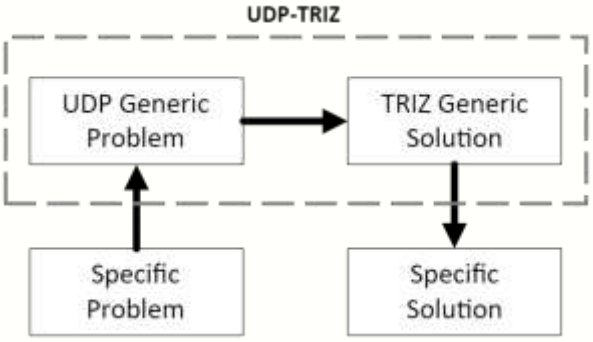

Fig. 1. UDP-TRIZ methodology framework

4. Results

In a design case study provided for designers by the moderator, each designer must propose a universal design kitchen knife considering the visually impaired person who will use it for daily purposes. Each designer must identify the issue(s) or problem(s) based on their knowledge and experience. Designers can use external tools such as web searching to research and brainstorm. The designer later tries to identify the related UDP with their design issue(s) or problem(s). Designers will identify UDP that is affected by the specific problems that have been identified in the brainstorming stage. The designer will match the appropriate theme of the specific problem with the available UDP as a generic problem. For instance, respondent #5 recognizes a specific problem with a need to improve how the product could communicate and guide visually impaired users and four related UDPs as the generic problem is selected based on

the specific problem. Respondent #5 identified UDP1 Equitable Use, UDP2 Flexibility in Use, UDP3 Simple & Intuitive Use, and UDP4 Perceptible Information as UDP generic problems. The respondent is confident these four identified UDP are fulfilling the theme of improving how the product communication and guidance can be improved. With the respective UDP as the generic problem is identified, the designers will then determine the corresponding TRIZ 40 inventive principles in the UDP-TRIZ tools, and the designers can select one or more inventive principles that are on designer consideration suitable to propose as part of the design. With TRIZ 40 inventive principles identified, the designer will be able to produce a specific design solution that will solve the identified specific problem and fulfill the universal design element of the product. The result of each designer using UDP-TRIZ is shown below in Table 5.

Table 5: UDP-TRIZ design proposal by respondents.

Respondent	Specific Problem	UD Generic Problem	TRIZ Generic Solution	Specific Solution
Respondent #1	Increase the safety of the users to hold and use the knife, focusing on protecting the sharp and risky part of the knife	UDP2a	#6 Universality	• Knives come with storage with a locking mechanism.
		UDP4d	#35 Parameter changes	•Remove the pointy end on the steel parts.
		UDP5b	UDP5b: #11 Beforehand cushioning	• Improving handguard • Embedded braille/tactile features to label the knife's size/type
Respondent #2	I am reducing the risk of injury and increasing safety by eliminating sharp features on the knife blade.	UDP6b	#6 Universality	• Remove the pointy end on the steel parts. • Improving holder to improve the ergonomic factor
		UDP6d	#20 Continuity of useful action	The designer wants to decrease the sharpness of the knives using the concept of pudding or steak knives. Users need to repeat the cutting motion before it will cut through.
		UDP7c	#6 Universality	Adding a thumb grip to improve product orientation when holding the knives
Respondent #3	Considering the visually impaired person uses touch sensory to guide them around the kitchen, a change of materials to increase safety to communicate with the visually impaired users on the risk part of the knife.	UDP5b	#11 Beforehand cushioning	Leaving only the sharp edges using steel materials. The material difference will allow visually impaired persons to safely explore the shape of knives.
			#10 Preliminary Action	The differences in materials will improve the awareness of visually impaired people identifying the knife using touch sense.
		UDP5c	#2 Taking out	Replace most of the material steels with wood but maintain the typical knife shape.
Respondent #4	Improve the ergonomics and performance of the knife's handle for the benefit of the users. The handle determines how the knife is used, as it is the most prominent component.	UDP7c	#6 Universality	• Adding a curve contour to knives spine area as tactile for the visually impaired person • Using memory foam-like materials to adapt different hand sizes and shapes

Respondent #5	The visually impaired person requires a preliminary action to communicate/instruct them. By standard, the usage of braille is a system to trigger/guide the user to do specific actions. The main concern is the safety of the users. Respondents want to implement these two criteria into the design.	UDP1a UDP1b	#6 universality #40 Composite Materials	The design for the knife should look like regular knives to include ordinary people, not just people with disabilities. Material selection to differentiate features on the handle.
		UDP2a UDP2b UDP2d	#6 Universality #4 Asymmetry #7 Nested Doll	The handle design is asymmetry and can be used on both hands. Safety features are retractable and can be stored inside the handle.
		UDP3a UDP3c UDP3d	#25 Self Service	Safety features should use a self-retract mechanism using a single push button on the handle. A mechanism for safety should be easy to use for both normal and impaired persons.
		UDP4d	#6 Universality	Tactile feature on the safety mechanism
Respondent #6	The primary factor to be imposed is user safety. The principal issue that should be highlighted is how the product communicates, and there is no visual demonstration training for visually impaired users.	UDP2b	#6 Universality	The product can be used regardless for normal or visually impaired persons.
		UDP6a	#4 Asymmetry #15 Dynamics	The handle design should be asymmetry to allow the visually impaired person to recognise the correct way to hold the knife. The grip contour should guide the orientation of the knife.
		UDP7c	#7 Universality	The product can be used regardless for the normal or visually impaired person.

Next, the designers present their designs visually using digital sketches. Researchers have taken the initiative to visualise the designs of the respondents in a 3D model. Table 6 shows the 3D illustration by each respondent. The specific solution for each design is labeled in the Fig. . ure.

Table 6. Design proposal using UDP-TRIZ

	**Respondent 1** a. Locking mechanism for safety b. Remove pointy features to reduce injury risk. c. Handguard improvement d. Braille for labeling and warning.
	**Respondent 2** a. Remove pointy features to reduce injury risk. b. Increase ergonomic features on the handle. c. Reduce the sharpness of the knife to avoid serious injury. d. Thumb grip to improve knife orientation.
	**Respondent 3** a. Using steel material only for cutting edges. b. Replace the steel material with wood to increase a visually impaired person's confidence to use touch sense to identify the knife. c. Maintaining the typical knife shape.
	**Respondent 4** a. Thumb rest to guide visually impaired persons in positioning their fingers. b. Memory foam material, to adapt users' hand size and shape.

	**Respondent 5** a. Maintaining the shape of the handle and using different materials so that visually impaired persons can identify the handle's features. b. Using asymmetry shape to differentiate the orientation of the knife and embedded retractable blade guard in the handle. c. Retractable guard using one push button to open and close. d. A button for a retractable guard comprised of distinct materials and tactile characteristics for simple recognition.
	**Respondent 6** a. This product can be used by any person regardless of ability. b. The handle should be asymmetry to allow the visually impaired person to identify the knife orientation. c. Grip contour should be designed to guide the visually impaired person to use the knife as per intent.

At the end of the design process, the researcher asked the respondents a series of questions related to their experience using UDP-TRIZ in their design process. All respondents agree that UDP-TRIZ improves how they understand the design problem related to universal design. One of the respondents claims that UDP-TRIZ enables them to understand precisely which aspect of the product they need to enhance to meet the UD. With TRIZ 40 inventive principles provided in UDP-TRIZ, respondents claim it helps them to realise that there is more potential improvement that could be considered to meet UD. All respondents are satisfied with their design and confident they could meet UD. According to the respondents, UDP-TRIZ allows them to justify the design produced and relate their design to the problems faced by users. These are helped by the systematic approach when using UDP-TRIZ to intervene in the design process when UD is required.

Aside from the benefits of UDP-TRIZ, which are highly beneficial to designers, the terminology employed in TRIZ 40 inventive principles is rather tricky for designers to comprehend. All junior designers concur that UDP-TRIZ may be improved by including a design solution case study or example as part of the TRIZ 40 inventive principles brief and examples, but only for UDP-TRIZ reasons. However, experienced designers in this study have contradictory opinions. They agree that, even though the TRIZ 40 inventive principles are difficult to understand, the main issues do not underlie the brief or examples provided by TRIZ. They claim that first-time users using TRIZ find some of the keywords of TRIZ 40 inventive principles confusing and unfamiliar. However, the brief given with the inventive principles is comprehensible. One of the experienced designers insisted that using the generic brief provided by TRIZ is adequate to comprehend for designers to generate ideas. Experience designers believe that if design examples are provided, UDP-TRIZ users (designers) will attempt to "play it safe" during design development by using existing examples and the creative process in design and development is absent. Consequently, it will create a similar and stagnant design.

5. Conclusions

Using the synergy between UDP and TRIZ 40 Inventive Principles, this study aims to produce an intervention tool for a universal design approach during design and development; designer response indicates a beneficial effect on their design process. This study presents a novel approach for designers to utilise TRIZ 40 inventive principles as one of the design process's tools. Using this UDP TRIZ for the first time challenges no difficulties for designers. The proposed intervention could stimulate the designer's ideation process throughout the design process's brainstorming phase. Most designers who participated in the experiment remarked that UDP-TRIZ expanded their perspective on problems. UDP-TRIZ also gives the designer a clear grasp of challenges and feasible solutions.

Using UDP-TRIZ, designers find it easier to justify universal design-related recommendations, particularly during the design concept creation phase. The conceptual design stage is crucial for designers to make decisions concerning universal design. This study demonstrates that UDP-TRIZ is integral to the creative components of idea generation. Although all designers employ UDP-TRIZ and provide the same case studies in the experiment, the findings collected from the design process demonstrate that UDP-TRIZ does not restrict the designer's ability to propose a suitable universal design solution.

Regarding design solutions that correspond to the universal design principles, neither of the designs

proposed by respondents is rigid. Each designer can offer a unique design based on knowledge of universal design principles. Given the possible use of the newly created UDP-TRIZ, designers can use this method to determine which TRIZ 40 inventive principles correspond to the universal design principles. It can also guide designers in proposing designs compliant with UD. This method can also be used as a validation tool to examine whether the design contributes to universal design.

References

Abramov, O. Y. (2017). Generating New Product Ideas with TRIZ-derived 'Voice of the Product' and Quantum -Economic Analysis (QEA). 17th International TRIZ Future Conference, (January), 80–87.

Amer, Y., Ong, M. S. B., Al-Zuheri, A., Truc Doan, L. T., & My Tran, D. T. (2019). A Systematic Framework to Integrate TRIZ into DFSS for New Product Development. Proceedings of 2019 International Conference on System Science and Engineering, ICSSE 2019, 355–361.

Batas Pambansa Bilang 344 Accessibility Law (1982), Available on line at:

https://www.ncda.gov.ph/disability-laws (accessed on August 7, 2022)

Brad, S., & Brad, E. (2015). Enhancing SWOT analysis with TRIZ-based tools to integrate systematic innovation in early task design. Procedia Engineering, 131, 616–625.

Convention on the Rights of Persons with Disabilities (2018), Available online at:

https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities.html (accessed on May 3, 2022)

DADG:2018 – Different Abilities Design Guidelines (2018), Available online at:

https://www.pujajournal.com/Resources/DADG (accessed on August 16, 2022)

Erdtman, E., Rassmus-Gröhn, K., & Hedvall, P.-O. (2021). Universal Design as Guiding, Striving, and Unifying: A Qualitative Study about how Universal Design is Understood, Practised and Realised in Contemporary Sweden. Scandinavian Journal of Disability Research, 23(1), 158–168.

GP015 – A Garis Panduan Perancangan Rekabentuk Sejagat (Universal Design) (2011), Available on line at:

https://www.planmalaysia.gov.my/index.php/garis-panduan-perancangan (accessed on July 9, 2022)

Heylighen, A. (2014). About the nature of design in universal design. Disability and Rehabilitation, 36(16), 1360–1368.

Heylighen, A., Van der Linden, V., & Van Steenwinkel, I. (2017). Ten questions concerning inclusive design of the built environment. Building and Environment, 114, 507–517.

John Clarkson, P., & Coleman, R. (2015). History of Inclusive Design in the UK. Applied Ergonomics, 46 Pt B(PB), 235–247.

Mace, R. (1985). Universal design: Barrier free environments for everyone. Designers West, 33(1), 147–152.

Ministerial regulation on Facility in Building for Persons with Disability and Elderly B.E. 2548 (2005), Available online at:

https://old.ieat.go.th/handbook/Program_IEAT/pdf/laws/en/ETC010.pdf (accessed on July 13, 2022)

Moore, A., Lynch, H., & Boyle, B. (2022). Can universal design support outdoor play, social participation, and inclusion in public playgrounds? A scoping review. Disability and Rehabilitation, 44(13), 3304–3325.

MS 1183:2015 – Specification for Fire Precautions in the Design and Construction of Buildings (2015), Available online at:

https://mysol.jsm.gov.my/ (accessed on July 9, 2022)

MS 1184:2014 – Code of Practice on Access for Disabled Persons to Public Buildings (2014), Available online at:

https://mysol.jsm.gov.my/ (accessed on July 9, 2022)

MS 1331:2003 – Code of Practice for Access of Disabled Persons Outside Buildings (2003), Available online at:

https://mysol.jsm.gov.my/ (accessed on July 9, 2022)

MS 1184: 2014 Universal Design and Accessibility In The Built Environment - Code Of Practice (2014), Available online at:

https://mysol.jsm.gov.my/ (accessed on July 9, 2022)

Panduan Rekabentuk Sejagat (Universal Design) Kemudahan Rekreasi Taman Awam (2010), Available on line at:

http://www.jln.gov.my/index.php/pages/view/69 (accessed on July 9, 2022)

Pelt, A. Van, & Hey, J. (2011). Using TRIZ and human-centered design for consumer product development. Procedia Engineering, 9, 688–693.

Peraturan Menteri Pekerjaan Umum dan Perumahan Rakyat Nomor 14/PRT/M/2017 (2017), Available on line at:

https://peraturan.bpk.go.id/Home/Details/104477/permen-pupr-no-14prtm2017-tahun-2017 (accessed on July 13, 2022)

Republic Act No. 7277 Magna Carta for the Disabled Persons and the Likes (1992), Available online at:

https://www.dinf.ne.jp/doc/english/intl/z15/z15007le/z1500711.html (accessed on August 10, 2022)

S Shahrin et al 2020 IOP Conf. Ser.: Mater. Sci. Eng. 932 012100

Standard of Construction 01:2001 (Standard of construction assures the accessibility for people with disabilities) (2001), Available online at:

https://www.academia.edu/936040 (accessed on August 2, 2022)

Standard of Construction 265: 2002(roads and pavements- basic constructing principles for people with disabilities to approach) (2002), Available online at:

https://www.academia.edu/936040 (accessed on August 2, 2022)

Steinfeld, E., & Maisel, J. (2012). Universal design: Creating inclusive environments. John Wiley & Sons.

The guideline on Water, Sanitation and Hygiene (WASH) for Persons with Disabilities and Older people (2017), Available online at:

https://washmatters.wateraid.org/publications/cambodia-national-guidelines-on-wash-for-persons-with-disabilities-and-older-people (accessed on July 28, 2022)

Universal Design Guide for Public Places (2016), Available online at:

https://www1.bca.gov.sg/regulatory-info/building-control (accessed on July 22, 2022)

Universal Design Guide (2007), Available online at:

https://www1.bca.gov.sg/regulatory-info/building-control (accessed on July 22, 2022)

Universal Design Guidelines (Commercial Buildings) (2006), Available online at:

https://www1.bca.gov.sg/regulatory-info/building-control (accessed on July 22, 2022)

Van Der Linden, V., Dong, H., & Heylighen, A. (2016). From Accessibility To Experience: Opportunities for Inclusive Design in Architectural Practice. Nordisk Arkitekturforskning, (2), 33–58.

Yang, C. M., Kao, C. H., Liu, T. H., & Yang, F. H. (2010). Applying TRIZ Principles to Construct Creative Universal Design. Int. J. Systematic Innovation, 1(1), 49–60.

AUTHOR BIOGRAPHIES

MOHAMAD SUHAIMI BIN SHAHRIN is an experienced academician with 8 years of teaching undergrad students in the field of industrial design. Graduated with Bachelor of Engineering Technology (Industrial Design) with Honors from University Kuala Lumpur, Malaysia, and Master of Design Technology from Universiti Teknologi MARA, Malaysia. He is currently pursuing his Doctor of Philosophy in Industrial Design Studies at Universiti Putra Malaysia, Malaysia. He is recognised as a Professional Technologist by the Malaysia Board of Technology (MBOT) and also a certified industrial designer by the Malaysia Design Council and a CATIA V5 mechanical design specialist. Prior to his academic career, Mohamad Suhaimi had 4 years of industrial experience as a designer and CAD engineer which gave him a strong foundation in the practical aspects of design and engineering. Suhaimi's passion for industrial design, generative design, and universal design is reflected in his research interests. He is committed to exploring innovative design solutions that address the needs of diverse user groups.

KHAIRUL AIDIL AZLIN ABD RAHMAN is a Professor at the Industrial Design Department, Faculty of Design and Architecture, Universiti Putra Malaysia. He is one of the pioneer Certified Industrial Designers from the Malaysia Design Council (CIDe). He received more than 70 designs and innovation awards in Malaysia and International such as Product Innovation and Techniques, Geneva, Switzerland 2006, International Invention Fair of the Middle East, Kuwait 2008, Pin Up 2008 Award, South Korea and Gold Medalist for Eureka 2010, Brussels and Double Gold Medalist and Gold Medalist British Invention Show in 2012 and 2014. He was the President of PEREKA (Malaysia Industrial Design Society) for 2018-2020 and is currently the Deputy President of PEREKA for 2022-2024. He is the founder of Dekoponix Sdn Bhd and his principal areas of research are furniture design, design management, industrial design, bio-composite materials, and hybrid arts.

KHAIRUL MANAMI KAMARUDIN graduated with a Bachelor of Design (Industrial Design) from Universiti Teknologi MARA (UiTM), in 1999, MSc. - Ing. of Global Production Engineering, Technische Universität Berlin, Germany in 2010, and Doctor of Philosophy of Jointly Awarded Research Degree (JARD) in Engineering Design, with both Advance Manufacturing Research Centre (AMRC) with Boeing, The University of Sheffield, United Kingdom, and University Putra Malaysia. She was involved in the automotive industry, from an independent automotive research company to working with R&D team of a Malaysian car manufacturer. She has been involved in many concepts, CAID towards manufacturing experiences, as well as having internships in local and international companies, namely MTRIZ Berlin and AMRC, TUoS. She is now active in disseminating Industrial Design, Safety by Design, and TRIZ methodology in her research.

ROSALAM CHE ME is a Senior Lecturer in the Department of Industrial Design, Faculty of Design and Architecture, Universiti Putra Malaysia (UPM). He is a UPM alumnus, where he earned his Bachelor of Industrial Design and MSc in Biocomposite Product Design. In 2017, he completed his PhD in Design (Industrial/Engineering Design) from Politecnico di Milano (POLIMI), Italy and in the same year, he officially joined the Industrial Design department. He is now a member of InvenTeD research group and an Associate Researcher for Malaysian Research Institute on Ageing (MyAgeing) UPM. In 2020, he went for a 6-month Industrial Attachment at DreamEDGE Sdn Bhd, Cyberjaya after being selected to represent UPM as one of the fellows for CEO @ Faculty Programme (CFP) 2.0 by the Ministry of Education (MOE). He was awarded a Technologist (Ts) by Malaysia Board of Technologists (MBOT) in the same year. He is also a member of Persatuan Pereka Perindustrian Malaysia (PEREKA) and the pro tem President of Industrial Design Alumni Club UPM (KAReka). His research interest lies in Product Design and Manufacturing, Assistive Technology, User-Centred Design, Design for the Disabled, Computer-Aided Systems for Health and Biocomposite, and Advanced Materials