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Health Monitoring Kiosk: A Use Case of the DM4O Design Methodology

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Abstract. The rapid and revolutionary transitions in the second decade of the millennium are forcing us to observe and include new perspectives to shape our present and future. Some believe that, at this point, it is crucial to learn from the possibilities brought by diversity and the search for equity. The DM4O is a digital product conceptualization strategy for digital products developed to allow novel design practitioners or students to envision scenarios in which vulnerable groups of people might struggle with human-machine interactions. This document presents a use case in which the methodology was tested with a group of pre-grade Data Science students at Tecnologico de Monterrey University. The results show that 1) Engineering students can benefit from including human factors considerations in their conceptualization processes; 2) The DM4O is a practical approach to promote an inclusive approach; and 3) The application possibilities of the method can promote sustainable and inclusive solutions for digital product design.

Keywords: Design Methodology, Inclusive Design, Complex Reasoning, Higher Education, Educational Innovation.

1 Introduction

The Sustainable Development Goals set global commitments to reach desirable advances regarding human, societal, and technological development areas. Indeed, to achieve many of those Goals, it is prescribed the need to combine actions and strategic collaboration between fields, stakeholders, and entities. SDG number 10 [1] sets the reduction of inequalities within and among countries, which exist in many dimensions; this paper focuses on promoting equity through inclusive design approaches and tools.

The design and development of products and systems for vulnerable groups is a complex process that requires the addressing of multiple factors and demands a search for strategies, tools, and approaches to embrace that complexity while increasing designers' problem-solving abilities [4]. Conceptualization is one of the initial phases in the design and development of a new product or system. It involves the generation and exploration of ideas, concepts, and potential solutions to address diverse needs or problems. It is a crucial stage as it helps ensure that the solutions are well thought out, viable, and aligned with the people's needs before significant resources are committed to its development. The DM4O (Design Method for the Outlier) is a conceptualization strategy for Smart, Sensing, and Sustainable [2] Products and Service Systems (S^3PSS) developed to allow novel design practitioners or students to envision scenarios in which Non-Typical Users (N-TU) of technological devices [3], might struggle with human-machine interactions.

This document presents one part of a four-year study as a research question "How can a design methodology allow designers to develop adaptive and inclusive UIs for Non-Typical Users?" Firstly, we will present the background and the methodology for the DM4O Matrix development, highlighting the differentiated value of this study. Then, the description of the DS students' use case focuses on the results and contribution of the methodology. Finally, the conclusions and impact of the DM4O will be exhibited.

1.1 Background

To gain perspective on how to offer helpful visualizations of interaction breakdowns caused by a mismatch between users' abilities and interaction demand features, we conducted four experimentation activities to develop and validate the DM4O (Design Methodology for Outliers) and its sequential process. The samples were: novice and experienced designers, spanning the national and international environment. In addition, the industrial context and non-designers were also represented in parts of the study. Lastly, the DM4O was applied to a group of Data Science senior bachelor students to validate if the proposed process was understandable and helpful for a data collecting system's conceptualization.

In 2021, two groups of students, 35 in total, were set to develop an academic project with one single design brief using the Challenge Based Learning (CBL) educational approach [5]. The groups included students from programs related to the design process, all at the pre-grade level from Tecnologico de Monterrey University. Group 1 was a multidisciplinary group with Industrial Design and Innovation and Development Engineering; Group 2 was formed by students from Mechatronics Engineering. The brief provided to students set the requirements to design an interactive smart device to record the user's behavior and health condition through vital signs reading. The targeted population was older adults (over 65 years old) from an urban Mexican context.

The pursued outcome was obtaining information about the interaction breakdowns and deviations the older users might experience when interacting with the UI. But mainly, the records from the health condition have the potential to assemble a national

database with this population sector health record that can be used for planning and preventive strategies.

1.2 Framework

The inclusive design approach places the user in a prominent role in which a product or service feature specification starts with the users' needs and capabilities [6]. At the same time, it brings human and economic development opportunities in sustainable responses [7]. To conceptualize inclusive products or services, a designer should be able to simultaneously visualize diverse scenarios, risks, possibilities, features, and profiles; this study aims to foster those complex reasoning processes through a design process tailored to achieve such results. This challenging task demands a search for strategies, tools, and approaches to embrace that complexity while increasing designers' problem-solving abilities [8].

The concept of Flexible Technology Integration proposed by Boy [9] in the context of aircraft systems design is used for the DM4O methodology development. The intention is to combine the capabilities of smart, sensing, and sustainable products and systems with autonomous responses triggered by the sensed information about the user. It would also support sustainable functionality, reducing energy waste and the number of attempts to reach the user's goal and the device's purpose. Through it, we expect the resulting product to allow the user's capabilities development while the device's features mediate, allowing the system to understand and respond to those capabilities.

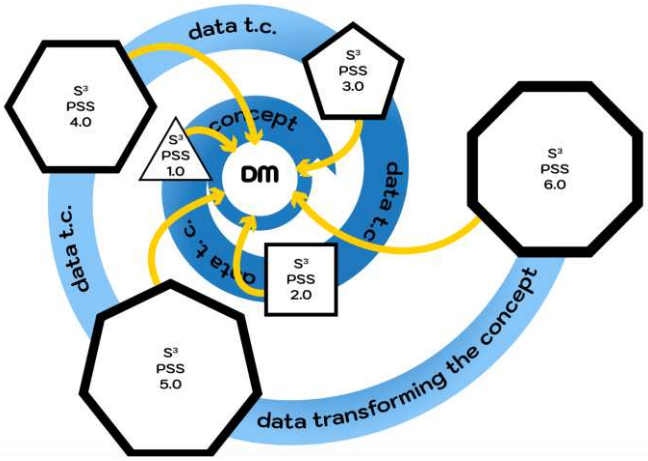

Fig. 1. Incremental innovation process proposed in the DM4O. Source: Own elaboration.

Flexible technology integration can be reached by an incremental innovation approach in which the proposed methodology would foster results addressing potential limitations of N-TUs, and the product or system iterations will be nurtured by information collected from the interactions. Fig. 1 is a schematic representation of those cycles in which a concept is created through a Design Methodology (DM) that allows a first level of adaptability to N-TU, and the data collected transforms the image in

sequential stages. The result in each cycle, represented by the index in each shape, should be more complex and have a better outcome to address diversity within the users. Furthermore, when implemented, each product will provide feedback on the design process itself to achieve iterative closed incremental cycles of development, promoting innovative results.

2 Method

The methodological approach entails mixed methods research [10, 11], nurtured with various visions and contexts to describe the phenomenon under study from different stances. Accordingly, the information and data collection from the survey and the experimentations were examined with an analytical, integrative strategy [12], observing a multi-perspective stakeholder vision and a synthesis based on a sequential building of the methodological stages of the proposed design process. Each use case was an instrument for interpreting the situations and discovering the elements to assemble a design process that shaped the DM4O methodology. The goal was to enable adaptability and flexibility in the features' configuration of a product or service with smart, sensing, and sustainable capabilities; this is a flexible technology integration.

Table 1. Scoring on the achievement for Flexible Technology Integration in design students.

Group		Industrial Design + Engineering pre-grade students				Engineering pre-grade students					
Capacity	Project / Reference	D-1	D-2	D-3	D-4	E-1	E-2	E-3	E-4	E-5	E-6
Self-adaptable	Qualitative Assessment	1	1	0	1	0	1	1	1	0	0
Responsive	Qualitative Assessment	1	0	0	1	0	0	1	0	0	1
Smart	Molina et al. [13]	1	1	1	1	0	1	0	1	0	1
Sensing	Molina et al. [13]	1	1	1	1	1	1	1	1	1	1
Sustainable	Molina et al. [13]	0	1	0	0	0	1	1	0	0	0
Supervision	Boy [9]	1	0	1	1	0	1	1	1	1	1
Autonomy	Boy [9]	1	1	1	1	1	1	0	1	1	0
Mediation	Boy [9]	1	0	1	1	0	1	0	1	0	0
Understanding	Boy [9]	1	0	0	1	0	1	0	1	0	1
TOTAL SCORE		**8**	**5**	**5**	**8**	**2**	**8**	**5**	**7**	**3**	**5**

The first two groups of students conceptualized the Health Monitoring Device by applying the most used design methods and strategies, according to the survey with scholars above mentioned: Design Thinking [14], User-Centered Design [15], the Double Diamond [16], the User Journey maps [17], and the Quality Function Deployment (QFD) tool [18]. The results shown in Table 1, demonstrated that the highest scores were reached by students with previous experience in attending to older adults or designing this type of device. Those groups of students who did not have at reach those

memories found that the task of visualizing potential interaction breakdowns was virtually out of their reach. The results were analyzed by a group of seven experts from various disciplinary areas, such as mechatronics, biomedical engineering, industrial design, and service design, from Mexico, Japan, and China during online sessions.

The subsequent research stages for this study were carried out with a Participatory Action Research approach (PAR) [19] in two workshops. The participants were eight juniors to mid-level experience design practitioners working in the UK with different backgrounds and occupational fields, including product designers, UX designers, and interaction designers. The workshop's five design tasks allowed the participants to envision potential user limitations that older adults might experience when interacting with a microwave oven UI. The results showed that the design process for the DM4O can be assembled in three moments 1) Scenarios visualization; 2) Search for alternative functionalities; and 3) Flexible integration. Combining a generic list of interaction tasks with the expected user's behaviors the designer is able to envision potential limitations that can cause interaction breakdowns. Moreover, the features included in the conceptualization addressed the envisioned limitations, observing diversity in the information display channels or the applied resources to facilitate the reach of various capabilities in potential users.

2.1 The DM4O Matrix

The workshop for the Data Science bachelor students took place in April 2023, with nine Tec de Monterrey students in their fourth year, as a terminal integrative project. The topic was the system's configuration for a health monitor device (kiosk) developed to measure and record the vital signs of older urban adults. The system's design should collect some data from the interactions and those containing the health records, from vital signs such as saturation, blood pressure, heart rate, respiratory frequency, temperature, weight, and body mass index. The focus was asking the students to envision a scenario in which a system would collect data that must be encrypted for privacy and security reasons.

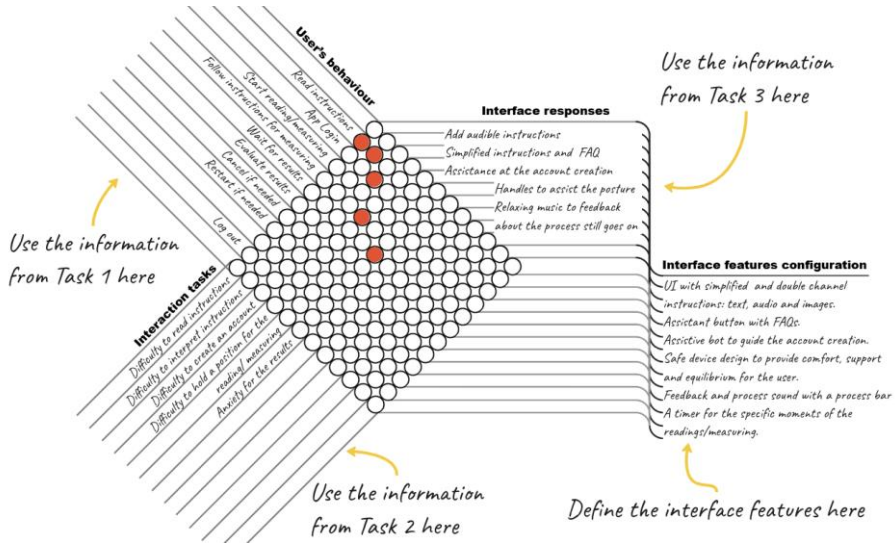

Fig. 2. DM4O Matrix filled by one of the DS students' workshop participants. Source: Own elaboration.

The design stages mentioned in the previous section are steps towards a smart, sensing, and sustainable product's features conceptualization. Stage one, Scenarios Visualization, is fed with three pieces of information: 1) the interaction tasks that the user must perform to achieve the interaction goal; 2) the User's Behavior that can be expected when responding to the interaction tasks, and 3) the potential barriers that a person could find due to their limitations that can play a role in triggering interaction breakdowns. The DM4O Matrix (see in Fig. 2), designed and tested with other use contexts for UI's development, is a graphic tool that allows the combination of these three pieces of information to identify the interaction breakdowns risks and an alternative functionality in the UI as a feature to prevent them.

For this use case, the application of the DM4O followed a similar structure to the previous ones (one with design and engineering students and another with design practitioners), having a PAR approach and using the DM4O Matrix. As shown in Fig. 2, the right side of the Matrix, in the section "Interface Features Configuration," describes the features as a first attempt to shape the UI. Every participant in the workshop filled out one Matrix, adding ideas and perceptions of the potential user behavior and their limitations. As can be observed, the list of features includes alternatives for sensory limitations but also cognitive or even mobility limitations.

The scoring chart from this use case showed that the results were much closer to the aimed capacities, as seen in Table 2. The workshop's individual conceptualizations offered a flexible technology configuration to benefit the addressed group.

Table 2. Scoring on the achievement for Flexible Technology Integration in DS students.

Group		Data Science students								
Capacity	Project / Reference	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9
Self-adaptable	Qualitative Assessment	1	1	1	1	1	1	1	1	1
Responsive		1	1	1	1	1	1	1	1	1
Smart	Molina et al. [13]	1	1	1	1	1	1	1	1	1
Sensing		1	1	1	1	1	1	1	1	1
Sustainable		1	1	1	0	0	0	0	1	1
Supervision	Boy [9]	0	0	1	1	1	1	1	1	1
Autonomy		1	1	1	1	1	1	1	1	1
Mediation		1	1	1	1	1	1	0	1	1
Understanding		1	0	1	1	1	1	1	0	1
TOTAL SCORE		**8**	**7**	**9**	**8**	**8**	**8**	**7**	**8**	**9**

Once each participant followed their process, the group was divided into workgroups to divide the project is work packages; a) Web design; b) Security and Data Protection; c) Data storage; and d) Analytics. Each group selected the best feature configuration alternative according to the project's requirements and priorities. In any case, the results reached in the workshop were used as a prompt to work with in the final product or system configuration.

3 Results

The system structure for a technological device designed for a rapid measuring of vital signs of older adults to be located within different drugstores in urban areas. The device is equipped with the necessary technology to record the patient vitals such as heart rate, respiratory rate, oxygen saturation, temperature, blood pressure, weight, height, and body mass index. It also has a user-friendly interface to guide older adults to carry out all measurements consecutively during the session. The same interface displays a final screen with the values obtained from the measurements and a final message confirming that the information has been stored in the central database of the computer platform.

As a front-end, it will use a digital platform to allow the user to log in or create an account, follow the process of vitals reading, and access the record from that very same day or the records' history. There is also a second web platform for the back-end processes that hold separate access to different user's roles and holds different types of information (see Fig. 3). All this process happens simultaneously with the permanent care of the person's sensitive information, according to the regulations of the Mexican norm NOM-0240SSA3-2010 [21] and the USA HIPAA [22].

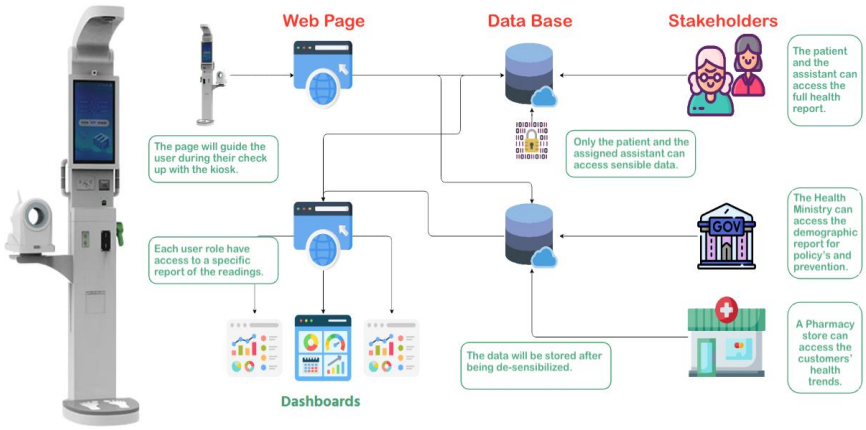

Fig. 3. Description of the system's structure proposed by the Data Science students, assessed by Tecnologico de Monterrey. Source: Project report [20]

The design required for the device considers a dual platform to serve users. The first part of the platform aims at taking vital signs, while the second provides a web portal for accessing patient data through their access credentials. In addition, due to the nature of the information stored in the platform, all patient data must be encrypted with the highest security standards to prevent it from being altered, deleted, or stolen from the system. All the secure encryption of the information happens at three stages: (a) in the platform that records the information when the vital signs are measured, (b) during the transmission of the vital signs to the central records of the platform using the internet, and (c) at the level of the IT infrastructure in that the information will be stored (either physical hard drives or in a cloud storage service).

4 Conclusions

This paper addressed the conceptualization of a product/system as a case study for the application of the DM4O tool. In this work, it is considered that the "conceptualization" stage is one of the most important steps in the design of creative and inclusive solutions, and it is at this stage where designers can define the level of inclusivity of "products and systems" by integrating their research and knowledge into their creative process. The use of design tools, methodologies and methods such as DM4O play a crucial role in contributing positively to the design and development of socially responsible and equitable products in several ways:

1. User-Centered Design: The DM40 emphasizes user-centered design principles. It encourages designers to understand the needs, preferences, and challenges of diverse user groups, including marginalized and underserved populations.

2. Data-Driven Insights: DM4O can incorporate user data collection features. By analyzing this data, designers can identify disparities in product usage and tailor solutions to better meet the needs of different user groups.

3. Prototyping and Iteration: The DM4O can enable rapid prototyping and iteration. By involving a wider range of voices, designers can uncover potential biases and shortcomings in the product and make necessary adjustments to ensure equity and fairness.

4. Collaboration and Accessibility: The DM4O can be a collaborative tool, making it easier for multidisciplinary teams to work together, including experts in accessibility and inclusivity.

5. Accessibility Features: The DM4O incorporates features to assess and improve accessibility. For instance, it gives a framework to provide guidelines and checks for accessibility standards.

6. Ethical Design Guidelines: The DM4O can increasingly promote ethical design guidelines and principles across designer practices. By following such guidelines, designers can create products that are more socially responsible.

7. Testing for Bias: The DM4O can assist in identifying and mitigating biases in user interfaces. During conceptualization stages, designers can evaluate and rectify biases that may exist in the product's design, ensuring equitable outcomes.

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