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Augmented intelligence for open education: bridging the digital gap with inclusive design methods

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Artificial Intelligence (AI) development with an inclusive vision will not happen without the design theory and committed practice, but neither can it be carried out from a biased in-a-silo design vision. Having as its primary goal to augment human capacities, it is crucial to overcome the bias produced by human fuzziness. The application of the DM4O design methodology enables the envisioning of different scenarios to conceptualize inclusive digital education platforms as key resources to bridge the digital gap for learners in a global context. Aligned with Sustainable Development Goal (SDG) number 4, the objective of this study is to identify potential higher education (Hi-Ed) students' limitations when interacting with an open education digital platform (OE-DP), to propose a set of inclusive design guidelines. Following a mixed methods approach, this article sets the state of the art across a systematic literature review; then presents the DM4O design method as the data gathering tool; and finally reports the results of a survey application to capture the perceived limitations experienced by Hi-Ed students as users of an OE-DP. This study marks valuable insights for designers, educators, and institutional administrators, toward a digital transformation that promotes inclusive OE-DPs innovation in three dimensions: (a) inclusive guidelines for digital platforms; (b) a comprehensive list of interaction tasks suitable for digital platforms; and (c) the potential limitations that these platforms must cover during the design process.

KEYWORDS

educational innovation, higher education, design methods, inclusive design, augmented intelligence

1 Introduction

> "Intelligent machines have become the intimate companions of humans, where the interaction and cooperation between a human and an intelligent machine will become integral in the formation of our future society" (Zheng et al., 2017).

As technology becomes the means and the purpose for contemporary development, it is relevant to examine the approaches used to reach Socio-Technical objectives (de Torres, 2018). Augmented Intelligence (AI) development has undoubtedly allowed the coexistence with intelligent machines and has created specific types of interaction between humans and systems, in which humans enhance their capabilities for the decision-making process (Rouse and

Spohrer, 2018). All this has been crucial in shaping our present and future society; simultaneously, it has influenced the many challenges we have to cope with in searching for a smooth coexistence with intelligent systems. Many challenges are related to the lack of consideration for the accessibility and inclusion of diverse users, especially those traditionally marginalized or neglected, while conceptualizing products and systems that use AI as core features. Regarding this, it is also crucial to consider the unintended consequences of oversimplified responses to the complexity that implies inclusive design (Treviranus, 2019), for instance, when we pretend to offer a one-fits-all solution without fully understanding the diversity of those we intend to serve.

Even though there is a myriad of guidelines and principles for the design of inclusive user interfaces and smart systems, during the design process, only a few methods are systematically applied, and many are modified or complemented with other methods to match specific objectives (Acharya et al., 2020). Still, designers and usability professionals have been working on means to increase the efficiency and effectiveness of integrating usability assessment into earlier stages of the design process and to justify the resources that must be invested in these practices (Dumas and Salzman, 2006). In this sense, this chapter initially presents a mixed methods study that recovers design guidelines for digital interfaces and platforms, identifying a gap in the design process. Then, the DM4O matrix is introduced as a tool to cover the aforementioned gap, and as the base for a decision-making algorithm used in user interfaces. Later, based on the results obtained from data collected from participants in the 2023 Comillas' Bootcamp "Building the future of education together: innovation, interdisciplinary research and open science," we discuss the potential benefits that shaping educational platforms under this approach can bring as a contribution for the design process for novel designers.

The conclusions show that designers in training can benefit from diverse practices and that might go beyond physical tangibility to exist digitally, transforming our present to achieve the desired future. This study aims to contribute to the better understanding of how to connect the design process with an artificial intelligence algorithm, that learns from people's needs and limitations, to shape a system's features as alternatives to create flexible and responsive systems for the years to come.

2 State of the art

A systematic literature review (SLR) was performed to identify design guidelines that would allow the designing of flexible and adaptable systems. A flexible design means configuring a system that allows for various needs and abilities (Boy, 2019). In addition, an adaptable system would recognize patterns in users' behavior, and adapt its functionalities according to them, offering supervision, mediation, autonomy, and understanding (Boy, 2021) about the interaction so that the human can benefit from it. It is worth mentioning that this review is the second performed by this research team; the first one being wider and deeper, aiming to discover how inclusive methods offer accessibility.

Following PRISMA methodology (Page et al., 2021), the SLR for this study came from one database (i.e., Scopus), with the search string from Title, Abstract, and Keywords, being (inclusi*) OR (access*) AND ("design guidelines") OR ("design principles"), with a five-year timespan from 2019 to 2023. The subject areas were limited to Engineering, Arts and Humanities, and Multidisciplinary and only sought publications in English from Journals, excluding Books, Conferences, and Reviews. These filters showed 218 documents; only 115 were open source. The PRISMA method (Page et al., 2021) was used to select the reviewed documents; surprisingly, after the qualitative analysis only 13 documents included design guidelines for smart systems that were helpful to extract relevant information for this study. The documents reported various design process stages; the overall findings include three key stages in the process. *Scenario Visualization*, to picture users that might struggle with the system's functionalities due to their abilities or capabilities. The *Alternative Functionalities* stage offers the opportunity to include and design the possible answers to the pictured limitations. Finally, the *Flexible Integration* would enable to design a configuration of the envisioned alternatives within the context of the user and the designed product or system.

From the previous analysis, it can be drawn that there are effective design processes for products and services in the context of smart systems, although none of the retrieved documents reported all the three stages. These approximations mainly involve phases for scenario envisioning and alternative seeking to serve the diverse stakeholders' needs; however, we are proposing to incorporate an additional step in the design process to integrate possibilities for the flexible responsiveness of a system. In this phase, after envisioning the struggles and barriers a vulnerable user might go through during the interaction with a User Interface (UI) and the consequential search for alternatives to solve them, the design team would picture a means to offer alternatives to several of the identified scenarios.

Moreover, in the context of Industry 4.0, where innovation and development rely on the combined and sometimes overlap effort of many, sharing innovative ideas and possibilities openly can allow to offer up-to-date resources to address the demanding challenges and to open the possibility of erasing (or at least bypassing) some "traditional" barriers to problem- solving in terms of equity and inclusion. This work is building up on a previous reported in a doctor's degree thesis (Alvarez-Icaza et al., 2023) which describes the followed sequence of the academic projects described in the next section.

3 Methods

We agree with Clarkson and Keates (2013) when discussing that the existing design approaches for everyone can only be addressed to specific cases. It is then required to assemble a description of what type of people's capabilities can be served by a product. As there are countless possibilities, a system that can adapt to the user's behavior and context can be more efficient and effective. Augmented intelligence, which combines human and artificial intelligence (Zheng et al., 2017), may be particularly well-suited for this type of adaptability. An augmented intelligence system can make more informed and nuanced decisions about responding to a user's profile or behavior. This feature could lead to a more personalized and efficient experience for the user (Malizia et al., 2018). Figure 1 represents the interaction and the response selection from a system adapting it to a user's conduct. Eventually, AI would learn that for every Behavior "D," it should offer a Response "D." To do that, the

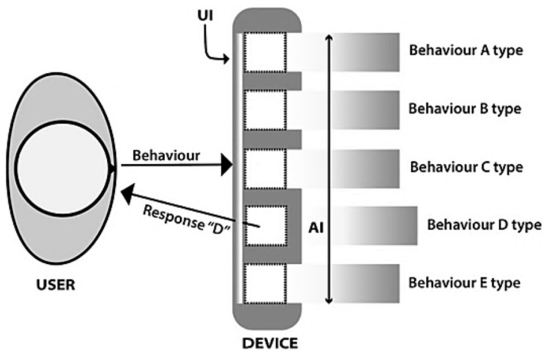

FIGURE 1
Schematic representation of the user-interface adaptability. Own elaboration.

design team should describe which is the Behavior "D" and what would be the ideal response for it.

As well as the peoples' conditions can cause a variety of situations, the augmented intelligence of a system could respond much better than human criteria to adapt to what a system has to offer in such scenarios. Although, to be able to design a system as described, it is required to prefigure the possible scenarios and potential responses to human behavior, and it must be done during the early stages of the design process using a precise method. The design methodology for inclusive intelligent systems has been tested and iterated within different contexts: from academic projects with industrial design and engineering bachelor students in Mexico to a group of practitioners in the United Kingdom.

The applied methodological approach is mixed methods research, which has been practiced for more than seven decades with a growing number of researchers advocating for its value compared with a purely quantitative or purely qualitative study (McKim, 2017). There is a consensus between researchers stating that mixed methods are not the arithmetic addition of the quantitative with the qualitative data, rather it combines both types of information in a strategic manner to reach a significant contribution to knowledge (Åkerblad et al., 2021). Creswell et al. (2003) defines a mixed methods study as the collection or analysis of both quantitative and/or qualitative data, in a sequence that allows a hierarchical and an integrative analysis at one or more stages in the process of research.

3.1 Academic projects as iterations

For the design stages delineation (i.e., methodological elements) in typical smart systems conceptualization process, we performed three academic projects with 50 Undergraduate students from Industrial Design, Mechatronics Engineering, Development and Innovation Engineering, and Data Science at Tecnologico de Monterrey, between August 2020 and March 2023. The tasks included conceptualizing a health monitor for older adults with an inclusive user interface. The results showed that the most common methods (Dubberly, 2005; Kumar, 2012) for designing a smart product (Molina et al., 2021) were not enough to reach flexible integration (Olewnik and Lewis, 2006; Boy, 2019), because they only prescribed tasks during the process to ideate for an average user. However, students' groups succeeded in including steps that lead to better results in terms of self-adaptability and responsiveness. These capabilities represent that the system would have the means to answer with differentiated functionalities to the users' needs and limitations.

Due to the demands and requirements of the current socio-technical panorama, it is required for smart Products and Service Systems (PSS) (Wang, 2019) to collect information perceived from the surroundings and the users and adapt their functionality. The benefit of this adaptation goes from reducing energy consumption to improving the user experience. The ultimate impact we pursue is to reduce the digital gap in users from a variety of contexts with diverse capabilities. Therefore, to find a design method that would allow designers to propose a flexible integration (Boy, 2021) of functionalities in a product or system allowing the user to be autonomous while offering supervision, mediation between the users' needs and the system's possibilities, and finally, granting a possibility for users to understand the system and the interaction expected from them.

The academic projects were evaluated following the description of the desired products mentioned above, as a flexible integration. A pool of experts, from diverse disciplines such as Product Des., Service Des., Biomedical Eng., Mechatronics Eng., and User Experience (UX), evaluated the results. The projects that scored the higher were the ones that added the three stages mentioned before during their design process. The analysis showed that the most effective design processes searched for specific limitations and scenarios in which the users would struggle with the interaction. Also, some design teams looked for solutions that could be found in a variety of systems and applications. Finally, the features included in the higher-ranked design proposals were diverse, offering multiple channels and ways of assisting the user and adjusting the interface.

4 Results

From an average sequence of actions, a list of basic and generic tasks can be used as a checklist for every project conceptualization, this list should be modified, adjusted, or increased according to the interaction type and the device's purpose. The tasks we used in the workshop were adapted from Dr. Morris' Doctoral Dissertation (Morris, 2016) and were intended to trigger ideas in the participants, as they were having the possible limitations in mind already. It is appropriate to say that for the data collection during the Comillas' Bootcamp, the tasks were adapted to those relevant for OE-DP design. However, for the workshops with participants, the used list of interaction tasks allowed participants to envision a specific scenario (i.e., using a microwave for a ready-meal dinner) and to break the process down into steps or actions required to complete the process.

During the online workshop, design practitioners were asked to use the DM4O Matrix (showed in Figure 2) to create their ideal design brief, this is a description of the desired interface, with a list of jobs to be performed, the context of use, and the target user. One assumption made by the research team was that participants would use the tool in a way it would make sense to them and their respective design process, starting with the section they could grasp better after the first three design tasks. We wanted to understand if the order in which the participants filled the template or the type of information included, affected the type of design brief they would be able to craft by themselves. The practitioners managed to navigate the design tasks

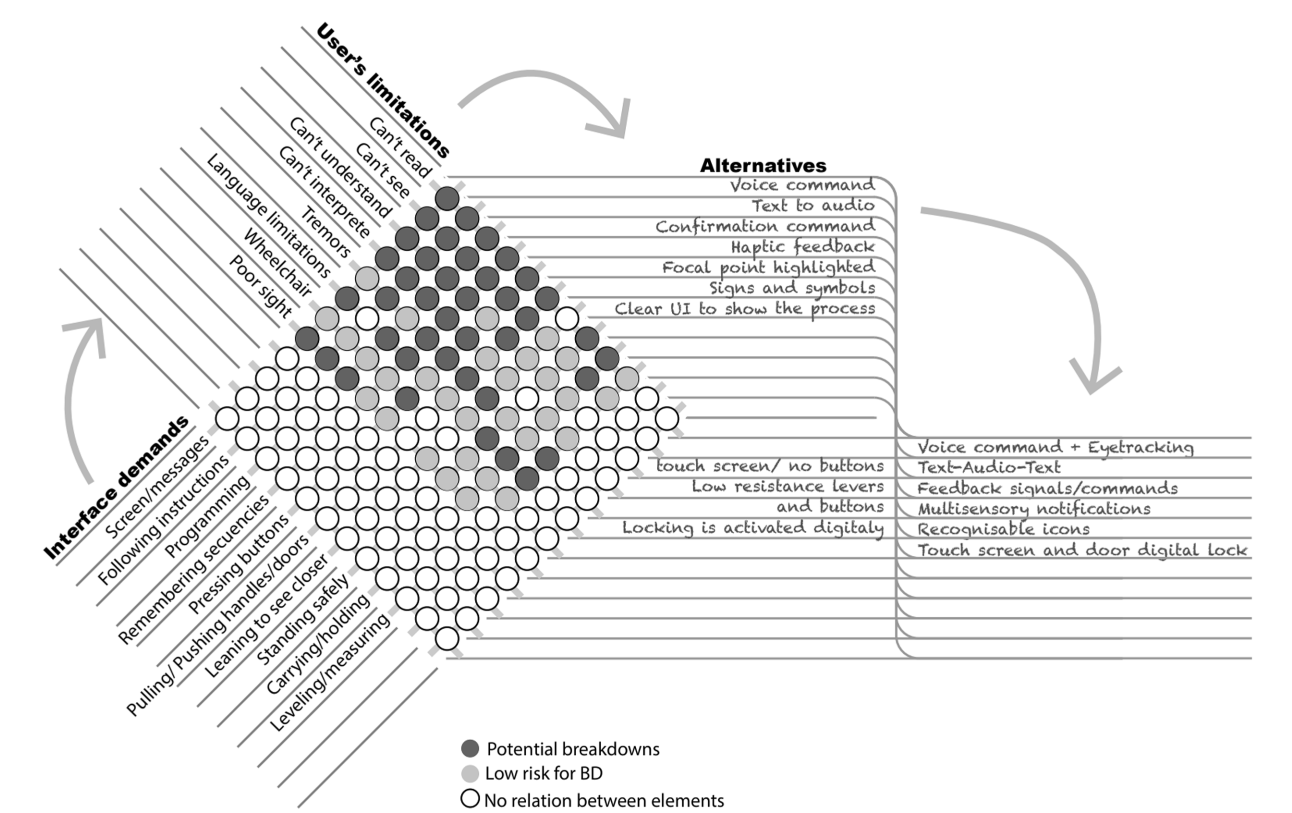

FIGURE 2
DM4O tool, filled by one workshop participant. Own elaboration.

FIGURE 3
Scenario envisioning by Bootcamp participants (October, 2023). Own elaboration.

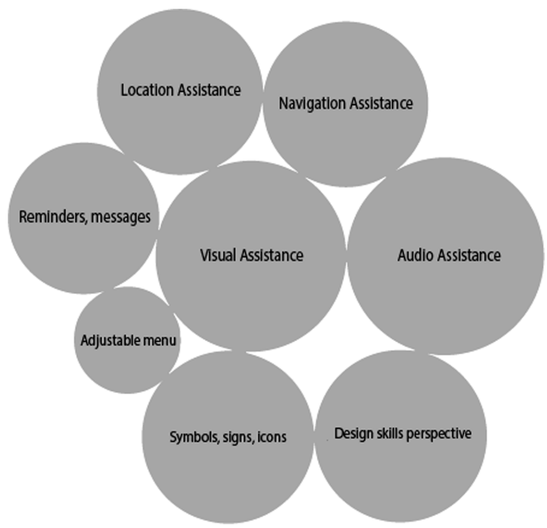

FIGURE 4
Flexible alternatives proposed by Bootcamp participants (October, 2023). Own elaboration.

smoothly and showed that they could straightforwardly use the process to assemble a design brief and integrate the DM4O tool into their design process. In addition, the participants expressed in which context they would apply the tool, validating its convenience.

5 Discussion

The envisioning of a use scenario and the breaking down of a specific activity into user behaviors, successfully proved to allow the transformation from pieces of information referring to use scenarios into new interaction tasks (Figure 3). To train an AI system it is required to have as many as possible scenarios in which interaction tasks are combined with users' limitations or conditions, and those combinations will derive in flexible alternatives (Figure 4). We intend to have a comprehensive group of scenarios and potential limitations of Hi-Ed students as users of an OE-DP to feed an AI assisted system that can help designers and education experts in the conceptualization of functionalities and features of open educational resources based on smart PSS.

As possible future work, the applications of the presented design methodology can be applied in diverse areas such as cybersecurity or mental health, providing possible scenarios in which a designed system could fail of need alternative functionalities. Additionally, from the current study, we could draft some recommendations as a guide future research endeavors in the field of flexible and responsive systems, to always foster innovation and address human challenges in dynamic and evolving environments.

- Adaptability: Explore the development of adaptive learning algorithms that can continuously evolve and respond to human changing conditions in flexible and responsive systems. This can be promoted through machine learning and artificial intelligence.
- Humans and Machines working together: promote human-machine collaboration strategies in flexible systems. Integrate human input seamlessly into the decision-making processes of responsive systems, fostering a symbiotic relationship between humans and machines.
- Data is knowledge and knowledge is power: Keep systems responsive through efficient real-time data integration within flexible systems. Identifying and integrating this data will continue to be an important challenge.
- No intelligent system is smart enough: Design for resilience and unpredictable environments. Develop strategies to enhance the robustness of systems against unexpected disruptions, ensuring their ability to adapt and recover quickly.
- Ethical Considerations: ethical considerations associated with the use of smart and responsive systems, particularly in contexts where decision-making impacts individuals or communities will continue to be very important.
- Energy-Efficient Design: Research strategies for designing energy-efficient flexible systems. Explore technologies and methodologies that minimize resource consumption while maintaining high responsiveness, particularly in applications where energy efficiency is critical.
- Keeping humans at the core: Adopt human-centered design approaches and incorporate user feedback to enhance the overall user experience and acceptance of responsive technologies.
- Keeping an eye on the law: with technology developing at a fast pace, regulatory frameworks and new policies will inevitably follow. How these will evolve in the future is unknown but what is true is that they will continue to be strongly connected as they will govern the deployment and operation of flexible and responsive systems.

6 Conclusion

We have described the application of a design method that seeks to facilitate the conceptualization of adaptable, smart, sensing, and sustainable products and systems. This process has been tested and iterated within different contexts: three academic projects with Mexican industrial design and engineering bachelor students and a group of practitioners in the United Kingdom. The main goal of this research is to understand how to connect the design process with an artificial intelligence algorithm, people's needs and limitations, the system's response, and the features' alternatives to create flexible and responsive systems for the years to come.

As this research does not include the actual algorithm design and development for a tangible product integration, this work's limitation is the incapacity of testing in a real-life environment. However, future work for this research focus on building a system based on the specified features configuration to be applied as an AI design assistant, producing an augmented intelligence scenario in the human decision-maker. The testing also should consider an analysis of the impact and effectiveness of the designed systems, to evaluate how well-being and opportunities for all are promoted by this system.

The adaptative functionality requirements can be as diverse as the pursued development. It was found that traditional design methods created in the 20th Century, and commonly used for product development, do not always satisfy the demands and necessities of Education 4.0, and limit the value design represents to the current socio-technical transition we experience in this decade. The applications for adaptive systems are as diverse as the types of users that can need them: from adaptive learning and upskilling platforms to threat detection and cybersecurity services or mental health attention. Aligned with the SDG, the AI development must secure alternatives steering to a fairer and equitable resources at reach, promoting wellbeing, and opportunities for everyone.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements.

Author contributions

IA-I: Conceptualization, Formal analysis, Funding acquisition, Methodology, Writing – original draft. OH: Investigation, Methodology, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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