The Multidimensional Screen Model

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Abstract— **The visual dimensions of the screen can be projected along the axes of aesthetics, use, or interaction. Each axis plays a crucial role in shaping the design interface practically. These practices are brought to life through various design techniques. A thorough exploration of these dimensions reveals the nuanced experience of the screen's multidimensionality, taking into account both the designer and the interactor realm. The result is a model that delineates three aspects of the multidimensionality of the screen: space, which represents the realm of the designer; meaning, which serves as a shared realm between the designer and the interactor; and performance, which pertains to the interactor's realm. The model has implications for the teaching and practice of design, as it supports the understanding, analysis, and design of the multidimensionality of the screen.**

Keywords-space; performance; meaning; screen; dimensions.

I. INTRODUCTION

Our society is increasingly reliant on screens for various purposes. This trend originated with screens displaying static images, such as painting and photography, capturing a singular moment of imagination. Over time, this evolved into screens featuring moving images, like those in cinemas, which extended the imaginative experience over a period. With the introduction of television into our homes, screens demanded more of our visual attention, akin to paintings and photographs hanging on the wall that clamoured for attention as the cinema. As we transitioned from one type of screen to another, our perception adapted, accepting and interpreting their images as technological advancements.

Images serve as bridges between the object, its representation on the screen and the viewer, intertwining dimensions of use and aesthetics [1] to enrich the interface's complexity.

According to [2], technology is a multifaceted entity encompassing technical knowledge and human attitudes. It becomes ingrained in our routines, offering convenience and enhancing our comfort.

The intricate nature of technology also manifests in interface design education, where one must navigate the practical application of technology in design and the artistry of its poetics or creative expression. Poetics constitute the principles of design that best define an object or work [3]. A central poetic of the digital interface is remediation: the representation of one media into another [4].

For instance, a digital calendar is expected to replicate its printed counterpart. The months appear in a tabular format, with days displayed within cells. Consequently, this paper suggests that perceiving the screen as flat is a direct outcome of the remediation process.

For [4], remediation progresses through a four-level evolution, wherein the representation of a new media diverges increasingly from its predecessor. Therefore, we argue that achieving each level necessitates comprehension of contemporary media and acknowledging its unique language and properties, ultimately giving rise to its poetics.

Another poetic aspect of digital media is its multidimensionality, which is grounded in the principle of numerical representation [5]. This principle enables new dimensions of use by leveraging the artefact to express various aesthetic elements and forms of interaction.

The poetic of multidimensionality, as explored by [6], is established through data density, a concept defined by [7] as the intense flow of information captured and sent by the interactor+artefact dynamic. Consequently, the screen mediates this data density across visible, perceived, or social dimensions. Reference [1] devised a "visual dimensions framework" based on these three dimensions. In addition, teaching poetics benefits from visualising each dimension, allowing students to design and explore the interconnectedness among dimensions to add depth to their creations.

Therefore, we argued in a previous paper [1] that the screen is not flat, as its depth develops by mastering remediation and data density manifested as aesthetic, use and interaction and draws the boundaries for the aesthetics of the screen. This paper develops each dimension regarding design techniques to support teaching and designing a screen that explores its multidimensionality. The result is a multidimensional screen model.

The method follows qualitative research, highlighting screen dimensions from the literature and dialoguing with teaching practice. The model is built by closely reading the framework. This practice enabled many observations about students' difficulties visualising screen dimensions.

The remainder of this paper is organised as follows: Sections II and III present the background review of the aesthetic, use, and interaction dimensions. Section IV extends the visual screen dimension to encompass the design techniques and introduces the multidimensional screen model.

Section V discusses the model. Finally, Section VI draws a brief conclusion.

II. AESTHETIC DIMENSION

The multiple dimensions of the screen become undeniable when establishing the possibilities of the interface design aesthetic. One option is simulating three-dimensional objects, i.e., the object is created in its three dimensions. In addition, layers of information, movement, and Information Design (ID) are visual dimensions. These dimensions are constructed through the lens of remediation and data density.

A. The screen interface

The interface can be understood as a mediating layer between the artefact and the interactor. The user interacts with the product through the physical or digital interface. Thus, a product can be complex to manipulate, and its use may require a layer of translation of its mechanics. For example, a typewriter presents itself to the interactor through a coating, which hides its gears and leaves enough in view to be used. Therefore, [8] associates design with the interface to link the user, the tool, and the action. Thus, it is likely that the more complex the object's engineering, the more critical the role of the interface as a tool facilitating use. This role becomes evident with digital interfaces, given the complexity of the artefact.

Reference [9] states that the interface is the software for the user, which means it does not matter if the algorithm is highly complex or has a layer of artificial intelligence. What the user perceives is the contact and control over the tool mediated by the interface.

Thus, digital interfaces have made this mediating layer visible (hypermediation), often because of the complexity of its use. By understanding this complexity, many designers seek to create invisible or transparent interfaces (immediacy). However, one of the main qualities of digital objects is their oscillation between hypermediation and immediacy.

This oscillation is also referred to as remediation by [4]. The authors argue that the opacity of the interface is necessary for interaction to occur, as the interactor needs to see the options to act on them (hypermediation). On the other hand, immersion happens when engaging with the content, and the interface becomes transparent (immediacy). Therefore, this oscillation is another poetic of interactive media and a dimension of the interface.

To decrease the oscillation, [10] advocates the narrativization of the interface. Lessening the oscillation can be accomplished by (1) narrativized 'look and feel' of the interface, (2) behavioural mimic and behavioural metaphors, (3) narrativized perspective, and finally, by building (4) bridges and mixed-reality interfaces.

The 'look and feel' incorporates narrative elements into the graphic representation. The aforementioned has to do with the visual identity of the artefact and how the imagery representation is expected to reinforce the project concept. For instance, feedback could be presented as illustrations, reinforcing the adopted narrative.

Also, interface elements can mimic behaviours or behavioural metaphors. For example, if an interface element demands an urgent response, its graphical representation can assume a hurried behaviour, such as getting agitated.

On the other hand, the narrative perspective acts on the depth dimension of the screen. That is, the screen's graphic design makes the z-axis of the spatial representation explicit. This representation is evident in in-game scenarios or environments where the interactor can simulate moving around.

Finally, data density can support the bridges and mixed-reality interfaces establishing digital and virtual connections. Augmented reality artefacts are excellent examples, as they apply new layers of dynamic data on top of the captured image of the place (Figure 1). Other bridges can be established using interactors' information to capture environmental information. Locative media are examples of this dynamic.

Thus, design techniques to support designing a multidimensional screen involve mastering remediation as oscillation and representing an older media into a new one. Mastering oscillation evolves with a narrativized interface, and when one of the concepts associated with the interaction, such as dialogue, transmission, tool use, optimal behaviour, embodiment, experience, and control, is clear for the interactor. Section III-C discusses these concepts. Mastering the representation of one media into another emerges, encouraging the creation of the meaning of the artefact in the use, language, genesis and ecology of the artefact [11]. Thus, design techniques, such as metaphors, affordance, user mental models, and Gestalt, can be applied to foster meaning-making.

Figure 1. Example of augmented reality artefact using Google translate App.

B. Tri-dimensional objects

Treating objects in three dimensions allows different renderings to simulate their spatiality, such as rotating the object or moving it in the screen space. So, it requires the object to be thought of in true 3D, which moves away from the printed media as it requires a 2D representation. In 3D, the design domain would approach the realm of sculpture because it would encompass elements of 3D representation such as body, weight, movement, and lines of action, among others, expanding design to volume treatment.

Figure 2 shows an interface of an app prototype that presents content on the skeletal system for medical students. The skeleton is presented in 3D and can be rotated and zoomed. This paper suggests that this control over the visualisation encourages exploring the object. 3D objects occupy the multidimensional space of the screen and offer many possibilities for representation. Just as the screen's

surface allows it to be treated as a 3D surface, objects can also be designed within 3D dimensions.

Figure 2. The Meduca App screenshot was developed by Boesing and Wagner (2020).

The calendar, for example, which is constantly translated into digital with firm reference to its printed predecessor, could be represented by a 3D object, such as a sphere. The spherical calendar allows movement to explore new possibilities of representation.

In addition to 3D representation, space simulation enables layers of movement and different forms of interaction. By treating the screen as a three-dimensional space, motion layers are created in the depth of this space, where objects can move around. For example, a disabled element can occupy a bottom layer of space and project to forward layers when enabled.

Moreover, the space can become active, posing as a design and communication element. As advocated by [12], the digital space, as a remediation of the medium, expands the possibilities of interaction as it becomes a meaningful dimension. Beautiful interfaces explore 3D dynamics by presenting 3D objects and a 3D scenario. The beauty is supported by a spectacle involvement that evolves through the excitement about the images and 3D forms.

The screen's rectangle format suggests the space as a two-dimensional space. But some examples, such as the Apple Watch®, bring new possibilities when the screen is designed in its three-dimensional space (Figure 3). The surface is considered spherical, which implies that the graphic elements can slide around the sphere, assuming different sizes when traversing it. They increase in the centre and decrease when approaching the edges. The treatment of the surface in 3D enables new attention arrangements, given primarily by size and position.

Figures 2 and 3 are examples of remediation. The former remediates a real skeleton, and the latter remediates the screen as a ball. Thus, remediation and space-medium remediation are techniques for designing 3D representation.

Figure 3. Apple Watch Interface.

C. *Information layers*

Two fronts provide an understanding of information layers: position and meaning. While the positioning layer defines different layers in different spatial positions (on any of the three axes of the screen), the meaning layer implies different degrees of importance built through Information Design using contrast, hierarchy, typography, composition, colour, and image. Figure 4 shows a login screen highlighting the input fields in a front layer. The background layer is out of focus to improve the distance between layers.

The positioning layer uses the spatial geometry of the screen to place the information layers. Spatial geometry implies the independence of the layers, both at the content and interaction levels.

One of the best examples of this arrangement of multiple layers on the same screen is Augmented Reality (AR) applications. AR presents a layer of dynamic information on the physical environment, whether captured by a camera or not. That is, its definition guarantees a multidimensional understanding. AR can happen in 3 arrangements: (1) through information projected on a physical space, such as films projected on buildings; (2) using an instrument to capture the physical space and, on the same screen, insert the dynamic information; and; (3) using glasses or lenses on which the information is projected while the ocular system captures the physical space [13].

AR is distinguished from a simple projection of a video onto a screen by considering the three characteristics that [13] attributes to AR:

- It combines the real and the virtual;
- It is interactive in real-time;
- It is registered in three dimensions.

The multidimensionality of the screen is explicit, given that the interactor is the one who builds it. This co-creation allows the interactor a certain degree of control, given the dynamism of the composite image.

In the composition of AR, one can have several layers of information organised by the distance between the object and the interactor, the screen's permanence, the interactor's importance, or any other design criterion. These criteria that are exposed by AR composition can be applied in other interface design projects. AR makes it easier to understand this multidimensional composition of information. Therefore,

AR and Information Design can be considered design techniques to improve the screen depth. The independence between layers relies upon the space-medium remediation.

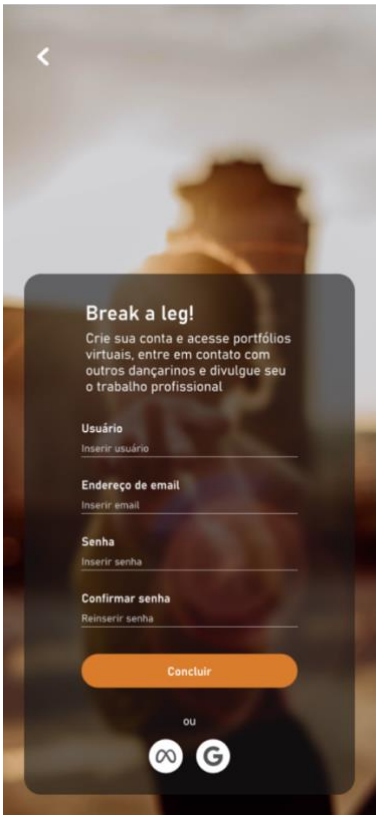

Figure 4. The Pulse App screenshot was developed by Bevilacqua and Paiva.

D. Movement

Movement is another screen dimension that can be understood using four approaches: (1) moving images and objects, (2) user physical interaction, (3) the movement of the interactor in the space, and (4) the movement of the device itself. Movement is the poetic aspect of digital media that attracts attention and reveals the wonders of the multidimensional screen. Movement can be applied to deliver feedback, transitions, and humour.

Given the principle of numerical representation, objects projected onto the screen can be created in true 3D, which allows the objects to be manipulated on all three axes, as discussed in Section II-B. The object movement through animations, micro animations, sliding in different directions, and appearance, among others, adds dynamism to the interface elements, providing feedback to the interactor. Feedback, such as loading animation, uses movement to inform the interactor without distraction.

Moving images, such as videos, graphic motion, or animations, are characteristic of media based on time. These complex media translate narratives into different dimensions, such as time, space, or sequential images. For example, the horizontal scrolling of gapsystudio.com remediates an art gallery as the interactor moves the 3D scenario. This remediation facilitates understanding the space sequentially and the studio's work as art. In addition, the transition from one page to another, between views or states, can be designed using a visual effect, such as fade, mask, or slide. Transition builds continuity that guides the attention from one object to the other, reinforcing the depth between objects.

Humour can be delivered through movement because the animated objects are perceived as alive and reactive and, therefore, they become partners in a shared experience. Emphasis on-screen depth is essential because the animated object shows personality. Micro-interactions shape humour using small movements that smooth interaction.

Interactor's movement occurs in physical space or/and on the screen, navigating among pages. As argued by [7] and [14], the former is supported by mobile technology with small screens. The coincidence of movement and the creation of spatial representations is called "performative cartography" [14]. This simultaneity highlights the screen depth, as the image is created as it is perceived (see Section III-B). The moving interactor also implies locative media, which explore the augmented space [7] by triggering an interaction. The three principles of performative cartography on locative media [14] can enhance the depth of the screen: tagging, plotting and stitching. Tagging adds metadata to objects or locations. Plotting places the tagged objects into a map while stitching integrates visual layers and digital cartography [14]. The multidimensionality of performative cartography requires multiple levels of the interface. At the same time, software communication tags the objects and the screen plots and stitches as a navigable space.

The device's movement brings new possibilities of embodied or haptic interaction. That is, the control of the screen can occur through actions with the device. For example, shaking the device can switch pages. It is also a powerful accessibility technique.

E. Information design (ID)

The design project introduces new dimensions by intertwining interaction and navigation within Information Design (ID). These layers incorporate various design elements that enhance the screen's depth. The ID plays a crucial role in processing information, enabling seamless interaction and navigation. For instance, when creating an interactive button, the ID is meticulously designed to provide clear guidance on the available actions.

Navigation Design shares a similar dynamic, defining pathways across digital pages, while Information Design focuses on delivering optimal solutions for user guidance. From metaphor to practical implementation, navigation signifies a connection with the artefact beyond the physical confines of interaction space. It can be argued that navigation is an interaction mode that gained popularity with hypertext systems in the 1980s [15]. These systems, featuring graphic-textual interfaces, are explored through user inputs like

clicking or tapping, leading to the discovery of interconnected information segments. However, it's important to note that scholars like [16] point out that navigating information has historical roots in traditional artefacts such as books and printed materials. The visual cues in these materials, such as page numbers, headings and indexes, can be viewed as "navigational devices" between documents contents.

The metaphor of navigation emerges from the imperative to comprehend a spatial semantic system, as suggested by [17]. In intricate interfaces with information layers distributed horizontally and vertically, navigation becomes pivotal in shaping the experience. This process defines personal preferences, information retrieval patterns, and identities, underscoring navigation as a dialogue between the user and the system. The interaction reveals boundaries between the two entities, both technically and politically.

It is, therefore, possible to comprehend these navigable systems as mediators of the relationship between users and the world represented by the system's information. This relationship entails technological mediation, as understood in the post-phenomenological sense articulated by [18] and [19]. This concept involves an interpretation of technology based on how humans engage with it dynamically, where the human actor defines themselves in conjunction with their technological counterparts through the interactive process.

The poetics of navigation are intricately connected to movement. The resulting perception is so impactful that it gives rise to new ways of existence and interaction. The concept of cyberspace, initially depicted in the science fiction novel Neuromancer [20], embodies an interaction model that transcends mere positioning on a two-dimensional screen. Instead, it embraces the phenomenon of semantic exchange as described by [21]. Navigation can be seen as a performance within a specific time and space framework inherent to the experience of projecting oneself into abstract space.

Through "navigational practices" such as search systems, dialogical operations, or simply browsing smartphone and tablet screens, a responsive dimension emerges from the programming of artefacts. Consequently, a system can exhibit different states depending on its usage. Each usage presents a unique phenomenon, and each navigation action serves as a form of expression. As a result, interaction modalities such as clicking, scrolling, or zooming in on a map can be viewed as a technological manifestation of the human capacity to navigate. Navigation Design introduces multidimensionality into its conceptual framework by navigating information that may be distributed in depth (layers) complexity or exploring the special aspect that constitutes the object.

Interaction Design encompasses the entire process of designing an interactive object, which includes information and navigation design [22]. Moreover, it can be viewed as the design of the mechanisms that enable users to navigate effectively [23].

Hence, Navigation Design is responsible for mapping out the potential paths, while Interaction Design devises the mechanisms to empower interactors to act upon the interface. Information Design, in turn, conceptualizes these mechanisms.

III. USE AND INTERACTION DIMENSIONS

The prevalence of mobility has heightened the use of digital objects, accentuating the screen's significance. This attribute underscores the necessity for the usage to fall within the encompassed reception area for data transmission and reception. The interface is dynamically developed through the seamless integration of receiving, processing, and presenting data, a process referred to as performative cartography [14]. Thus, mobility and performative cartography emerge as integral dimensions of the screen.

A. Mobility

Mobility, defined as the utilization of digital products across various locations, is facilitated by individual Internet access technology and the compact size of artefacts like smartphones and tablets, allowing for their usage while users are on the move. This mobility has enhanced data density, transforming space into an active entity by gathering user data or providing locative data and information. The screen now functions as a gateway through which information about a location is relayed to the user. Locative media, including games and apps, have the potential to introduce novel levels of responsiveness influenced by spatial factors.

Reference [5] coined the term "augmented space" to describe this interactive space and proposed that this expansion should be viewed as a concept or a cultural and aesthetic practice. This reconceptualization broadens the scope of creative possibilities, transforming the screen into a multifaceted space. Within this complexity lies the notion of continuous monitoring, a process often overlooked by interactors but essential to consider within the design domain. Monitoring is an inherited aspect that can be disregarded or integrated by digital artefacts, requiring addressing it in the interface.

As a cultural practice, numerous objects have become intertwined with work and leisure routines, such as ubiquitous computing, artificial intelligence, augmented reality, and wearables. Despite this integration, aesthetics as an art form often remains disconnected from the interactor's presence and surroundings. Furthermore, these objects are typically envisioned in isolation, leading to a lack of consideration for their overall ecology. For example, the Internet of Things (IoT) features could be integrated into the digital artefact design to enhance the use of data and functionalities.

These are some of the challenges to consider within the mobility dimension. The cultural practice of performative cartography makes these challenges explicit.

B. Performative cartography

The simultaneous displacement of individuals in both the physical environment and on the screen is defined as

"performative cartography" [14]. In this process, the interactor navigates the interface while the interface is being shaped. A practical example of this concept is the map displayed in Google Maps, which is dynamically generated based on the subject's real-world location (Figure 5).

The visualisation and image construction process co-occur in a creative endeavour that [14] describes as a 4D operation within a 3D space. To address the challenge of representation, the author proposes that the fourth dimension should focus on space-time rather than solely on time. The assertion that time and space are manifested during usage supports this suggestion. Consequently, the concept of performative cartography entails changes, distinctions, and a degree of unpredictability in the evolving movements.

Figure 5. Example of performative cartography using Google Maps.

C. Interaction

Due to interactivity, interaction with digital objects occurs in new dimensions in addition to the physical movement of the device. Interactors' experience with the screen is shaped by their actions and perceptions - how they engage and comprehend. This dynamic establishes a two-way communication process between the interface and the interactors. The interactivity of a narrative experience is categorized [24] into four modes: cognitive, functional, explicit, and meta-interactivity. Cognitive Interactivity [24] involves revisiting a text that challenges previous understanding. Functional Interactivity pertains to physicality, usability, and Information Design. Explicit Interactivity examines user action within the interface and the interaction itself. Meta-interactivity explores engagement with the text beyond the immediate experience, such as discussing it with others.

Interaction can be understood through various categories outlined by [25], encompassing concepts such as dialogue, transmission, tool use, optimal behaviour, embodiment, experience, and control. Each concept offers a unique perspective on the relationship between product and human, shaping the poetics of use and meaning within the screen space.

The interface engages in a dialogue with interactors, aiming for a seamless conversation where both parties understand how the interface functions and the responses they can provide. This mutual exchange underscores the importance of considering the mental model dimension in design.

Viewing interaction as a form of transmission requires a focus on the quality of the communication channel and the amount of information transmitted, with noise management being a crucial factor.

When interaction is seen as tool use [25], it influences how users interact with the system, emphasizing the mediation role of the interface and the user's engagement with the tool itself. This perspective requires considering the extension of the body and senses, as proposed by [26].

Optimal behaviour in interaction includes balancing performance and resource allocation (both human and technological) to achieve the best outcomes. Therefore, the time-space-statistical dimension [25] of the screen emerges.

Designing interaction as embodied requires situating its agents in a physical world. Reference [25] indicates that situating interaction involves intention, coupling, and context.

Conceiving interaction as experience means understanding how the interaction unfolds. It considers the technology's qualities and aesthetic, emotional, and holistic aspects, deepening the value attributed to the screen. Finally, the control in interaction design focuses on error management and system adjustments based on feedback to align actions with the desired outcomes.

As discussed in Section II-D, haptic interaction provides feedback through tactile sensations like vibration, enhancing accessibility. The advent of touch screens has introduced new interaction possibilities [14] eliminating the need for intermediary devices like a mouse and allowing for touch-based interactions that incorporate narrative elements, enriching the depth experience of the screen.

IV. THE MULTIDIMENSIONAL SCREEN MODEL

Reference [1] argued that the multidimensionality of the screen is an inherent characteristic of digital conceptualisation and introduced the screen dimensions framework. This framework examines the screen's dimensions through aesthetic, use and interaction lenses. (1) Aesthetics encompasses the graphic qualities of the interface, 3D representation, space as a medium, layers of information, movement and the design of information. (2) Use dimension comprises mobility and performative cartography. (3) Interaction is associated with narrative interactivity and the interaction concept itself.

Furthermore, the nature of the media involves remediation. Therefore, defining its poetics, including the screen dimension, is essential in creating new media. Section II outlines various design techniques that contribute to determining these poetics. This paper contributes to the screen dimension framework [1] by introducing design techniques tailored to each dimension (Figure 6).

The outcome expands the framework for the visual dimensions of the screen, which are structured around three

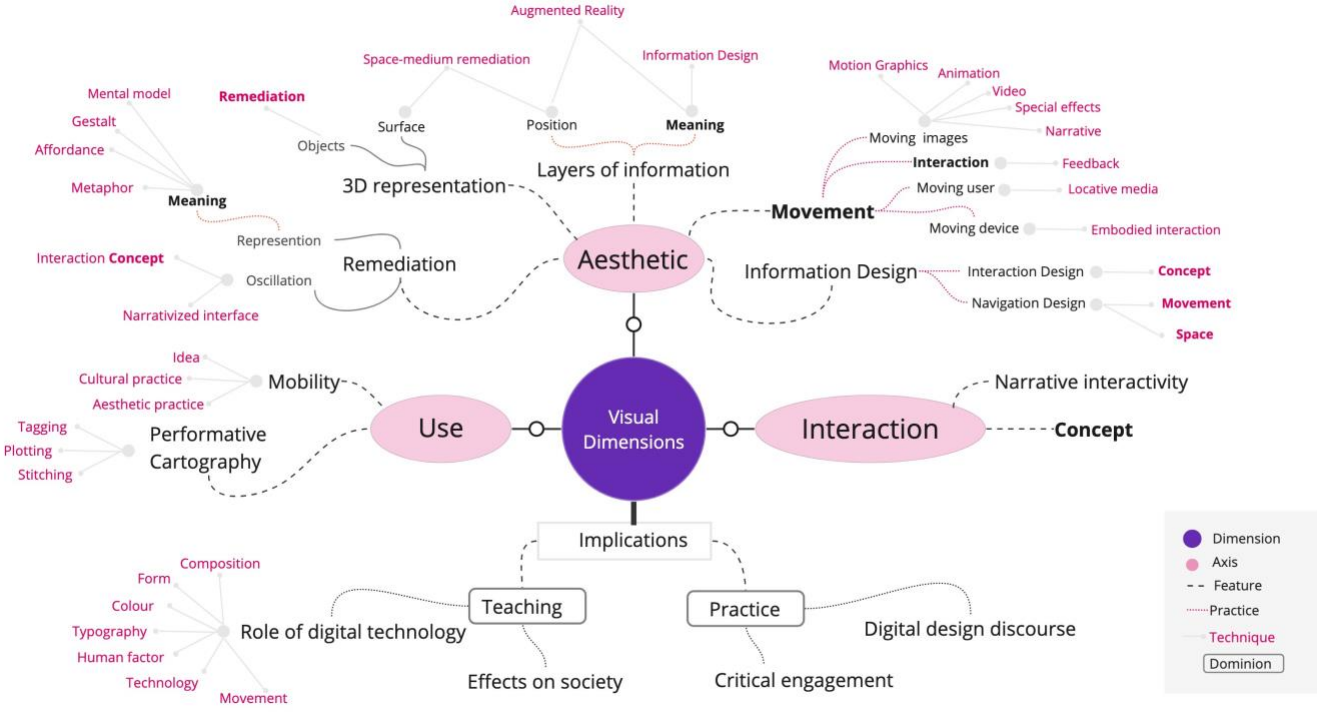

Figure 6. The expanded visual dimensions framework.

axes: aesthetics, use, and interaction. Subsequently, the paper discusses practices with qualities that strengthen the screen's multidimensionality. Lastly, it describes techniques to create a design capable of effectively representing these visual dimensions.

The close reading method was applied to establish a connection between the framework's elements and their respective realms. Several tables were created to compose a configuration that articulated the framework regarding the designer and the interactor realms. The final table highlighted elements such as narrative, remediation, interaction or movement in various configurations and positions. The dynamic interplay of these elements suggests three aspects of the screen's multidimensionality: space, meaning and performance.

Space encompasses the constituent elements of the interface and those linked to the materialisation of the design. Meaning pertains to the components contributing to the interactor's apprehension of the design. Finally, performance encompasses the aspects that manifest through the interactor's action. These aspects intersect, forming the axes of the visual dimension: aesthetic, use and interaction.

In this setup, aesthetics is situated at the intersection of space and meaning, as both aspects engage the senses. Use occurs at the intersection of meaning and performance, as it represents the realization of the artefact by the interactor. The

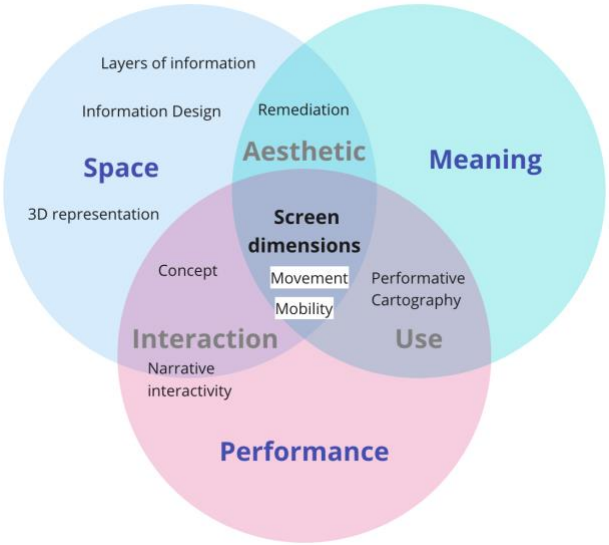

Figure 7. The multidimensional screen model.

artefact is fulfilled when it is put to use. Finally, interaction resides in the intersection between performance and space, where the materialisation becomes part of a dynamic reconfiguration with the interactor. Figure 7 shows the model

that accomplishes the three aspects of the multidimensional screen.

V. Discussion

The model establishes three aspects of screen multidimensionality: space, meaning and performance. These aspects are designed to enhance the experience of screen multidimensionality. The space aspect encompasses the dimensions crafted by the designer using various design features, making it a tangible construction within the realm of the designer. Space plays a crucial role in the experience of multidimensionality as it often draws upon the three-dimensional metaphor of physical space, a standard visualization tool. The performance aspect of the screen's multidimensionality is experienced through the active participation of the interactor. The interactors generate the interface through their interactions, completing the object and adding a dynamic element to the experience. Meaning, on the other hand, is attributed by the interactor to the object, especially when it delivers aesthetic and functional possibilities envisioned by the designer thus supporting the interactor's performance. The model suggests that performance and meaning are more abstract than space, given the intense involvement of the interactor. This participation underscores that space belongs to the designer's realm. At the same time, performance is the interactor's realm, and meaning emerges as a co-creation between the designer and the interactor.

Moreover, the model can be applied in teaching and practising design to explore screen dimensions [1] and their respective aspects, offering a structured approach to deepen understanding and analysis. Therefore, the model is a teaching and design tool for effectively creating and analysing projected dimensions.

A. Teaching practice

Understanding the multidimensionality of the screen requires responsible teaching of interface design. This starts with acknowledging digital technology as a customary element in our lives. This approach prompts critical questions about technology's role in society and everyday interactions.

Reference [1] proposed addressing these questions, focusing on seven axes of design: composition, form, colour, typography, human factors, technology, and movement. Each axis contributes to the artefact's role in daily life, and design education should emphasize their interconnections to channel their societal impact effectively.

Composition involves organizing elements within the design, and spatial understanding can be expanded through meaningful remediation techniques like narratives and imagery. Form explores representing information in various geometric or organic forms, such as images, photographs, graphics, or illustrations. The students could be motivated to try different forms to express the same information and articulate the final alternative in terms of dimension.

Colour delves into the dynamic representation of the light on the screen. Light is dynamic and complex as it presents millions of possibilities. Thus, screen depth can be creative using light. Students should be motivated to create simple solutions, with light as the only element.

Typography explores the variability of font characteristics to enhance communication.

Human factors consider that people will interact with the object and bring all their previous and expected experiences into the new one. Thus, design benefits from human sciences, such as psychology, sociology, and anthropology.

Technology serves as the object's medium, requiring designers to master its properties and qualities for harmonious, effective, efficient, and beautiful work. Thus, the screen's dimensions are expected to contribute to this harmony.

The movement has become an axis for digital design, given the principle of numerical representation, which supports time-based media. Furthermore, the movement has been studied through the persistence of vision, which has shaped Gestalt studies since its publication by Wertheimer in 1912 [27]. Or even as an evolutionary priority over the perception of forms [28], recognising danger was decisive for survival. The perception of movement is a fundamental aspect of vision; even micro-movements can attract attention. Therefore, movement, as one of the axes of design, emphasises the depth of the screen, as commented on in Section II-D.

Accordingly, to address the role of digital technology, design teaching could expose different contributions of the screen depending on the type of artefact in focus. For each axis, the design elements and their contribution to the role of the screen would be related. This construction promotes a critical position and develops the analytical skill of the designer. The three screen dimensions of Aesthetics, Use, and Interaction could elaborate on other issues raised in this paper.

The study of aesthetics enhances understanding of the interface, identifying it as an active mediator. An active medium requires viewing the interface as a dynamic entity oscillating between opacity and transparency. In addition, the elements of the interface support and react to the interactor's actions, providing information and feedback. Furthermore, teaching 3D modelling encourages abstract thinking about spatial dimensions on the screen and its objects.

Design education delves into layers of information by its very essence. Objects (type, form, and function), action (passive or interactive), hyperlinks in depth, design choices such as gamification and metaphors, or even behaviour, such as movement, shape this essence.

Motion often takes a back seat in design projects. Therefore, the crucial need for design education to emphasize its incorporation into projects is notorious.

Teaching movement requires considering time and space and favours narrative constitution. Teaching narrative as a poetics of design requires treating narrativization of the

interface, that is, treating the design elements as passive or active agents of the narrative. Concepts and elements of narrative will be revisited for this purpose.

Information Design is a consistent element in design projects, albeit assimilated into the specialities required in digital design, such as interaction design and navigation. Teaching digital Information Design underscores the interconnectedness and distinctions among these specialized areas. As seen in our brief description of the navigational aspects of the experience, there remains ample room to investigate the role of Information Design in the expressive and political outcomes that emerge from navigating informational spaces. An individual's identity within a specific context is intricately linked to their level of visibility, accessibility, and interaction. Instructing designers on what to permit or restrict in user terms forms the foundation of navigational interfaces.

The implications of dimensions in teaching about use and interaction lie in the recognition of mobility and performative cartography as requirements and properties of the object. Therefore, teaching can highlight such factors and discuss the axis of technology and its consequences on artefact's use, production, and creation.

The interaction dimension implies teaching interactivity through some biases such as narrative, embodied, and agency. These biases can broaden interaction treatment and incorporate new technology methods, presenting the potential for accessibility.

B. Design practice

In design practice, the multidimensional aspects of the screen shape a digital design discourse that emphasizes iterative and responsible construction and creation of artefacts. Designers engage with the space aspect through aesthetics and interaction, critically examining elements that enhance screen depth and their effect on reception by the interactor. This active and collaborative practice values diverse perspectives and knowledge sources, leading to innovative design solutions and systematic analysis processes.

The performance aspect identifies these two dimensions based on the active participation of the interactor. This performance clarifies the value of this participation, which can be understood as a project requirement and therefore, projectable.

Design practices are shaped by design methods. In the case of the Iterato method [23], the spatial aspect is materialised in the structure and sensory design phases but has been thought of since its conceptualisation. The screen dimensions are part of the artefact's design that constitutes, creates, materialises, and promotes the construction of meanings by the interactor. The aspect of meaning establishes this imbrication.

Overall, having a model for creating multidimensional screens provides visibility to these dimensions and requires a comprehensive understanding of the role and interactions between space, meaning, and performance in design and educational practices.

When confronted with existing models [29,30,31,32, 33], the Multidimensional Screen Model complements the knowledge framework for this practice. The complementation situates the design of the screen as the interconnection between the interactor's use, the design of aesthetics and the performance between the two. It also highlights the consequences of design teaching, which is rarely mentioned.

Reference [29] reviewed 45 articles focusing on the interface for mobile learning and identified four critical dimensions of the user interface: (a) design principles of mobile learning applications, (b) context of use, (c) hardware specifications, and (d) modelling language. The design principles refer to the craft of the interface, highlighting four elements: size of the elements, proximity, transition and minimalist design. The context of use centres on the design based on the users' context, especially their mobility. The hardware specifications require support collaborative work among users and adaptations to varying device screen sizes. The modelling language advocates for an object-oriented approach as the preferred modelling language for user interface design.

Reference [30] introduces a Schema that outlines the dimensions of the User-Product Experience. The schema, which underscores the interaction between concrete and abstract product dimensions, the user, the context of use and the temporality of the experience, is not just a theoretical construct. It is a practical tool based on user and product sensors and responses in a specific use context.

Reference [31] delves into the intricacies of designing augmented reality, highlighting the importance of human perception dimensions, product dimensions, context of use, and temporal factors. It underscores the need to separate geometric relationships (locales) from semantic relationships (contexts) for effective design. In virtual reality design, the focus shifts to examining input as semantic dimensions and virtual targets as dimensional outcomes, further illustrating the complexity of the design process [32].

Reference [33] creates a consumer experience using five dimensions organized into three categories. Effort and Usability: (1) browsing, searching, finding and (2) comprehending, consuming, interacting); Power and Usefulness: (3) creating meaningful content and interactions; Persuasion and Emotion: (4) responding to value — calls to action and (5) perception of brand.

Table I summarizes these models. Other references for designing interfaces focus on specific dimensions such as the cognitive load of the learner [34], cultural dimension [35], or personality dimension [36].

While these models acknowledge the key role of user, product and context properties in the experience (UX), the model's focus in this paper is not on UX itself but instead on the properties of the screen. This approach aims to enhance

TABLE I. PRODUCT AND USER EXPERIENCE MODELS

Authors	Focus	Dimensions	Features
(HAMZAH, PERSADA and HIDAYATULLAH, 2018)	Mobile learning applications	Design principles	Size Proximity Transition Minimalist design
		Context of use	Mobility
		Hardware specifications	Collaborative works Screen size
		Modelling language	Object-oriented approach
(BONGARD-BLANCHY and BOUCHARD, 2015)	Product design	Human perception	Physiological sensors Cognition and affect Percept-action loop
		Product	Sensors Functional behavioral Semantic sensorial properties
		Context of use	Situational Cultural Social dimensions
		Temporal dimension	Interaction sequences Long-term UX
(SCHMALSTIEG, FUHRMANN and HESINA, 2000)	Collaborative augmented reality	Geometric relationships (locales)	
		Semantic relationships (contexts)	
(YEO, KWOK, *et al.*, 2024) Metaphor-guided quadrant model	Virtual reality	Input dimensional semantics	2D-Dimensional Input 3D-Dimensional Input
		Dimensional outcomes	2D or Less 3D or More
(GODDARD, MCLEARY and GORNEY, 2008)	E-commerce	Browsing, searching, finding	Effort (Usability)
		Comprehending, consuming, interacting	
		Creating meaningful content and interactions	Power (Usefulness)
		Responding to value — calls to action	Persuasion (Emotion)
		Perception of brand	

understanding of the relationships between different dimensions and their potential impact on the user experience.

VI. CONCLUSION

Several researchers have examined the multidimensional nature of screens across various design axes, including composition, shapes, colour [37], typography [38], human factors [39], technology [40], and movement [41]. The emergence of virtual and augmented reality artefacts has stressed the need for research on other dimensions of the artefact [42].

Establishing the boundaries of different screen dimensions inspires investigations and draws attention to the complexity of the screen. This complexity goes far beyond the reach of this paper because it involves social, emotional, psychological, historiographic, and philosophical dimensions, among others.

This paper contributes to this field of research and practice by presenting a multidimensional screen model. The model locates the space, meaning and performance as aspects of the multidimensional screen experience. The design for this experience offered the aesthetic, use, and interaction dimensions of design techniques to support teaching and designing a screen that explores multidimensionality. Our experience teaching digital design pointed to great difficulty for students in giving depth to the screen. One issue is the visualisation of this depth. It is hoped the multidimensional screen model supports the visualisation and creation of these dimensions.

The taxonomy of these dimensions and their implications for user experience are promising avenues for future research, which the author intends to pursue. Further studies could explore the relationship between these dimensions and their impact on UX, providing a deeper understanding of the multidimensional screen model and its applications.

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