The Screen is not Flat

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***Abstract*— A characteristic of the digital interface is its multidimensionality. However, its design continues to be influenced by multiple remediations, mainly from printed media, which give the interface a flat surface, suppressing its communicative and interactive potential. Interface design has dealt with this problem fragmentedly, focusing on specific elements. For the students, there remains the need to visualize the blurred screen depth. This paper outlines the multidimensionality of the interface in terms of use and aesthetics. To this end, it draws the boundaries for the aesthetics of the screen and interaction dimensions, combining 30 years of experience teaching digital design with the current literature on the topic. The results establish design dimensions that contribute to understanding the interface's imagistic potential in terms of use and aesthetics. In addition, the results highlight some of the challenges to be addressed by designers.**

Keywords-screen; interface; design; remediation; dimensions.

I. INTRODUCTION

Our society is moving towards an intensive use of screens. This use began with screens of static images such as painting and photography, which framed a moment of the imagination. From there, it migrated to screens with moving images, such as cinema, which framed a period of the imagination. When the TV occupied an essential space in our homes, its screen demanded more hours of visual contact, as it became accessible as the paintings and photographs hanging on the wall and clamored for attention as the cinema. Between one screen and another, we learned to see, accept, and apprehend its images as technology.

According to [1], technology is a complex reality involving technological knowledge and a human attitude. As an attitude, technology becomes habitual, and it is believed to make our lives easier and contribute to our comfort.

The complexity of technology also occurs in the interface design teaching, either by facing technology in its manifestation (designing) or the craft of its poetics. Poetics constitute the principles of design that best define an object or work [2]. Remediation is a central poetic of the digital interface.

Remediation is the process of representing one media into another [3]. For example, a digital calendar is expected to simulate its printed form. The months follow a table form, and the days are presented by cells. Therefore, this paper suggests that understanding the screen as flat is a consequence of the remediation process.

For [3], remediation undergoes a 4-level evolution, where the representation of a new media moves further away from the media that precedes it. Therefore, we argue that each level is reached through understanding contemporary media and recognizing its language and properties, i.e., creating its poetics.

Another poetic of digital media is its multidimensionality, rooted in the principle of numerical representation [4]. This principle enables new dimensions using the artifact through multiple aesthetic expression and interaction forms.

The poetic of multidimensionality, investigated by [5], is established by the data density that [6] defines as the intense flow of information captured and sent by the interactor+artefact. Thus, the screen mediates this data density from visible, perceived, or social dimensions. This paper focuses on the visual dimensions because it is a reasonable first step to building the base to comprehend others. In addition, teaching poetics benefits from visualizing each dimension, as the students could design each one or even play with the interconnection among dimensions to create depth.

Therefore, we argue that the screen is not flat, as its depth develops through its many dimensions. This paper draws the boundaries for the aesthetics of the screen and interaction dimensions.

The method follows qualitative research, highlighting screen dimensions from the literature and dialoguing with teaching practice. This practice enabled many observations about students' difficulties in visualizing the screen dimensions.

The remainder of this paper is organized as follows. Section 2 and Section 3 present the background review of the aesthetic and interaction dimensions. Section 4 discusses its implication on interface design. Finally, Section 5 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, remediation, layers of information, movement, and Information Design (ID) are screen dimensions.

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A. *The screen interface remediation*

The interface can be understood as a mediating layer between the artifact 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 requires 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, [7] associates design with the interface. For the user, the interface links 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 artifact.

Reference [8] 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. 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 [3]. 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, [9] advocates the narrativization of the interface. Lessening the oscillation can be accomplished by (1) narrativized 'look and feel' of the interface, (2) behavioral mimic and behavioral 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 artifact, as all the imagery representation should reinforce the project concept. For instance, feedback could be presented as illustrations, reinforcing the adopted narrative.

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

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

Finally, data density can support the bridges and mixed-reality interfaces establishing digital and virtual connections. Augmented reality artifacts 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 by using interactors' information and capturing information from the environment. Locative media are examples of this dynamic.

Figure 1. Example of augmented reality artifact 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 in true 3D, which moves away from the printed media since this support requires a 2D representation. In this case, 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 to volume treatment.

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 [10], the digital space, as a remediation of the medium, expands the possibilities of interaction as it becomes a meaningful dimension.

The screen's shape implies a reduction in the treatment of a two-dimensional space. But examples, such as the Apple Watch® bring new possibilities when the screen is designed in its three-dimensional space (Figure 2). 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 center and decrease when approaching the edges.

The treatment of the surface in 3D enables new attention arrangements, given primarily by size and position.

Figure 2. Apple Watch Interface.

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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, color, and image.

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 [11].

AR is distinguished from a simple projection of a video onto a screen by considering the three characteristics that [11] 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 a certain degree of control to the interactor, given the dynamism of the composite image.

In the composition of AR, one can have several layers of information organized 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.

D. Movement

Movement is another screen dimension that can be understood on four approaches: moving objects, moving images, the movement of the interactor in space and navigation, or the movement of the device itself.

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. 3D object occupies the multidimensional space of the screen and offers many possibilities of representation. Just as the screen's surface allows it to be treated as a 3D surface, objects can also be designed with three dimensions.

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

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. Moving images is characteristic of media based on time, such as video, movies, or animation. These media are complex, translating narratives into different dimensions, such as time, space, or sequential images.

The interactor's movement occurs in physical space or/and on the screen, navigating among pages. As argued by [6] and [12], the former is supported by mobile technology with small screens. 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.

E. Information design (ID)

The design project also presents new dimensions because ID parallels interaction and navigation.

The layers intertwine various "designs" that increase the depth of the screen. The ID acts on the implications for the reception of the information that allows interaction and navigation. Thus, when creating a button to serve as an interaction element, the ID crafts the button to better inform about the possible action.

The Navigation Design presents the same dynamic, as it establishes a path among digital pages, while the Information Design delivers the best solutions to offer the way.

Therefore, it is considered that Navigation Design plans the possible paths; the Interaction Design proposes the mechanisms to allow the interactor to act upon the interface, while Information Design conceives these mechanisms.

III. USE AND INTERACTION DIMENSIONS

Mobility has intensified the use of digital objects. This property amplifies the concept of screen since the place of use needs to be within the covered reception area to transmit and receive data. The creation of the interface happens dynamically from the imbrication in receiving, treating, and providing the data, which is named performative cartography [12]. Thus, mobility and performative cartography become dimensions of screen use.

A. Mobility

Mobility, i.e., the use of digital products in different places, is supported by the technology of individual Internet access and the size of artifacts, such as smartphones and tablets, which enables their use while the interactor is on the move. Mobility has enabled data density, making space active by collecting data from interactors or delivering locative data and information. The screen has become a portal through which the information about the place is presented to the interactor. Locative media, such as games or apps, can create new dimensions of responsiveness provoked by space.

Reference [6] labeled this active space as augmented space and argued that this expansion should be seen as an idea or a

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cultural and aesthetic practice. This reconceptualization expands the creation possibilities, making the screen a complex space.

This complexity embraces the idea of constant monitoring, which goes unnoticed by the interactors. These two situations need to be faced as design domains. That is, monitoring is a fact, and it can be omitted or used by the digital artifact, which requires addressing it in the interface.

As a cultural practice, several objects integrate the work and leisure routine, such as ubiquitous computing, artificial intelligence, augmented reality, and wearables. Aesthetics accompanies this engineering but still disconnects from the presence of the interactor and its surroundings. In addition, these objects are still imagined alone, and thus, their ecology is not much considered. For instance, the IoT (Internet of Things) features could be integrated into the digital artifact design to improve the use of the data or functionalities.

These are some of the challenges to be thought of in the mobility dimension. These challenges are made explicit in the cultural practice of performative cartography.

B. Performative cartography

The double displacement of the individual in the physical environment and on the screen is known as "performative cartography" [12]. The interactor navigates the interface while the interface is formed. For example, the map in Google Maps is generated from the subject's position in space (Figure 3).

Thus, visualization and image construction co-occur in a creative process that [12] indicates is a 4D operation of a 3D space. To solve the representation dilemma, the author suggests that the 4th dimension would treat space-time instead of treating time. The argument that both time and space are revealed in use supports this suggestion. For this reason, performative cartography implies changes, differences, and a certain unpredictability of movement that forms.

Figure 3. Example of performative cartography using Google Maps.

C. Interaction

In addition to the device's movement, interaction with the digital object occurs in new dimensions because of interactivity. Considering that the interactors' experience with the screen occurs through actions and perceptions, that is, how they act and understand, a two-way communication process is established between the interface and the interactors. Thus, the interactivity of a narrative experience is discussed by [13] in 4 modes: cognitive, functional, explicit, and meta-interactivity. Cognitive Interactivity [13] relates to revisiting a text that conflicts with the previous understanding. Functional Interactivity deals with its physicality, usability, and Information Design. Explicit Interactivity examines the actions when using the interface, the interaction per se. And Meta-interactivity considers the involvement with the text outside the experience when the interactor talks about it.

Interaction can be interpreted through the categories pointed out by [14]. The authors list different concepts associated with interaction, such as dialogue, transmission, tool use, tool use, optimal behavior, embodiment, experience and control. Each concept conceives the relationship between product and human in a particular way. In this paper, all these concepts imply dimensions of the screen, as they establish poetics of use and meaning.

The interface establishes a conversation with the interactor through a dialog. It is expected to be a fluid conversation, either from the side of the interactors who understand how the interface works and what "response" they can send or from the side of the interface that also responds according to the interactors' emission. Therefore, it is likely that the mental model dimension of conversation is strongly considered in this design.

Interaction, as transmission, requires a design focused on the quality of the channel as it pays attention to the number of bits transmitted. In this case, the noise dimension becomes the most relevant.

For [14], interaction conceived as tool use has three implications: (1) the tool shapes how the interactor will act (focus on the task artifact); (2) the focus can be on the mediation value of the interface; (3) the focus falls on the use itself. Thus, looking at interaction as a tool requires a dimension of the extension of the body and senses, as proposed by [15].

When interaction is optimal behavior, there is a confrontation to establish the best result between performance and resources (both human and technological). Therefore, the time-space-statistical dimension [14] of the screen emerges.

Designing interaction as embodied requires situating its agents in a physical world. Reference [14] indicates that situating interaction involves intention, coupling, and context.

Conceiving interaction as experience means understanding how the interaction unfolds. It considers the qualities of the technology and not only the object's properties and turns to aesthetic, emotional, and completeness aspects. Therefore, the value dimension deepens the attribution and expectations regarding the screen. Finally, the concept of control highlights errors against an ideal, meaning the system adjusts actions following feedback.

IV. IMPLICATIONS OF THE DIMENSIONS

This paper argues that the multidimensionality of the screen is a property of digital media conceptualized in [6] principle of numerical representation. From this principle, the dimensions of the screen can be understood in the field of 1) Aesthetics, which involves the graphic qualities of the

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interface; 3D representation; space as a medium; layers of information; movement and the design of information, and 2) Use and Interaction, comprising at least mobility; performative cartography and interaction.

However, the new media's nature is the older media's remediation. Therefore, in order to form a new media, it is necessary to construct its poetics. Thus, determining the screen's dimensions can contribute to its definition and recognition of its language and properties. Once defined, the dimensions can be addressed in both the teaching and practice of design. Figure 4 summarizes the main findings.

A. Teaching design

Recognizing the multidimensionality of the screen implies responsible teaching of interface design. This responsibility lies in treating the various dimensions of the screen, starting with understanding digital technology as habitual. Therefore, this treatment suggests facing questions about the role of digital technology in everyday life, and its effect on society.

This paper proposes to address these questions focusing on the seven axes of design: composition, form, color, typography, human factors, technology, and movement. Therefore, to address the role of digital technology, design teaching could expose different contributions of the screen depending on the type of artifact 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 field of Aesthetics, Use, and Interaction could elaborate on other issues raised in this paper.

The teaching of Aesthetics develops the gaze towards the interface, i.e., recognizing the interface as an active mediating field. An active media requires treating the interface as a dynamic object oscillating between opaque and transparent. In addition, the elements of the interface support and respond to the actions of the interactor, delivering information and feedback. Furthermore, teaching 3D modeling promotes the abstract reasoning of thinking about the screen space and its objects in three dimensions.

Teaching design also explores layers of information by its nature. Objects (type, form, and function), action (passive or interactive), hyperlinks in depth, design choices such as gamification and metaphors, or even behavior, such as movement, shape this nature.

The movement remains on the periphery of design projects. Thus, the urgency of teaching design to promote its integration into projects is notorious.

Teaching movement requires building the ability to deal with time and space, favoring a narrative's constitution. Teaching narrative as a poetics of design requires treating the 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 constant in design projects, but it has been absorbed by the specialties required in digital design, such as interaction design and navigation. Teaching digital Information Design reinforces the intertwining and boundaries of these specialties.

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 the artifact'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.

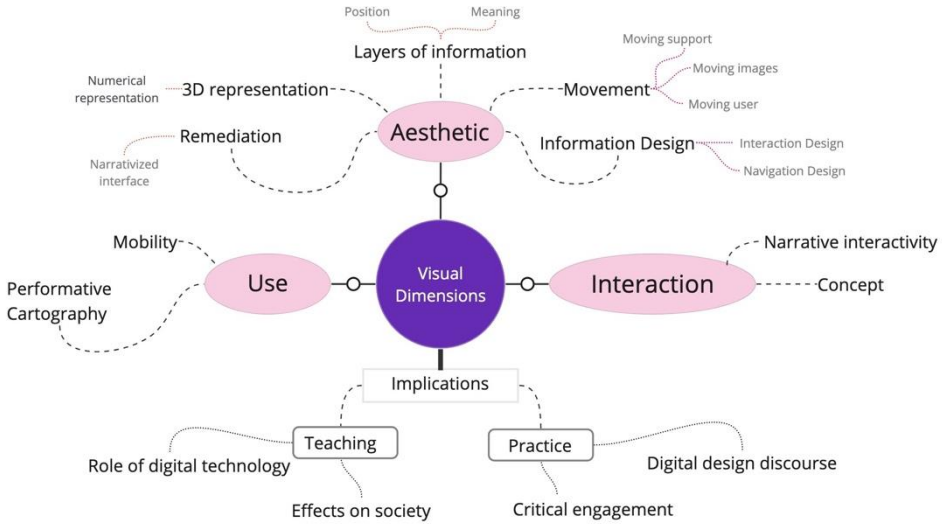

Figure 4. Visual dimensions and its implication in teaching and practice.

B. Design practice

The implications of dimensions in design practice are configured in a digital design discourse through the iterative and responsible construction and creation of artifacts that shape a cyber society. It is argued that facing the multidimensionality of the screen provokes thinking, recognizing, analyzing, and discussing interface design in its multifaceted practices.

The practice of the aesthetic dimension provides a critical engagement with the elements that contribute to the depth of the screen and its effect on reception by the interactor. It requires an active, managerial, collaborative practice that values the participation of multiple agents, human and non-human. It also requires encompassing various areas of knowledge as a source of ideas and inspiration, which can be realized in alternatives through the design method. It also allows systematizing iterative analysis processes and creating the dimensions of use and interaction.

V. CONCLUSION

The multidimensionality of the screen is a characteristic investigated by several researchers in the axes of design, such as composition, shapes, color [16], typography [17], human factors [18], technology [19], and movement [20]. The design of virtual and augmented reality artifacts has imposed the need for research on other dimensions of the artifact [21].

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 drawing interface dimensions in terms of use and aesthetics. Our experience teaching digital design pointed to great difficulty for students in giving depth to the screen. One issue is the lack of visualization of this depth. It is hoped that multidimensional interface design supports the visualization of these dimensions.

The taxonomy of these and other dimensions presented in the literature is left as future research. In addition, future research should develop each dimension regarding design techniques to support teaching and designing a screen that explores its multidimensionality. This work is currently ongoing by this researcher.

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