Empowering Online Learning: AI-Embedded Design Patterns for Enhanced Student and Educator Experiences in Virtual Worlds

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ABSTRACT

Desktop virtual world learning environments (DVWLEs) hold significant promise for the forefront of online learning platforms, offering noteworthy potential for widespread adoption. These environments are characterized by two distinct characteristics: a sense of place and a sense of presence, setting them apart from conventional online learning platforms. These unique characteristics of DVWLEs align their design more closely with the physical architectural design elements and principles (AEPs). In addition to AEPs, interaction design elements and principles through affordances and signifiers, play a pivotal role in shaping DVWLEs. However, there is a lack of comprehensive research on the integration of AEPs, interaction design elements and principles, and the design of affordances and signifiers, including their associated design patterns, in desktop VWLEs design.

Our research aims to bridge this knowledge gap by providing conceptual frameworks for categorizing AEPs, and interaction design elements and principles in DVWLEs design based on their affordances. We seek to identify and develop their common design patterns across various DVWLEs, with the goal of integrating them into an AI agent. This AI co-designer will empower educators to create customized educational environments tailored to their instructional needs. By simplifying and automating this process, our research aims to make the educational environment design more straightforward, streamlined and efficient for educators, thereby improving students' educational experiences.

CCS CONCEPTS

• **Human-centered computing** → **HCI theory, concepts and models**; • **Computing methodologies** → **Computer vision**; • **Information systems** → **Social networks**.

KEYWORDS

virtual worlds, virtual learning environments, interactive virtual environments, a sense of place, a sense of presence, metaphors, architectural design, interaction Design, affordances, signifiers, design principles, design patterns, AI design assistant, AI co-designer

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1 INTRODUCTION

The advancement of desktop virtual worlds learning environments (DVWLEs) is driving a paradigm shift in educational systems. These immersive, interactive virtual environments are reshaping how students interact with educators, fellow learners, and the educational content. The use of DVWLEs highlights the critical role of virtual environment interaction design as a significant factor, bringing together students' learning experiences and the design of DVWLEs. In most commonly used VWs in education, this interaction design contributes to crafting interactive virtual environments that serve as symbolic, schematic, and multi-sensory representations of physical world phenomena [4]. As argued by Rogers et al., these representations, in the form of metaphors, significantly influence the formation of students' mental models for using using virtual learning environments. Interface metaphors, such as the desktop metaphor, are integrated into the user interface, enabling students to interact with these representations through human-computer interfaces. Building upon that, virtual environments, provide students with additional two or three-dimensional spatial interaction affordances that create a sense of presence and a sense of place[25].

In creating the sense of place and sense of presence, Kalay and Marx argue that as the web evolves and adopts a more fully realized role as a space rather than a mere method of communication, there has been a rising need to design it using place-making conventions and principles rather than document-making ones [13]. These spatial characterises, and replicating the physical world phenomena, brings VWs design closer to physical architectural design. This suggests the importance of incorporating architectural elements and principles (AEPs) as metaphors in DVWLEs design, in addition to the interaction design elements [9].

Multiple VWs have been created to date, and many of them have been used by educators and educational organizations. Despite their initial acceptance, the popularity of the VWs began to wane in the 2010s. However, the emergence of COVID-19 in 2020 revitalized interest in real-time remote education and engagement [29]. Tools for real-time video conferencing, such as Zoom, and VWs, such as Gather.Town, were used to meet these essential needs during the lockdown and when in-person meetings or lessons were not feasible. Specifically, During that period, Zoom conferencing technology was widely utilized [24]. However, many Zoom users reported various deficiencies for instructional employment of this

tool, such as "Zoom fatigue," a lack of engagement, and a sense of void [16]. This prompted us to conduct a comparative study between a video conferencing virtual classroom conducted in Zoom and a VWs classroom in Gather.Town, and analyze the benefits and drawbacks of each tool. Our study revealed that the Gather.Town VWs provided students with a more engaging, meaningful, and interactive experience compared to Zoom [19].

The results acted as a catalyst for us to undertake a more in-depth investigation of the design aspects of available desktop VWLEs by reviewing the relevant literature. In this review, we excluded the literature pertaining to virtual reality (VR), as many of these virtual worlds are not easily accessible for average users without VR devices. Additionally, this technology is still grappling with numerous usability issues [26].

One of the findings of this literature review was that, despite the potential of VWs, elements of interactive spaces and spatial design within these environments often resulted in disorientation and confusion among students [5]. As the physical space doesn't exist in these VWLEs, "perceptual space" and "cognitive space" are existing spaces that manifest within the cognitive faculties of students. To a significant degree, the spatial characteristics of the studied VWLEs bore a similarity to those found in the design of real world places [2]. In the design of interactive spaces and students' interactions with and within the world, the architectural metaphors are employed in the VWLEs design through the incorporation of affordances and signifiers [12].

Several studies indicate that many of the inadequacies of VWs design are closely linked to flaws in the design of their affordances and signifiers [14, 17, 18, 23].

To address this gap, we have allocated portions of our ongoing research to outline and categorize the affordances related to integrated interaction design and AEPs in VWLEs. Notably, while affordances are generally similar across various VWLEs, the design of their corresponding signifiers often differs.

2 INTEGRATION OF INTERACTION DESIGN ELEMENTS AND PRINCIPLES AND AEPS IN DESKTOP VWLES DESIGN

Considering the importance of interaction design and AEPs in the design of DVWLEs, our research endeavors to identify the key interaction design elements and AEPs integrated into VWLE design. From a broad perspective, for the purpose of summarizing literature and categorizing the integration of these elements and principles based on DVWLEs affordances, we introduce a conceptual framework (Figure 1). In this framework, at a fundamental conceptual level, interaction design elements and principles, along with AEPs, are used to create a sense of place and presence within these environments. This is achieved through the design of affordances and signifiers of the world, virtual objects, and avatars.

2.1 Integration of interaction design elements and principles in desktop VWLEs design through Affordances and Signifiers

The design of immersive DVWLEs focuses on facilitating interactions to achieve a sense of place, presence, co-presence, agency,

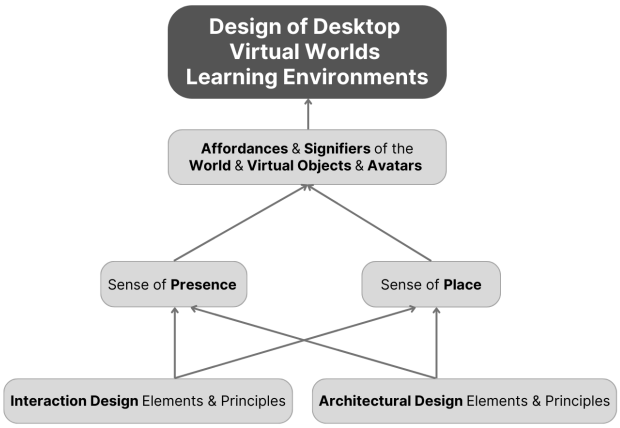

Figure 1: Framework for the Integration of Interaction Design and Architectural design elements and Principles for Designing VWs for Online Education

embodiment, belonging along with students' socialization and collaboration [22]. To provide an overview of students' potential interactions in DVWLEs, we present a framework (Figure 2). This framework organizes the interaction design elements of learning environments in DVWs. These interactions can be categorized in various ways, depending on the specific design objectives or techniques. In our research, we categorize DVWLEs interactions based on the affordances they provide students for their learning experiences.

Students' interactions in the DVWLEs, at the highest level, fall into three main classifications: interacting with the world, virtual objects, and avatars. The VW's interface (Figure 3), known as the world, encloses all features, content, and affordances of the virtual world, supporting students with a wide range of options within the virtual environments; such as affordances like chatting, broadcasting, navigating, or teleporting [20]. Since Desktop VWLEs are web-based, world features usually are affordances that are common on web platforms [15].

Interacting with virtual objects involves two types: One type is creating or modifying editable virtual objects, and the other type is interacting with existing objects that cannot be altered. Examples of unmodifiable existing objects include those with embedded course information or content, which instructors use or create to integrate handbooks, manuals, class PowerPoint presentations, or other instructional materials [3]. The example of an editable virtual object includes students' presentations or posters, which can be displayed in the virtual classroom and subsequently removed from the class settings if needed [21].

Another significant category of interactions in DVWs, is students interactions with avatars. Avatars enable students to engage with their virtual representations, giving them a sense of agency and allowing them to express their identity within the virtual realm [27]. Through affordances such as selecting gender, pronouns, alias, or

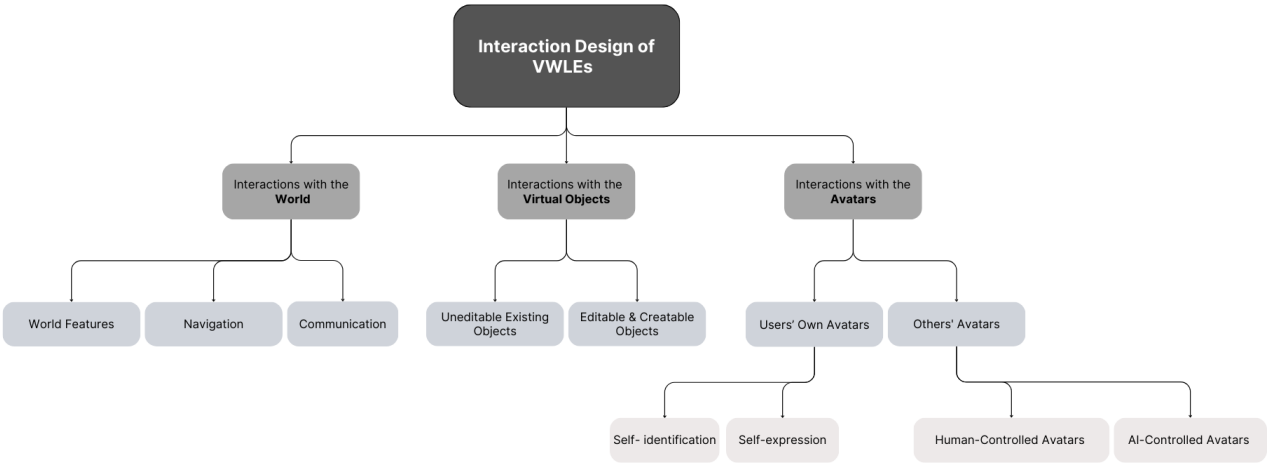

Figure 2: Framework for the Interaction Design of Desktop VWLEs

attire, students can personalize their avatars and express their self-identification. (Figure 4)[11]. Furthermore, many virtual worlds provide affordances for students to express their emotions or thoughts, such as raising a hand or clapping [1]. Apart from interacting with their own avatars, students can also engage with other human-controlled avatars, including those controlled by fellow students or instructors [10]. As artificial intelligence continues to advance, a novel form of interaction has emerged within DVWLEs, interaction with AI agents through AI-controlled avatars [30]. An example of these interactions is engaging with an AI teaching assistant that can guide, assist, and support students in their class materials, providing tutoring and answering their course-related questions [7].

Figure 3: The World Affordances in a Virtual Classroom in Gather.Town VWs

2.2 Integration of AEPs as metaphors in design of desktop VWLEs

Many virtual worlds replicate the architectural design of the physical world. However, in cases where virtual worlds deviate from this design approach, often are disorienting and challenging to navigate. In the absence of metaphorical signifiers from the physical world,

Figure 4: Expressing/Manifesting Self-identity by Selecting and Customizing Avatars in a Virbela Campus

users have limited cues to assist them in exploring and comprehending virtual environments[6]. In order to create immersive learning experiences that prevent learners from feeling disoriented or confused, it is crucial to explore the AEPs in the design of DVWLEs. To this end, We present a framework for categorizing the AEPs integration within DVWLEs (Figure 5). At a highly abstract level, AEPs can be categorized into three categories: physical, conceptual, and perceptual. Since virtual worlds lack physical components, physical elements and principles of architectural design, such as scale, mass, solids, or voids, are perceived or comprehended perceptually or cognitively. Thus, our research exclusively concentrated on the perceptual and conceptual AEPs.

In our research, we conducted an in-depth exploration of each category and identified several conceptual and perceptual AEPs. For instance, Figure 6 illustrates a framework for the conceptual AEPs. This framework includes conceptual AEPs that are already integrated or have the potential to be integrated into the DVWLEs design.

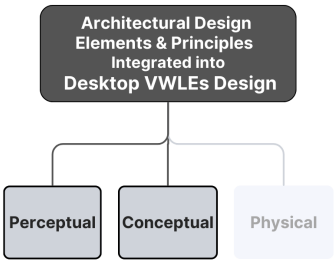

Figure 5: Framework of Main Categories of AEPs for Integration in Desktop VWLEs Design

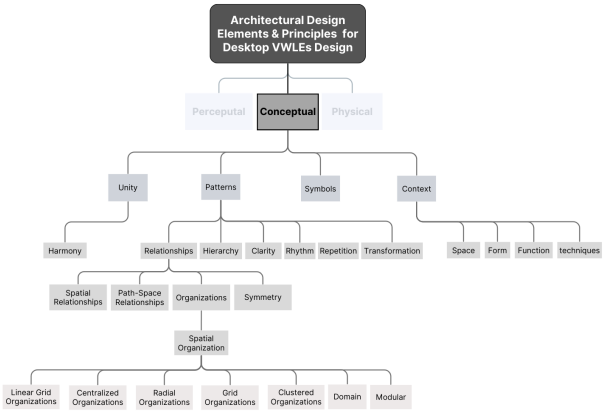

Figure 6: Framework of Conceptual AEPs Integrated or with the Potential for Integration in Desktop VWLEs Design"

3 CONCLUSION

The literature highlights two significant areas of influence in the design of DVWLEs: interaction design and architectural design elements and principles. The integration of elements and principles of these disciplines create a sense of place and a sense of place, setting VWLEs design apart from other web-based online learning platforms.

By integrating interaction design elements and principles, and replicating the design characteristics of real-world learning environments, VWLEs establish a familiar and meaningful educational context for learning. This familiarity and transformation of spaces into the meaningful virtual places such as virtual campuses or classrooms, enhance students' cognition, perception and engagement with the learning materials, environments and activities [8]. By promoting these senses through the design of affordances and signifiers, the design of VWs facilitates diverse and immersive modes of communication, collaboration, and social interactions among students and instructors. Consequently, students feel a sense of belonging, community, embodiment, ,ownership, agency and purpose within the virtual environments, which contribute to their academic success [28].

In our research, we noted a lack of comprehensive research on the design of affordances and signifiers and their design patterns by integration of AEPs metaphors and interaction design elements and principles in the DVWLEs design. The current literature provides instances of the design but does not include underlying design concepts and principles that could serve as a framework to guide the designers of DVWLEs.

To bridge the research gap, we have presented frameworks for categorizing the interaction design elements and AEPs. In our future work, we will:

- Outline all AEPs with the potential to improve VWs design.
- Identify design patterns in the design of affordances and signifiers across different VWs
- Develop design patterns of VWs design in three categories:
  - Design patterns based on AEPs that have been used successfully in VW design.
  - Design Patterns based on unapplied AEPs that have not been leveraged in these environments yet.
  - Design Patterns based on combining principles from both applied and unapplied categories.

REFERENCES

[1] Konstantinidis Andreas, Thrasyvoulos Tsiatsos, Theodouli Terzidou, and Andreas Pomportsis. 2010. Fostering collaborative learning in Second Life: Metaphors and affordances. *Computers & Education* 55, 2 (2010), 603–615.
[2] Mark W Bell. 2008. Toward a Definition of. *Journal For Virtual Worlds Research* 1, 1 (2008).
[3] Curtis J Bonk. 2002. *Online training in an online world.* CourseShare. com Bloomington, IN.
[4] Vassilis Bourdakis and Dimitrios Charitos. 1999. Virtual Environment Design–Defining a new direction for architectural education. *Virtual Site Planning* (1999), 403.
[5] Meredith Bricken. 1991. Virtual worlds: No interface to design. *Cyberspace: first steps* (1991), 29–38.
[6] Dace Campbell. 1995. Design in virtual environments using architectural metaphor. *New York* 64 (1995).
[7] Anna Comas-Quinn, Beatriz de los Arcos, and Raquel Mardomingo. 2012. Virtual learning environments (VLEs) for distance language learning: Shifting tutor roles in a contested space for interaction. *Computer Assisted Language Learning* 25, 2 (2012), 129–143.
[8] Barney Dalgarno and Mark JW Lee. 2010. What are the learning affordances of 3-D virtual environments? *British journal of educational technology* 41, 1 (2010), 10–32.
[9] Michele D Dickey. 2004. An architectural perspective for the design of educational virtual environments. *Journal of Visual Literacy* 24, 1 (2004), 49–66.
[10] Sue Gregory, Barney Dalgarno, Matthew Campbell, Torsten Reiners, Vicki Knox, and Yvonne Masters. 2011. Changing directions through VirtualPREX: engaging pre-service teachers in virtual professional experience. *ascilite 2011 changing demands, changing directions* (2011), 491–501.
[11] Agneta Gulz, Magnus Haake, and Betty Tärning. 2007. Visual gender and its motivational and cognitive effects–a user study. *Lund University Cognitive Studies* 137 (2007), 928–935.
[12] Remzi Ates Gürsimsek. 2014. Designing Virtual Worlds: Multimodality and Co-Creation of Meaningful Places in Multi-User Virtual Environments. *Online Journal of Art and Design* 2, 2 (2014).
[13] Yehuda E Kalay and John Marx. 2006. Architecture and the Internet: Designing places in cyberspace. *First Monday* (2006).
[14] Victor Kaptelinin. 2014. *Affordances and design.* interaction design foundation.
[15] Daniel Livingstone, Jeremy Kemp, and Edmund Edgar. 2008. From multi-user virtual environment to 3D virtual learning environment. *ALT-J* 16, 3 (2008), 139–150.
[16] Geert Lovink. 2020. The anatomy of Zoom fatigue. (2020).
[17] Saipunidzam Mahamad, Fasihah Mohammad Shuhaili, Suziah Sulaiman, Dayang Rohaya Awang Rambli, and Abdullateef Oluwagbemiga Balogun. 2022. Visual Signifier for Large Multi-Touch Display to Support Interaction in a Virtual Museum Interface. *Applied Sciences* 12, 21 (2022), 11191.
[18] Maria Malvela. 2016. Affordances and signifiers in virtual learning environment design. (2016).
[19] Nadia Najjar, Arghavan Ebrahimi, and Mary Lou Maher. 2022. A study of the student experience in video conferences and virtual worlds as a basis for designing the online learning experience. In *2022 IEEE Frontiers in Education Conference (FIE)*. IEEE, 1–8.
[20] Sofia Nteliopoulou. 2017. Using Virtual Worlds In Distance Education. (2017).

[21] Masataka Okutsu, Daniel DeLaurentis, Sean Brophy, and Jason Lambert. 2013. Teaching an aerospace engineering design course via virtual worlds: A comparative assessment of learning outcomes. *Computers & Education* 60, 1 (2013), 288–298.

[22] Danielle Oprean and Bimal Balakrishnan. 2020. From engagement to user experience: a theoretical perspective towards immersive learning. *Learner and user experience research* (2020).

[23] Lindy Orwin. 2011. *Affordances of virtual worlds for professional development conducted using action learning.* Ph. D. Dissertation. University of Southern Queensland.

[24] Jiyeon Park and Sooyun Sohn. 2023. Exploring Students' Experiences of Virtual Learning Environment for Art History Classroom. *Harmonia: Journal of Arts Research and Education* 23, 1 (2023), 105–120.

[25] Yvonne Rogers, Helen Sharp, and Jennifer Preece. 2023. *Interaction design: beyond human-computer interaction.* John Wiley & Sons.

[26] Matthew Schmidt and Noah Glaser. 2021. Investigating the usability and learner experience of a virtual reality adaptive skills intervention for adults with autism spectrum disorder. *Educational Technology Research and Development* 69, 3 (2021), 1665–1699.

[27] Ulrike Schultze. 2011. The avatar as sociomaterial entanglement: a performative perspective on identity, agency and world-making in virtual worlds. (2011).

[28] Ya-Chun Shih and Mau-Tsuen Yang. 2008. A collaborative virtual environment for situated language learning using VEC3D. *Journal of Educational Technology & Society* 11, 1 (2008), 56–68.

[29] Ph D SHIMA TABATABAI. 2020. COVID-19 impact and virtual medical education. *Journal of advances in medical education & professionalism* 8, 3 (2020), 140.

[30] Iskander Umarov and Maxim Mozgovoy. 2012. Believable and effective AI agents in virtual worlds: Current state and future perspectives. *International Journal of Gaming and Computer-Mediated Simulations (IJGCMS)* 4, 2 (2012), 37–59.

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