Designing Presence and Place: A Framework for Engaging Student Interaction in Desktop Virtual World Learning Environments

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***Abstract*—This research full paper describes a conceptual framework for classifying the interaction design of immersive Desktop Virtual Worlds Learning Environments (DVWLEs). The increasing affordability of internet bandwidth and computer graphics processing power is making DVWLEs a promising option for next-generation online learning platforms. These environments offer advantages for widespread adoption, particularly for learners and institutions lacking access to expensive Virtual Reality (VR) hardware and devices. DVWLEs facilitate immersive learning experiences through interactive simulations, 3D modeling, and real-time spatial collaboration across various engineering and computing disciplines. Unlike traditional online platforms that rely primarily on text, images, and videos, DVWLEs leverage the power of 3D spatial characteristics to create a more tangible and interactive learning environment, potentially leading to enhanced understanding, knowledge retention, and increased student engagement. Research suggests that two fundamental characteristics differentiate DVWLEs from conventional online platforms and significantly impact student learning: a sense of place and a sense of presence. A sense of place refers to the feeling of being located within a meaningful space, while a sense of presence conveys the feeling of being truly "there" within the virtual world. These characteristics effectively promote spatial and immersive active learning. The framework builds upon these core characteristics, categorizing student interactions within DVWLEs based on the affordances (potential actions) provided by the virtual worlds. The elements and principles of interaction design, including affordances and signifiers (visual cues), are crucial in shaping the effectiveness of DVWLEs. Studies consistently show that poorly designed interactions within DVWLEs can lead to usability issues and unsatisfactory student experiences. Using successful examples from existing DVWLEs, this framework offers educators guidelines for creating virtual classrooms. By enhancing interaction design to cultivate a strong sense of space and presence, educators can access the full potential of DVWLEs, leading to more engaging, immersive, and effective learning experiences that cater to a broad range of learners and educational disciplines.**

***Index Terms*—online learning, learning environments, virtual classrooms, desktop virtual worlds, student experiences, interaction design, framework, affordances, signifiers, a sense of place, a sense of presence**

I. Introduction

Captivated by the prospect of crafting their ultimate world and facilitating immediate connection, humans have constructed tools to fulfill these aspirations; one such innovation is virtual worlds (VWs). This technological advancement has catalyzed a transformation within human social and educational systems. Within educational systems, this rapidly evolving technological landscape has shown a paradigm shift, reshaping how students experience and interact with educators, fellow peers, educational environments, content, and acquire knowledge. This transformation is facilitated by creating a sense of place and a sense of presence for students within VWs [1].

The concept of virtual environment interaction design has emerged as a critical focus for the user experience, coordinating the convergence of desired student experiences and the design of VWs. To enhance these learning experiences in desktop VW learning environments (DVWLEs) and promote their use and adoption, researchers have emphasized the importance of designing them so that they are interactive, familiar, usable, accessible and capable of providing an engaging educational experience for all students [2, 3].

The use and adoption of virtual places implies where, what, and how students learn. In some ways, this approach is similar to how designers design physical spaces to reflect the demand for space multi-usage. In this case, online learning becomes not only about transferring and delivering information and knowledge, but also about designing experiences and context for educational activities [4]. In the field of DVWLEs, there is a shift from developing learning content to building whole learning experiences based on exploratory and experiential learning paradigms rather thank only knowledge- or lecture-based approaches [5].

The growing emphasis on facilitating seamless learning experiences that exceed the boundaries of real, virtual, or imagined spaces poses challenges for educators. They are expected to curate efficient class interactions and learning contexts that provide satisfactory educational outcomes for students. Many educators have been hesitant to adopt VWLEs as educational tools due to concerns about the challenges of building and customizing these environments to meet their diverse pedagogical needs and facilitate class interactions.

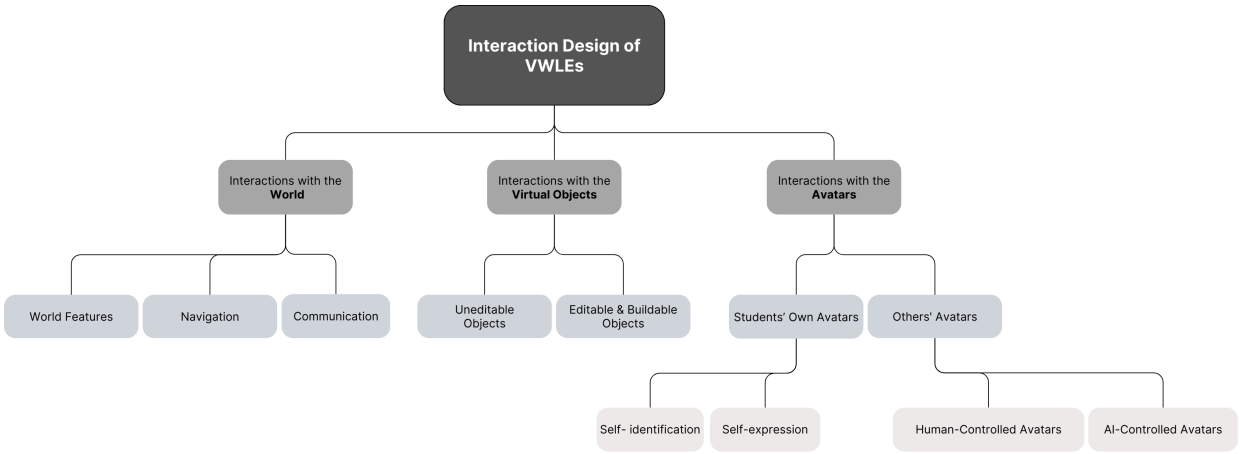


Fig. 1: Framework for the Interaction Design of Desktop Virtual World Learning Environments

Additionally, some educators have found it difficult to navigate the complex design of VWLEs, making it challenging for them to effectively use these tools [6].

The COVID-19 pandemic has particularly highlighted the importance of this issue. The unexpected COVID-19 pandemic forced educational institutions to migrate to fully online learning [7]. This crisis revitalized the need for virtual learning opportunities [8]. However, during that time, it became apparent that students were not satisfied with their online learning experiences. For instance, studies indicated that during lockdown, virtual classrooms were not well received by students [9]. However, the pandemic has provided motivation for adopting and improving VWLE design. It raised awareness about deficiencies in online technologies, including VWs.

To address these challenges, this research paper develops and describes an ontological framework for interaction design in virtual world learning environments. To guide our study, we focus on two key research questions:

1) What are the primary artifacts of interaction in virtual worlds?
2) What are the guiding principles for interacting with these artifacts?

In an effort to find answers to these questions and achieve our research objective, we developed a framework (Fig. 1) that provides insights into the design of VWLEs. This framework systematically organizes the complex interactions inherent in DVWLEs, to acknowledge the many difficulties educators encounter teaching in DVWLEs, and the crucial role that interaction design plays in shaping students' learning experiences; thereby assisting instructors as they build and modify their own DVWLE. This framework also serves to provide an overview of potential student interactions within the DVWLEs. We focus on desktop VWLEs because a significant number of students worldwide cannot afford virtual reality headsets, and access to desktop VWLEs is more feasible for them.

Although these interactions can be categorized in different ways based on the specific design or research objectives or techniques used, this paper categorizes them based on the affordances they provide students and educators. To illustrate each concept and element, we present examples of affordances and signifiers in different DVWLEs.

This framework represents the key contribution of this paper. It provides a structured approach for building and designing effective DVWLEs, guiding educators in understanding interactions within DVWLEs. By systematically organizing the intricate interactions of DVWLEs, it enables the identification of areas that can be improved and facilitates the implementation of customized targeted design strategies customized for creating specific virtual learning environments.

II. BACKGROUND

This section provides definitions of key terminology for VWs and online learning environments, as well as a brief overview of interaction types and modalities of DVWLEs. VWs are shared, multi-user, self-contained, and persistent virtual environments [10]. Since they resemble the physical world environments, they create a sense of place and presence for users [11]. A sense of place refers to an individual's cognition, perceptions, usage, and interactions with the places they occupy. A sense of presence is a feeling of agency, active engagement, or participation [12]. These unique characteristics of DVWLEs distinguish them from other online learning platforms. They have the inherent potential to improve students' learning experiences, outcomes, and overall success [13, 14].

Traditional online educational techniques have primarily focused on textually-centered interactions with students and dialogue approaches with instructors as strategies for knowledge transfer. In contrast, immersive DVWLEs provide a sense of place and presence, offer tailored and customized learning experiences, develop learner empowerment through increased involvement and engagement, and allow for more sophisticated interactions [15].

The research findings also revealed a notable relationship between place and presence, co-presence, and social presence. Notably, social presence appeared to have the most significant influence on student experiences. These findings provide valuable insights into the influential factors that influence the

success of VWLE design to enhance students' experience and engagement [16].

The concept of "being there" despite physical separation has captivated practitioners and academics since the advent of distance education over 150 years ago, when mid-nineteenth-century English students received courses through the Royal Post. Technological advancements have progressed to a stage where students feel almost physically present in virtual classrooms (a sense of presence and place). This evolution necessitates further exploration of how virtual world designers and, subsequently, educators create a sense of place and presence and how students experience these sensations [17].

In creating a sense of place and presence through interaction design, intangible elements such as software, services, and students' emotions and cognitions intertwine with tangible components, shaping the educational experience through the design of digital space [18].

Within DVWLEs, interaction design shapes students' experiences through affordances and signifiers [19]. Norman [20] defines affordance as the perceived relationship between an object's properties and the user's capabilities that determines how the object can be used. The existence of affordances is contingent upon the characteristics of both the object and the agent [20]. Affordances are provided by various cues, known as signifiers [21].

Today, with the considerable advancement in this area, DVWLEs have progressed into the domain of immersive virtual environments, where the realism of the virtual environment creates a psychological state in which the students view themselves as autonomous agents with a sense of presence and co-presence with others within these virtual environments [22]. One of the purposes of replicating real-life learning spaces in VWs is to provide a familiar atmosphere and environment for students who are new to VWs or to relate to real-world expectations and mental models of students [23]. The representations of the physical worlds in the VWs function as metaphors, playing a central role in the students' conceptual model. The user interface instantiates interface metaphors, like the desktop metaphor, and allows students to interact with these representations through human-computer interfaces. Built upon that, virtual environments, provide students with further two- or three-dimensional spatial interaction experiences that create the illusion of being immersed in a world rather than viewing a static image [24]. Building a structured and meaningful interactive experience and navigation within DVWLEs necessitates the imposition of distinct forms and structures, similar to the physical world [25].

The interaction design framework developed by Rogers et al. distinguishes five types of interactions: conversing, instructing, manipulating, exploring, and responding [24]. In the field of DVWLEs design, instructing is the primary interaction type. The learners instruct the system by typing, clicking, a combination of function keys, or interactive elements such as buttons and menu choices. In addition, students' engagement in manipulating virtual objects or avatars, such as opening doors, holding goods, shutting containers, or putting objects, is considered instructing, as the interactions take place using a keyboard or a mouse. Similarly, students explore the virtual environment by navigating the virtual world using either arrow keys, WASD keys, or a mouse.

Regarding the interaction modalities of DVWLEs, these platforms primarily incorporate the WIMP (Windows, Icons, Menus, Pointer) interaction modality. They use the display screen as the primary output source, often supplemented by audio and video streaming. DVWLEs also provide multimedia interaction modality to efficiently support a wider range of students' activities in virtual classrooms through affordances and signifiers [26].

III. Framework for interaction design of DVWLEs

In this section, we present our developed framework (Fig.1) for interaction design of DVWLEs. This framework emerged from our comprehensive narrative literature review on the design of interaction affordances in DVWLEs. This framework involved systematically analyzing and synthesizing findings from various sources, allowing us to identify recurring artifacts, and guiding principles in the design of DVWLEs.

While other frameworks for interaction design exist in the literature, such as Rogers et al.'s [24] work mentioned previously, none specifically addresses desktop virtual worlds. These existing frameworks often remain at a higher level of abstraction, leaving a gap in the literature on the specialized guidance for virtual world environments. Our paper bridges this gap by introducing a framework tailored to interaction design in desktop VWLEs. This contribution offers educators and designers targeted insights for this unique domain, advancing beyond general interaction principles to address the specific needs of virtual world education.

In this framework, students' interactions in the DVWLEs, at the highest level, fall into three main classifications for interacting with primary artifacts, that is, the world, virtual objects, and avatars. The following subsections explore the guiding principles for each of these classifications of interaction design for DVWLEs in more detail.

A. Interaction with the World

The DVWLE interface, known as the world, encloses all features, content, and affordances of the virtual world, providing students with a wide range of interactions within virtual environments. These interactions include a wide range of affordances in three categories: interacting with the world features, communicating with others, and navigating through the DVWLEs. The following is a discussion of each subcategory.

1) Interaction with the World Features: Since DVWLEs are web-based, world features are usually affordances that are common on web platforms.

Considering the evolution of web development, this common area includes the transition from text-based environments to 2D graphical environments and further to 3D virtual environments, which includes the development of VWs [28]. Several VWs also have desktop application versions that may be downloaded and installed. One of the recommended

Fig. 2: The world affordances in a virtual classroom in Gather.Town VWs [27].

effective approaches to mastering VWLE features is to let students learn them as needed, emphasizing the importance of a contextual and on-demand learning process.

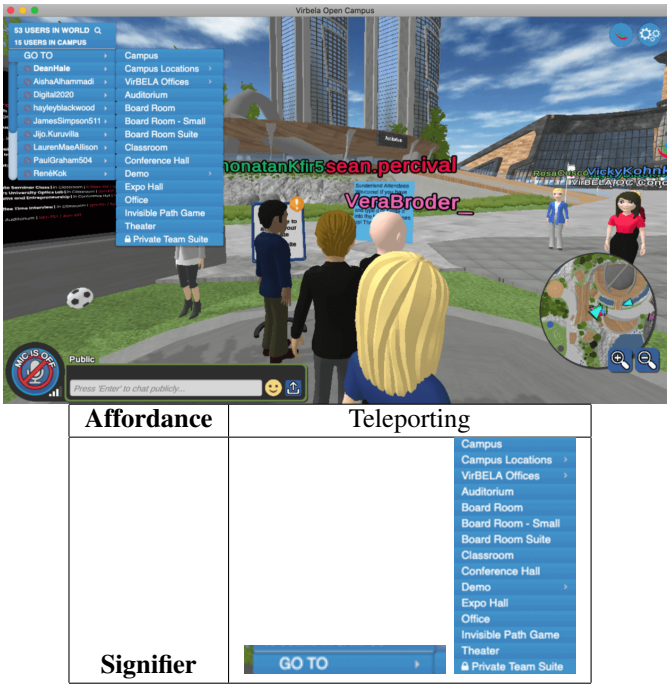
Fig. 2 provides a visual representation of affordances and their corresponding signifiers of the world in a virtual classroom on Gather.Town desktop VWs [27]. The figure depicts various icons that serve as signifiers for their pertained affordances. For instance, the gear icon represents the settings option, the chat bubbles icon signifies the affordance of chatting, and the microphone and camera icons signify the availability of audio and video chat affordances. Based on students' previous familiarity with these icons on the web platforms, these signifiers help students easily recognize and perceive the interaction affordances within the DVWLEs.

2) Navigation: In DVWLEs, students have the ability to navigate through virtual environments using avatars or through direct affordances within the world [29]. They can engage in various forms of navigation, including moving, climbing, walking, running, sliding, or even flying. The standard method of navigation in DVWLEs involves using WASD and arrow keys or a pointing device (e.g., a mouse) [30].

Teleportation is another navigation affordance that is widely available in DVWLEs. Students can instantly change their locations by teleporting to various destinations. This affordance saves students time by eliminating the need to move their avatars from one location to another on campus. For instance, students can teleport to specific classrooms or conference halls by selecting them from a list of available teleportation destinations.

Fig.3 shows the affordance of teleportation in Virbela VWs [31], where it is accessible through the menu on the left-hand side with a label signifier of "GO TO." Clicking on this option displays a list of available destinations, such as classrooms, conference halls, and auditoriums, to which students can teleport instantly.

3) Communication: By facilitating interactions to achieve a sense of co-presence, the design of immersive DVWLEs aims to enable socialization and collaboration [32]. In this regard, a crucial aspect of DVWLEs is to provide learners with the



Affordance	Teleporting
Signifier	GO TO

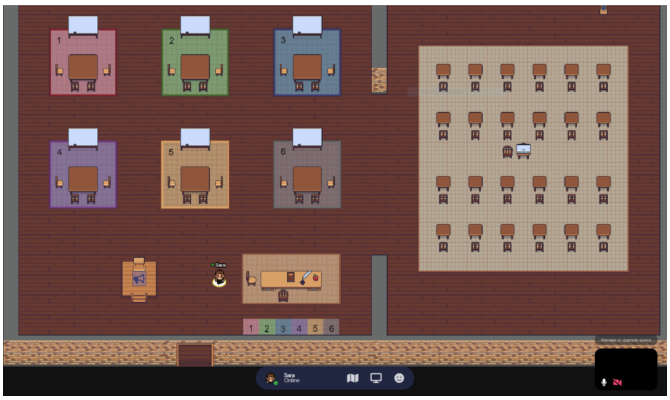
Fig. 3: Teleportation- A list of various destinations available to students to teleport to in a virtual campus in the Virbela virtual worlds[31].

means to interact with one another and with the instructional team. The ability to communicate forms the foundation for student collaboration. Exchanging ideas with peers is critical for the success of learning efforts, teamwork, and socialization objectives in a virtual classroom setting [33]. By employing the ability to communicate with others, students can better assess and share their acquired knowledge and engage in critical thinking about their education, ultimately elevating their learning experiences and outcomes.

Students can communicate with each other and engage in conversations using public or private audio or video chat affordances in DVWLEs [34]. In addition to the affordance of private text chat in the chat box, they provide spatial affordances for students working in teams, enabling private audio/video team chatting when their avatars are close to each other.

Rug or table areas in Gather.Town VWs [27] are examples of collaboration affordances (Fig.4). Numbered tables or rugs, along with chair object signifiers placed on rugs or around table areas, serve as signifiers of these private areas, where the team can hold discussions. The screens on the tables signify that students may share their screens for viewing by other team members. All of these affordances contribute to students' sense of co-presence and belonging as members of a team, thereby improving the overall experience of online team collaboration [35].

For courses like computer graphics or art classes, students can collaboratively create 3D objects, post their presentation



Affordance	Private audio/video group chat/ screen share
Signifier	

Fig. 4: Rug areas with table and chair signifiers indicating a private audio/video chat for team working in a virtual classroom in the Gather.Town virtual worlds [27].

posters on a virtual wall, or exhibit their digital artwork in a virtual on-campus gallery. Moreover, students may create and save note card objects in a folder object that they can attach to their team table or bookshelf object facilitating sharing them with their fellow teammates. Teams can archive the transcripts of their conversations to document group communications or provide records for team members who were unable to attend a group meeting. In Second Life [36], a tool called Machinima enables students to record the screen, further enhancing collaborations by capturing team activities for members who were unable to participate in real-time meetings but still wanted to contribute to team activities [37].

B. Virtual Objects

Two important features of desktop VWs are their affordances for building and editing learning environments. Desktop VWs provide instructors and students with the opportunity to build their own customized learning settings. These VWs offer a library of preset objects, including trees, walls, bookshelves, and various furniture objects such as interactive whiteboards, desks, and chairs, that can be combined, manipulated, and customized to build custom-made virtual learning environments, simulations, and objects.

Collaborative participation in creating virtual learning environments is another valuable aspect. Instructors and students can work together or independently to build and shape the environment according to their needs, preferences, and course objectives. This collaborative design process of virtual classroom settings empowers learners to externalize their knowledge and understand, cultivate a sense of ownership, and active engagement [29].

In terms of the modifiability of virtual objects, instructors have the flexibility to determine whether these objects should be editable or non-editable by students, depending on their pedagogical goals. For instance, instructors can set a virtual bookcase or object containing embedded textbooks as non-editable to preserve the embedded content. On the other hand, a virtual poster board can be configured to allow students to display their own posters, providing an opportunity for creative expression and customization. By enabling students to engage in edit mode and modify certain objects, virtual worlds promote active participation and personalization, enhancing the overall collaborative learning experience [2].

Fig.5 is an example of proximity-based interactive objects with embedded information that is not editable. By getting closer to the objects, a notification appears above the objects, signifying that the object encloses information, and by interacting with it, the information could be disclosed. The text notification signifier reads “Click here for the list of Spanish-speaking places” in Spanish. The Spanish text signifies that students who speak Spanish are the target audience for the embedded information.

In interacting with the editable virtual objects, customization and editing affordances of these objects are facilitated through the model window of each object. By right-clicking on an object, students can access the model dialog and make the desired modifications. Students can edit various aspects of virtual objects, such as their orientation, properties, and appearance characteristics. This includes affordances such as adding, copying, deleting, rotating, moving, rolling, and tilting objects. Students also gain additional interactive capabilities by using their avatars. They can directly manipulate objects by grabbing and moving them, giving a sense of control and agency [38]. Additionally, certain objects within the virtual environments can be linked to external websites, expanding the range of class resources available to students. This integration with external resources allows students to access additional course-related

Affordance	Accessing/disclosing embedded info in a non-editable interactive object
Signifier	- Floating notifications above objects signifies embedded information. -A spinning circle of stars around an object signifies it is interactive

Fig. 5: Interacting with a non-editable (for students) object to access its embedded information.

information, object models, and relevant materials in various formats [39]. This provision of relevant resources and immediate access to external information supports students in their learning process by delivering them valuable supplementary materials and diverse sources of knowledge [40].

C. Avatars

Avatars can serve as an endorsement or a means of enhancing engagement and agency, as well as conveying a sense of presence for students in virtual classrooms. They are also used for promoting key educational values and criteria that contribute to the students' academic success, including encouraging collaborative interactions, providing enjoyment value, offering customized self-identification and self-expression choices, and promoting inclusion in virtual classrooms. In addition to enhancing short-term memory retention, the visual component and the potential for real-time modifications through avatars also enhance students' individual and collective creativity [41].

Students exhibit diverse perceptions regarding the role of avatars in their learning experience. While some students consider avatars solely as tools for interaction with the DVWLEs and other students, others perceive them as extensions of their own selves. In any case, the impressions, expressions, gestures, and appearances of avatars serve as mediums to augment communication and engagement for students.

1) Students' Own Avatars: When students enter a world, they can choose their avatars from a library of avatars provided by that world [30]. They may switch between first-person (through their avatar's eyes) and third-person views of the surroundings (orthographic). In terms of viewpoints, the immersive VWs give first-person, egocentric experiences that leverage students' virtual movements (e.g., walking, running, head-turning, etc.) and convey a feeling of agency and embodiment [32, 42]. As avatars give students agency in the VWs, they can express their identity, thoughts, and emotions through them [43].

a) Self-Identification: Self-identification refers to awareness and acceptance of oneself, forming a distinct image relative to others, which is crucial for a person's sense of adequacy and ownership of their own identity [44].

Self-identification also refers to the feeling and experience of identifying with one's own body. In the DVWLEs, avatars serve as identification agents [45]. DVWLEs facilitate the customization of avatar appearance, attire, and user names, allowing students to establish a preferred identification with their chosen avatar representations, and, in this way, distinguish themselves from their peers. This personalization has an impact on their perceived sense of awareness and the presence of themselves and others.

In DVWLEs, students could present themselves by their preferred pronouns and names. No other student in the world may use this identity. Distinct identities help to establish accountability and trust [30].

Studies have shown that students can form empathic and powerful connections with their avatars. For instance, visual representation and appearance of avatars could stimulate or hinder students' cognitive processes, with potentially detrimental or beneficial results [46]. Additionally, the quality of a student's representation also affects their ability to effectively engage, collaborate, and communicate with others. Thus, the default affordances and options for avatar customization and personalization appear to have a significant impact on student learning experiences [47].

b) Self-Expression: Self-expression is the capacity to communicate one's feelings or intentions. Self-expression contributes to improving sociability and developing interpersonal skills. In other words, self-expression is one of the fundamental elements of socialization. One of the ultimate objectives of education is to enhance students' sociability; thus, one of the crucial personality features students need to develop in their education is how to express themselves [48]. However, despite the extensive research on this topic, educational institutions are often preoccupied with the cognitive components of learning and fail to encourage students' self-expression during class activities. Consequently, shy or introverted students who hesitate or are reluctant to speak up may experience a lack of confidence and social skills, and their negative outlook and behavior can impact their entire learning experience [49]. To mitigate these concerns, DVWLEs facilitate an "open culture," encouraging students' creativity and self-expression through their avatars [50].

To make it easier for self-expression, the first virtual environments only had text- or voice-based communication affordances. They didn't have avatars or nonverbal cues like body language and gestures, which made it harder for students to interact with each other. In recent advances, DVWLEs have provided affordances that allow students to express their emotions through gestural expressions of their avatars[51].

For example, Virbela [31] offers affordances for displaying gestures that signify thinking, confusion, impatience, dancing/joyful, or curiosity, simulating natural human gestures and facilitating faster and more easily perceived self-expression and enhanced communications (Fig.6).

On web-based platforms, the smiley face icon is also usually a signifier of a set of emoji expressions; these visual reactions signify that students can provide feedback and express their emotions or reactions using emoji signifiers more efficiently [52]. These emojis, which function as visual cues, convey different in-class gestures. For example, the "like" emoji represents agreement or approval of an opinion or request; the "question mark" emoji signifies that a student has a question about the discussion; or the "raised hand" emoji signifies a request to speak up.

2) Others' Avatars: In addition to interacting with their avatars, students in virtual environments also have the option to engage with avatars controlled by other individuals. We can classify these interactions into two subcategories: human-controlled avatars and AI-controlled avatars. Both types provide students with the opportunity to interact with a range of individuals or virtual characters within DVWLEs. These interactions facilitate socialization, collaboration, knowledge

Affordance	Displaying a gesture signifying the student is thinking(left) & confused (right)
Signifier	

Fig. 6: Expressing/manifesting self-identity by selecting and customizing avatars in Virbela virtual worlds [31].

sharing, and the development of interpersonal skills, contributing to interactive and relational learning experiences. In the following, we will present examples of affordances for these interactions.

a) Human-Controlled Avatars: These avatars include all avatars that are operated by human individuals, including students, instructional teams, and administrative personnel. Gather.Town [27] is one of the VWs that provides multiple such interactions. In Gather.Town [27], students can interact with other students' or instructors' avatars by right-clicking on them; this opens up a model window including a list of potential interaction affordances. For instance, for having a private conversation without a need to enter designated private chat areas, one interaction affordance is to put the other students' avatar in a chat bubble. This affordance enables students to engage in one-on-one discussions or exchange information privately.

Additionally, students have an option to follow other students' or instructional team's avatars by right-clicking on them or their user names in the list of in-world individuals and selecting the "Follow" option. This affordance enables students to keep track of specific individuals by automatically locating them and navigating in a virtual environment to get to them, creating a sense of connection.

So yet, there are a small number of such interactions; a contributing factor for this matter is maintaining students' autonomy and preventing its interruption by others. In future developments of DVWLEs, the design might incorporate additional interactions with other avatars, leading to enhanced collaborative benefits [53].

b) AI-Controlled Avatars: Interacting with AI agents is one of the emerging interactions that is expanding. Incorporating emerging interaction modalities and affordances into AI-controlled avatars is a growing trend in DVWLE design [54].

AI agents can communicate with human-controlled avatars in a variety of ways, including via text or speech [55]. A conversational agent is an autonomous system programmed to simulate human-like behavior and engage in conversations with humans to achieve specific tasks [56]. Specifically, with recent advances in LLMs, these intelligent avatars are designed to offer support, guidance, or assistance to users in virtual environments [57].

Furthermore, within educational environments, AI agents can seamlessly deliver automated services that closely resemble interactions with human-controlled avatars. They can serve as teaching assistants, offering responses to student queries, providing feedback on assignments, delivering instructional content, and facilitating simulations and learning activities [58].

IV. Discussion & Future Work

Desktop virtual world learning environments (DVWLEs) hold great promise for the next generation of learning settings. They offer a variety of features that are not available in other types of instructional tools and platforms. Distinctively, DVWLEs create a sense of place and presence. By promoting these senses, the design of DVWLEs enables varied and richer modes of communication, collaboration, and social interactions among students and instructors. Consequently, students feel a sense of curiosity, exploration, community, belonging, embodiment, ownership, and agency, which contribute to their academic success. Despite these advantages of DVWLEs, educators face many challenges in building or modifying learning environments due to their complex interaction design.

To support educators in addressing this significant challenge, in this paper, we presented an ontological framework for the design of DVWLEs, based on their affordances. In this framework, we recognized three primary artifacts: the world, virtual objects, and avatars (the first level in the framework diagram) with the guiding principles for interacting with these artifacts (the second and third levels).

While our framework is based on literature review and aligns with current educational practices in DVWLEs, it has a limitation: it has not yet been applied to guide future designs.

We partially evaluated the framework by applying it to analyze the interaction design of existing DVWLEs through the examples discussed in the section III. To further assess the framework's comprehensiveness and practical value, we will conduct interviews with educators experienced in teaching DVWLEs. This step will help us evaluate how well the framework aligns with their DVWLE experiences.

Furthermore, predicated on this framework, our future work aims to identify and define the design patterns of DVWLEs, with a particular focus on developing virtual worlds for educational purposes. These patterns will serve as a reference guide for designers and educators, providing a foundational framework for building immersive and effective learning environments within DVWLEs. We plan to develop patterns for

collaborative learning environments, lab-based digital simulations, and active learning scenarios. By establishing these design patterns, we aim to help instructors create improved collaborative and active learning experiences online, increasing engagement, and improving the overall educational experience in DVWLEs.

REFERENCES

[1] L. Rajasingham *et al.*, "Will mobile learning bring a paradigm shift in higher education?" *Education Research International*, vol. 2011, 2011.

[2] J. Shen and L. B. Eder, "Intentions to use virtual worlds for education," *Journal of Information Systems Education*, vol. 20, no. 2, p. 225, 2009.

[3] E. Palomäki *et al.*, "Applying 3d virtual worlds to higher education," Master's thesis, Teknillinen korkeakoulu, 2009.

[4] G. Siemens and P. Tittenberger, *Handbook of emerging technologies for learning*. University of Manitoba Canada, 2009.

[5] A. Schmeil, M. J. Eppler, and S. de Freitas, "A structured approach for designing collaboration experiences for virtual worlds," *Journal of the Association for Information Systems*, vol. 13, no. 10, p. 2, 2012.

[6] B. Attallah, "Post covid-19 higher education empowered by virtual worlds and applications," in *2020 Seventh International Conference on Information Technology Trends (ITT)*. IEEE, 2020, pp. 161–164.

[7] Z. Mseleku, "A literature review of e-learning and e-teaching in the era of covid-19 pandemic," 2020.

[8] N. Najjar, A. Ebrahimi, and M. L. Maher, "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, 2022, pp. 1–8.

[9] A. Sahbaz *et al.*, "Views and evaluations of university students about distance education during the covid-19 pandemic," *Educational Process: International Journal (EDUPIJ)*, vol. 9, no. 3, pp. 184–198, 2020.

[10] R. A. Bartle, *Designing virtual worlds*. New Riders, 2004.

[11] M. L. Maher, "Designing the virtual campus as a virtual world," 1999.

[12] V. Arora and D. Khazanchi, "Sense of place in virtual world learning environments: A conceptual exploration," 2010.

[13] L. Adler-Kassner, M. Safronova, Y. Dominguez-Whitehead, K. Gonzalez, S. Nguyen, M. Phommasa *et al.*, "Sense of place and belonging: Lessons from the pandemic," *Teaching and Learning Inquiry*, vol. 10, 2022.

[14] A. Ebrahimi, "Empowering online learning: Ai-embedded design patterns for enhanced student and educator experiences in virtual worlds," in *Companion Proceedings of the 2023 Conference on Interactive Surfaces and Spaces*, 2023, pp. 84–88.

[15] S. De Freitas, G. Rebolledo-Mendez, F. Liarokapis, G. Magoulas, and A. Poulovassilis, "Learning as immersive experiences: Using the four-dimensional framework for designing and evaluating immersive learning experiences in a virtual world," *British journal of educational technology*, vol. 41, no. 1, pp. 69–85, 2010.

[16] S. T. Bulu, "Place presence, social presence, co-presence, and satisfaction in virtual worlds," *Computers & Education*, vol. 58, no. 1, pp. 154–161, 2012.

[17] R. McKerlich, M. Riis, T. Anderson, and B. Eastman, "Student perceptions of teaching presence, social presence, and cognitive presence in a virtual world," 2011.

[18] S. Vosinakis and P. Koutsabasis, "Interaction design studio learning in virtual worlds," *Virtual Reality*, vol. 17, pp. 59–75, 2013.

[19] G. C. Smith, "What is interaction design," *Designing interactions*, pp. 8–19, 2007.

[20] D. Norman, *The design of everyday things: Revised and expanded edition*. Basic books, 2013.

[21] M. Malvela, "Affordances and signifiers in virtual learning environment design," 2016.

[22] J. Blascovich, "Social influence within immersive virtual environments," *The social life of avatars: Presence and interaction in shared virtual environments*, pp. 127–145, 2002.

[23] B. Reeves and C. Nass, "The media equation: How people treat computers, television, and new media like real people," *Cambridge, UK*, vol. 10, p. 236605, 1996.

[24] Y. Rogers, H. Sharp, and J. Preece, *Interaction design: beyond human-computer interaction*. John Wiley & Sons, 2023.

[25] V. Bourdakis and D. Charitos, "Virtual environment design–defining a new direction for architectural education," *Virtual Site Planning*, p. 403, 1999.

[26] S. Kumar, J. Chhugani, C. Kim, D. Kim, A. Nguyen, P. Dubey, C. Bienia, and Y. Kim, "Second life and the new generation of virtual worlds," *Computer*, vol. 41, no. 9, pp. 46–53, 2008.

[27] "Gather," https://www.gather.town/, n.d., accessed: [Insert access date here].

[28] D. Livingstone, J. Kemp, and E. Edgar, "From multi-user virtual environment to 3d virtual learning environment," *ALT-J*, vol. 16, no. 3, pp. 139–150, 2008.

[29] M. D. Dickey, "Teaching in 3d: Pedagogical affordances and constraints of 3d virtual worlds for synchronous distance learning," *Distance education*, vol. 24, no. 1, pp. 105–121, 2003.

[30] ——, "Brave new (interactive) worlds: A review of the design affordances and constraints of two 3d virtual worlds as interactive learning environments," *Interactive learning environments*, vol. 13, no. 1-2, pp. 121–137, 2005.

[31] "Virbela," https://www.virbela.com/, n.d., accessed: [Insert access date here].

[32] D. Oprean and B. Balakrishnan, "From engagement to user experience: a theoretical perspective towards im-

mersive learning," *Learner and user experience research*, 2020.

[33] F. M. Schaf, D. Müller, C. E. Pereira, and F. W. Bruns, "Computer supported collaborative social environment for education, training and work," *Remote Engineering and Virtual Instrumentation*, 2008.

[34] T. Kotsilieris and N. Dimopoulou, "The evolution of e-learning in the context of 3d virtual worlds," *Electronic Journal of e-Learning*, vol. 11, no. 2, pp. pp147–167, 2013.

[35] K. Andreas, T. Tsiatsos, T. Terzidou, and A. Pomportsis, "Fostering collaborative learning in second life: Metaphors and affordances," *Computers & Education*, vol. 55, no. 2, pp. 603–615, 2010.

[36] Linden Research, Inc., "Second life," https://secondlife.com/, n.d., accessed: [Insert access date here].

[37] R. Vernon, L. Lewis, and D. Lynch, "Virtual worlds and social work education: Potentials for "second life"," *Advances in Social Work*, vol. 10, no. 2, pp. 176–192, 2009.

[38] M. J. Callaghan, K. McCusker, J. L. Losada, J. Harkin, and S. Wilson, "Integrating virtual worlds & virtual learning environments for online education," in *2009 International IEEE Consumer Electronics Society's Games Innovations Conference*. IEEE, 2009, pp. 54–63.

[39] S. Warburton, "Second life in higher education: Assessing the potential for and the barriers to deploying virtual worlds in learning and teaching," *British journal of educational technology*, vol. 40, no. 3, pp. 414–426, 2009.

[40] H. Blake, F. Bermingham, G. Johnson, and A. Tabner, "Mitigating the psychological impact of covid-19 on healthcare workers: a digital learning package," *International journal of environmental research and public health*, vol. 17, no. 9, p. 2997, 2020.

[41] J. Díaz, C. Saldaña, and C. Avila, "Virtual world as a resource for hybrid education," *International Journal of Emerging Technologies in Learning (iJET)*, vol. 15, no. 15, pp. 94–109, 2020.

[42] M. J. Lee, S. Nikolic, P. J. Vial, C. H. Ritz, W. Li, and T. Goldfinch, "Enhancing project-based learning through student and industry engagement in a video-augmented 3-d virtual trade fair," *IEEE Transactions on Education*, vol. 59, no. 4, pp. 290–298, 2016.

[43] D. Zheng, "Caring in the dynamics of design and languaging: Exploring second language learning in 3d virtual spaces," *Language Sciences*, vol. 34, no. 5, pp. 543–558, 2012.

[44] E. Danilina, "Socio-cultural identification features student's identity in educational space."

[45] D. Romano, C. Pfeiffer, A. Maravita, and O. Blanke, "Illusory self-identification with an avatar reduces arousal responses to painful stimuli," *Behavioural brain research*, vol. 261, pp. 275–281, 2014.

[46] S. Nocchi, "The affordances of virtual worlds for language learning," Ph.D. dissertation, Dublin City University, 2017.

[47] M. Apostolos, K. Andreas, and T. Thrasyvoulos, "Collaboration in 3d collaborative virtual learning environments: Open source vs. proprietary solutions," in *2010 International Conference on Intelligent Networking and Collaborative Systems*. IEEE, 2010, pp. 124–131.

[48] M. Salam and M. S. Farooq, "Does sociability quality of web-based collaborative learning information system influence students' satisfaction and system usage?" *International Journal of Educational Technology in Higher Education*, vol. 17, no. 1, pp. 1–39, 2020.

[49] S. L. Bosacki, R. J. Coplan, L. Rose-Krasnor, and K. Hughes, "Elementary school teachers' reflections on shy children in the classroom," *Alberta Journal of Educational Research*, vol. 57, no. 3, pp. 273–287, 2011.

[50] K. Franceschi, R. M. Lee, S. H. Zanakis, and D. Hinds, "Engaging group e-learning in virtual worlds," *Journal of Management Information Systems*, vol. 26, no. 1, pp. 73–100, 2009.

[51] M. Bower, M. J. Lee, and B. Dalgarno, "Collaborative learning across physical and virtual worlds: Factors supporting and constraining learners in a blended reality environment," *British Journal of Educational Technology*, vol. 48, no. 2, pp. 407–430, 2017.

[52] T. Boutefara, L. Mahdaoui, and A. R. Ghomari, "Exploring the emotional aspect in learner's personal annotation colors," *Education and Information Technologies*, vol. 27, no. 5, pp. 6173–6195, 2022.

[53] R. Schroeder, *The social life of avatars: Presence and interaction in shared virtual environments*. Springer Science & Business Media, 2001.

[54] C. Kyrlitsias and D. Michael-Grigoriou, "Social interaction with agents and avatars in immersive virtual environments: A survey," *Frontiers in Virtual Reality*, vol. 2, p. 168, 2022.

[55] D. Griol, A. Sanchis, J. M. Molina, and Z. Callejas, "Developing enhanced conversational agents for social virtual worlds," *Neurocomputing*, vol. 354, pp. 27–40, 2019.

[56] S. Singh and H. Beniwal, "A survey on near-human conversational agents," *Journal of King Saud University-Computer and Information Sciences*, vol. 34, no. 10, pp. 8852–8866, 2022.

[57] V. Chheang, S. Sharmin, R. Márquez-Hernández, M. Patel, D. Rajasekaran, G. Caulfield, B. Kiafar, J. Li, P. Kullu, and R. L. Barmaki, "Towards anatomy education with generative ai-based virtual assistants in immersive virtual reality environments," in *2024 IEEE International Conference on Artificial Intelligence and eXtended and Virtual Reality (AIxVR)*. IEEE, 2024, pp. 21–30.

[58] F. Miao, W. Holmes, R. Huang, H. Zhang *et al.*, *AI and education: A guidance for policymakers*. UNESCO Publishing, 2021.