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PAPER

Navigating a 360-Degree Cued Virtual Classroom: A Case Study of Learner Behaviors and Experiences

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ABSTRACT

This study explores the navigation behaviors and learning experiences of six undergraduate and graduate students interacting with a 360-degree cued virtual classroom embedded within the learning management system canvas. Grounded in the cognitive theory of multimedia learning and signaling principles, the study employed a case study design. Data were collected through screen recordings, post-navigation surveys, and interviews. Findings revealed that learners predominantly engaged with front-facing cues, often missing those located in peripheral directions due to a lack of spatial navigation awareness. Prior experience with virtual reality (VR) and the type of instructional guidance influenced navigation effectiveness. While participants responded positively to the immersive format, several required additional training to fully explore the virtual environment. The study contributes to research on desktop-based VR integration in authentic online classroom contexts and offers practical insights for instructional designers developing 360-degree learning tools.

KEYWORDS

360-degree virtual classroom, desktop virtual reality (VR), navigation behavior, signaling principle, multimedia learning, canvas learning management systems (LMS)

1 INTRODUCTION

The rapid advancement of educational technologies has transformed how students engage with content, particularly in higher education. The COVID-19 pandemic accelerated the shift from in-person to online learning, heightening the need for instructional approaches that can replicate physical classroom experiences in digital formats. In courses requiring spatial or environmental immersion, such as health sciences, engineering, or horticulture, traditional lecture videos often fall short. In contrast, 360-degree virtual environments offer an immersive alternative that mimics real-world settings, enhancing context and learner engagement [1].

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A 360-degree desktop virtual learning environment allows learners to explore educational content using a computer or laptop. Navigation typically involves dragging and dropping or clicking a mouse to view content across different perspectives. This dynamic format supports interactive learning by encouraging students to uncover information situated in various directions—front, side, behind, or below—rather than only what's directly in view. Applications of 360-degree content in higher education include training simulations for emergency response [2], virtual lab tours, and enhancing intercultural competency in language courses [3].

Despite these promising uses, limited research has investigated how students interact with such environments, specifically, their navigation behaviors and experiences within 360-degree platforms embedded in learning management systems (LMS) such as canvas. Studies [4, 5] have examined user attention patterns using tools such as saliency mapping or head tracking, showing that learners tend to focus on specific zones within the visual field (e.g., equatorial regions). Duanmu et al. found consistency in individual navigation behaviors across multiple 360-degree displays, suggesting habitual viewing patterns [6].

However, several challenges persist. First, visually rich environments may distract learners from key content, reducing instructional effectiveness. Without clear cues, students may miss important material, thereby weakening learning outcomes [7]. Second, unfamiliarity with 360-degree navigation tools—particularly drag-and-drop mechanics—can limit engagement. Finally, integrating these environments within course platforms such as canvas introduces usability and orientation challenges, especially for learners accustomed to traditional 2D content.

Signaling theory offers one promising avenue for addressing these issues. According to the signaling principle, adding cues to highlight essential information can reduce cognitive load and direct learner attention effectively [8]. Yet few studies have explored how signaling functions within classroom-based 360-degree virtual environments, especially when accessed via desktop systems.

To address these gaps, this case study investigates student navigation behaviors and user experiences in a 360-degree cued virtual horticulture classroom embedded within LMS canvas. Six undergraduate and graduate students participated in the study, which examined how they interacted with cued content and navigated spatially distributed information. This study contributes to the growing field of multimedia learning by extending signaling theory to desktop-based 360-degree virtual environments and offers instructional design insights for improving content delivery in post-pandemic higher education contexts.

2 LITERATURE REVIEW

This section defines virtual reality (VR), with a focus on desktop-based VR, and then reviews literature on signaling effects and factors influencing navigation behaviors in low-immersion VR learning environments.

2.1 Virtual reality and desktop-based virtual reality

The emergence of VR as an educational tool has prompted researchers to explore how to optimize learning through immersive technologies. VR is commonly

defined as a computer-generated simulation that blends real and imagined environments to provide interactive experiences [9]. Depending on the level of immersion and the interface used, VR systems can be categorized into high-immersion environments (e.g., head-mounted displays) and low-immersion environments (e.g., desktop-based VR). This study focuses on low-immersion VR, specifically 360-degree desktop-based environments that use standard computer monitors and mouse navigation [10].

2.2 Visual signaling in 360-degree desktop virtual reality

360-degree desktop VR environments allow learners to interact with educational content presented in all directions. This spatial richness, while immersive, introduces cognitive demands—learners must choose where to focus, and non-essential visual elements may detract from key information. Signaling, or cueing, has been widely studied as a strategy to enhance learner focus by directing attention to critical elements in multimedia environments [8, 11].

Early studies on signaling in low-immersion VR found promising results. For instance, Nadolny et al. demonstrated that visual cues did not increase cognitive overload; rather, they enhanced engagement in a 360-degree learning experience [12]. Other researchers [13, 14] have emphasized the need for studying signaling within authentic educational settings, rather than controlled laboratory environments, to better understand its impact on learning.

2.3 Factors influencing navigation behaviors

Navigation in VR is shaped by the cognitive ability to construct and apply a mental map of the learning environment [15]. Navigation strategies can vary based on the learner, the content, and the nature of the virtual space. Researchers distinguish between active navigation (which involves physical movement) and passive navigation (which involves visual exploration without physical interaction). This study focuses on passive navigation, where learners use a mouse to drag, drop, and click within a virtual space [16].

Several key factors influence navigation behavior in 360-degree environments: (1) Training and familiarity: Users with prior exposure to VR environments tend to navigate more efficiently, using shorter paths and spending less time locating content [17]. (2) Consistent navigation preferences: Individuals exhibit stable patterns in how they explore VR spaces. For example, users who begin with rapid exploration often continue at that pace across scenes, and those who miss cues in one scene tend to miss them in others [6]. (3) Content characteristics: The nature of the visual content influences navigation. High-action scenes (e.g., rollercoasters) prompt focused viewing, while slower-paced content (e.g., time-lapse videos) encourages broader exploration. (4) Working memory and attention: Effective navigation relies on spatial and verbal working memory. Learners who allocate focused attention are more likely to engage meaningfully with the environment [18]. In sum, navigation behaviors in desktop VR are influenced by a combination of prior experience, content design, cognitive load, and instructional support. Understanding these dynamics is crucial for optimizing the design of 360-degree virtual learning environments.

3 THEORETICAL FRAMEWORK

This study is grounded in the cognitive theory of multimedia learning (CTML) and the signaling principle. Together, these frameworks explain how learners process and retain information presented in multimedia environments and provide a basis for designing more effective virtual learning experiences.

3.1 Cognitive theory of multimedia learning

Cognitive theory of multimedia learning posits that meaningful learning occurs when individuals actively engage with instructional materials that combine verbal and visual elements [19]. Learners process information through dual channels—auditory and visual—and construct mental models via three cognitive processes: selecting relevant information, organizing it into coherent structures, and integrating it with prior knowledge [19]. However, working memory is limited in capacity. When learners are presented with too much information, particularly in immersive, visually rich environments such as 360-degree virtual classrooms, this capacity can be overwhelmed, impeding learning.

In 360-degree environments, information is distributed in all directions—front, back, sides, above, and below—requiring learners to actively navigate and filter relevant content. This adds a layer of complexity to cognitive processing, as learners must not only comprehend material but also locate it spatially within the virtual environment.

3.2 Signaling principle

To address these challenges, CTML incorporates the signaling principle, which suggests that learning improves when cues are added to highlight essential content in multimedia materials [19]. Signaling helps reduce cognitive load by drawing attention to relevant information, minimizing extraneous processing, and enabling learners to locate and process key elements more efficiently [20, 21].

Originally developed for 2D learning environments, signaling strategies have been shown to guide attention, improve knowledge organization, and support integration of new material. For instance, Mautone and Mayer demonstrated the effectiveness of text-based cues [22], while De Koning et al. outlined how visual signals can direct attention in animated content [23]. These benefits appear to depend on multiple factors, including cue type, presentation format, learner expertise, and instructional strategy [24, 25, 26].

Extending signaling to 360-degree virtual learning environments introduces new challenges. Much of the content may fall outside a learner's immediate visual field, requiring navigation for discovery. Instructional designers must, therefore, consider how best to guide learners through spatially dispersed content, selecting cue types that optimize attention and comprehension in a dynamic visual landscape. This study contributes to the limited but growing body of research that applies the signaling principle to immersive desktop-based virtual learning environments integrated into platforms such as canvas.

4 PURPOSE OF THE STUDY AND RESEARCH QUESTIONS

Grounded in the CTML and the signaling principle, this study aims to explore how learners interact with a cued 360-degree virtual classroom integrated into the canvas LMS. Specifically, the research focuses on low-immersion, desktop-based virtual environments, where navigation is guided by mouse-based interactions and content-specific visual cues. The dual goals of this study are (1) to investigate how signaling strategies can enhance learner engagement and comprehension in 360-degree environments within an authentic online classroom context and (2) to contribute to the growing body of literature on multimedia learning and instructional design in immersive educational technologies. To achieve these goals, the study addressed the following research questions (RQs):

RQ 1) Navigation behaviors: How did six undergraduate and graduate students navigate the 360-degree cued virtual horticulture classroom integrated into the LMS canvas?
RQ 2) Influencing factors: What factors influenced these students' navigation behaviors and routes within the virtual environment?
RQ 3) User experience: What were the students' general experiences navigating the 360-degree cued virtual classroom?

5 METHODS

5.1 Study design, context, and participants

This study employed a qualitative case study approach to explore learners' navigation behaviors and experiences in a 360-degree cued virtual classroom built within the canvas LMS. Case study design is widely used in education and social science research to provide rich, contextual insights into complex phenomena [27]. A total of six undergraduate and graduate students participated, with each case analyzed individually and comparatively within a shared digital environment. This study was approved by the institutional IRB, and all participant data were anonymized and securely stored.

The virtual classroom simulated the lab portion of a 300-level turf-grass Establishment and Management course at a Midwestern university located in a state where agriculture plays a central role in supporting the livelihoods of farmers. While lecture sections were delivered in hybrid formats, the lab required in-person attendance due to its hands-on nature. The 360-degree learning module was designed to replicate the lab experience for remote learners. Learning objectives included identifying turf-grass species and distinguishing between warm-and cool-season grasses.

The first author captured panoramic field images using a 360-degree camera and collaborated with course instructors to determine filming locations. Using an articulate storyline, interactive cues—text, images, and audio—were embedded into six panoramic scenes. The completed simulation was published as SCORM files and integrated into canvas, where students could navigate by dragging and clicking with a mouse in a desktop-based environment (see Figure 1).

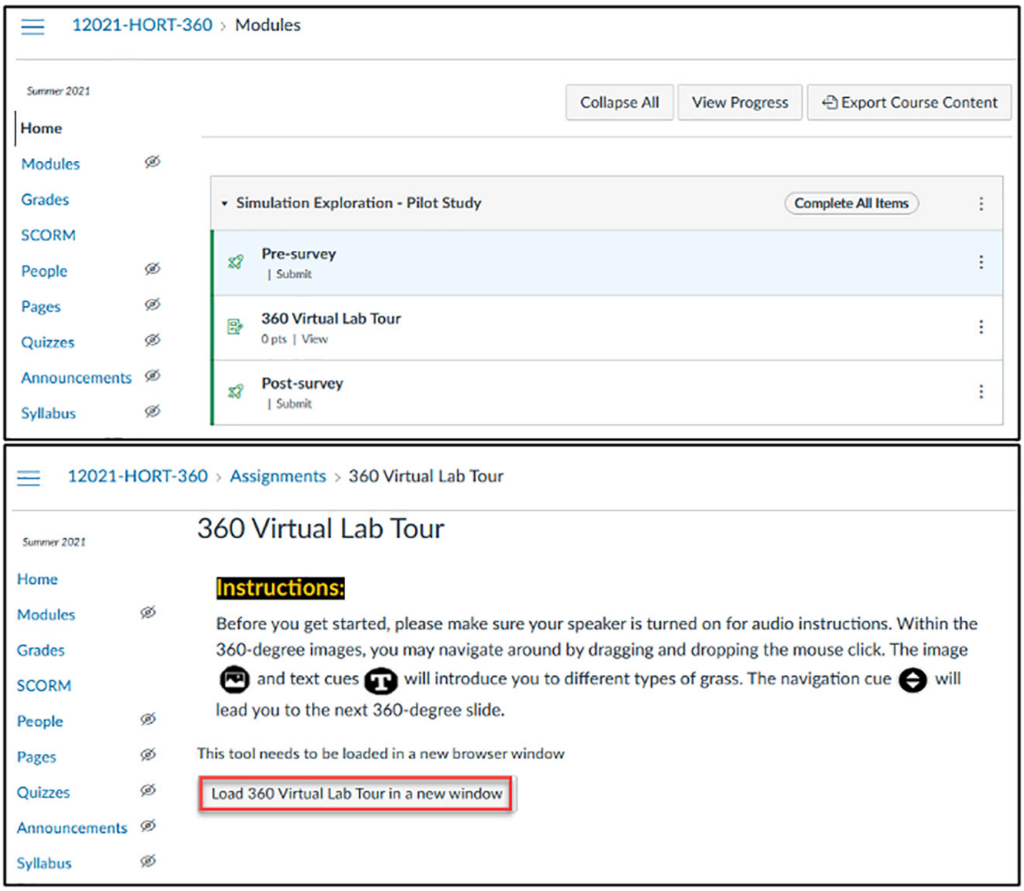

Fig. 1. Simulation access on canvas (Top) and simulation instruction (Bottom)

Six students (one undergraduate, five graduate) from diverse majors participated, including horticulture, education, HCI, and family studies (refer to Table 1). Three participants identified as white, two as Asian, and one as Hispanic. Five were highly familiar with canvas; however, most had limited or no prior experience with 360-degree learning. Participants received a $25 e-gift card upon completing the study.

Table 1. Participant demographic and background information from the pre-survey

	Fin	Anna	Ben	Claire	Dan	Ethan
Major	HORT	FSHD	HCI	HCI	EDUC	EDUC
Participants	Undergraduate	Graduate	Graduate	Graduate	Graduate	Graduate
Ethnicity	White	Asian	White	White	Hispanic	Asian
Age	18–23	Above 30	Above 30	Above 30	Above 30	Above 30
Familiarity with Canvas	Very familiar	Very familiar	Very familiar	Average	Very familiar	Very familiar
Familiarity with 360-degree learning	New	New	New	New	Average	Average

5.2 Data collection and analysis

Participants were recruited via departmental email lists and scheduled for 30-minute individual sessions conducted on Webex, a virtual conferencing platform.

During these sessions, participants accessed the canvas module, completed a pre-survey on their demographic background and familiarity with canvas/VR, and then shared their screen while interacting with the virtual simulation (see Figure 2). Each session was recorded to capture navigation behavior. Instructional support was embedded in the first scene through either audio-only or combined audio/text guidance.

Following the simulation, participants completed a post-experience survey consisting of both Likert-scale and open-ended items to assess their user experience. To enrich the data and clarify survey responses, follow-up interviews were conducted to gather deeper participant reflections.

Fig. 2. 360-degree learning landing map (Top) and cues 360-degree demo simulation (Bottom)

The simulation consisted of six 360-degree scenes with a total of 34 strategically placed content cues (including both text- and image-based cues) (refer to Table 2). These cues were distributed across various directions, requiring participants to drag

and explore the virtual space to access them, thereby simulating authentic interaction within a desktop VR learning environment. Screen recordings were analyzed frame-by-frame to track cue visits and directional navigation behaviors. These behavioral data were triangulated with survey and interview responses to develop a comprehensive understanding of participant interactions. Analysis focused on navigation routes, cue selection and misses, and participants' interpretations of their experience.

Table 2. Content cues information on 360-degree scenes

Names of the 360-Degree Scenes (Total Cues)	Types of Cues Used	Directions (A Total of 34)	Intended Navigation Behaviors
Scene 1: Field trip observation spot 1 (6)	Text cues (4); Image cues (2)	Front (2); Right (2); Back (1); Bottom (1)	Drag and drop the mouse, and click the mouse to navigate to the right, left, back, bottom of the 360-degree scenes.
Scene 2: Field trip observation spot 2 (4)	Text cues (2); Image cues (2)	Front (3); Back (1)	
Scene 3 Field trip observation spot 3 (4)	Text cues (3); Image cues (1)	Front (1); Right (1); Back (1); Left (1)	
Scene 4 Field trip observation spot 4 (6)	Text cues (3); Image cues (3)	Front (3); Right back (3);	
Scene 5 Field trip observation spot 5 (7)	Text cue (1); Image cues (6)	Front (2); Front right (1); Right (2); Back (1); Left (1);	
Scene 6 Field trip observation spot 6 (7)	Text cue (1); Image cues (6)	Front (3); Back (3); Bottom (1);	

5.3 Validity and reliability

To ensure reliability, cues were pre-coded and numbered for consistency. Triangulation was achieved through multiple data sources (screen recordings, surveys, and interviews), enhancing the credibility of findings. Anonymization protocols protected participant identities, and all data were securely stored.

6 FINDINGS

This study investigated how six undergraduate and graduate students navigated and experienced a 360-degree cued virtual horticulture classroom embedded within canvas, a widely used learning management system. Findings are organized by the three research questions.

6.1 RQ1: How did students navigate the 360-degree cued virtual classroom in canvas?

All six participants completed the full study. Across the six 360-degree scenes, a total of 34 content cues were embedded. Sixteen cues were positioned in the "front" field of view, requiring no navigation effort. The remaining 18 cues were distributed in other directions (back, right, right-back, bottom, left, and front-right), necessitating drag-and-drop navigation.

All participants accessed at least some front-facing cues. Two participants (33%) visited all 16 front cues, and the remaining four accessed most of them. However, directional cues requiring navigation were frequently missed. Front-right cues received the highest attention (67%), followed by left-side cues (58%). Cues at the bottom of the scene were most frequently overlooked (17%). Overall, participants

clicked on an average of 62% of the total cues (127 out of 204 possible cue interactions).

6.2 RQ2: What factors influenced navigation behavior?

Two primary factors were identified: prior experience with VR and the format of instructional guidance. Participants who had previous exposure to VR (e.g., Oculus Rift, HTC Vive, or Google Cardboard) demonstrated better navigation performance. For example, Ben (100% cue visits) and Fin (88%) navigated effectively, whereas Anna (38%)—who reported no VR familiarity—missed most directional cues despite receiving the same instructional guidance.

Instructional format also played a role. Claire, Dan, and Ethan received audio-only instructions, whereas others received combined audio and text. The data suggest that multimodal instructions better supported understanding of the navigation mechanics, particularly for participants with less VR experience.

6.3 RQ3: What were students' overall navigation experiences?

Post-survey and interview data provided insights into navigation experiences, awareness, and preferences: (1) Comfort and ease: Four participants (Ben, Fin, Dan, and Ethan) reported feeling comfortable navigating the environment. For some, the novelty added interest, though a few noted initial confusion even after reviewing instructions. (2) Perceived navigation directions: All six participants self-reported exploring left, right, and down. However, screen recordings indicated only 17% explored cues at the bottom, and just 50% navigated to the right, highlighting discrepancies between perceived and actual behaviors. (3) Cue completion: Only 33% believed they explored all cues before advancing to the next scene. Behavioral data showed that only one participant (Ben) actually did so. The rest either missed cues or were unaware of missed opportunities. (4) Navigation preferences: Most participants (67%) preferred a hybrid model—combining guided navigation and free exploration. Only one preferred full guidance, while the other preferred open exploration. (5) Perceived learning benefits: Participants largely viewed the VR environment as engaging and supportive of visual learning. They highlighted increased interactivity, spatial awareness, and the value of cues for understanding complex information. Notable participant comments include:

> "This technology is super fun. Study with visual cues will benefit me to really build up a deep understanding." — Anna
>
> "It was quick and easy to learn the navigation, so I spent my time exploring grass types, not figuring out the controls." — Dan
>
> "I think it's great for visual learners… I feel I remember more when seeing that." — Claire
>
> "This would enable an interactive learning environment… [It] helps make learning more fun." — Fin
>
> "It was intense to see all the pictures up close… If there's a clear purpose for navigating, I'd explore more meaningfully." — Ethan

These findings illustrate both the promise and challenges of integrating 360-degree cued VR environments in online learning platforms. Navigation was uneven across participants, suggesting a need for design refinements and user support strategies.

7 CONCLUSIONS, DISCUSSION, AND IMPLICATIONS

This study explored how six undergraduate and graduate students navigated a 360-degree cued virtual horticulture classroom embedded in canvas and what influenced their navigation behaviors and experiences. Key findings offer practical insights for instructional designers integrating desktop-based VR into authentic online learning settings.

Participants engaged unevenly with content cues. Cues directly in front of them, requiring no navigation, received the most attention. Cues on the bottom or back were often missed. Learners demonstrated consistent directional preferences: those who began navigating from a particular direction, such as the right, tended to maintain that pattern across scenes. Notably, some participants missed all cues requiring active navigation, confirming prior research suggesting stable navigation tendencies in VR environments.

These results emphasize the importance of strategic cue placement. Front-facing cues, which naturally attract attention, should include critical instructional content. They also serve as orientation anchors, helping learners remain grounded within the virtual space. Designers should consider including visual or auditory signals to highlight less visible content and support more balanced exploration.

Navigation behavior was shaped by prior experience with VR, familiarity with canvas, and the type of instruction received. Learners with prior VR exposure navigated more effectively, suggesting they transferred existing knowledge to the new context. In contrast, those unfamiliar with immersive environments defaulted to 2D navigation patterns, overlooking many cues. Participants who received both audio and text instructions generally navigated more successfully than those who received audio only, highlighting the value of multimodal guidance.

Although training was not formally tested, the data suggest that a short, initial orientation session could improve outcomes. Participants unfamiliar with 360-degree learning often struggled with navigation early on. A brief demonstration of interaction techniques, such as how to drag and explore, could enhance learners' ability to engage with the full environment.

Overall, participants reported positive impressions of the desktop VR simulation, citing its interactivity and visual support. However, inconsistencies between self-reported data and actual navigation behaviors—captured through screen recordings—underscore the limitations of relying solely on surveys. Objective behavioral data provided a clearer picture of learner interaction, revealing that some learners perceived they had explored thoroughly, though recordings showed missed cues.

Participants also expressed a need for timely guidance when navigating unfamiliar VR interfaces. Clear instructions and well-placed cues can enhance learner experience and reduce frustration. These findings affirm the potential of signaling principles to guide attention and promote deeper engagement in multimedia VR learning environments.

This study contributes to the evolving field of 360-degree VR learning by presenting an authentic case of desktop VR implementation within an LMS. It demonstrates

that thoughtful cue design, multimodal instructions, and learner preparation can support effective navigation and meaningful interaction.

Limitations include the small sample size and the interpretive nature of qualitative analysis. As a pilot case study, the findings are exploratory and context-specific. Future research should explore different cue types and instructional strategies to guide learners toward comprehensive exploration in VR settings. Researchers are also encouraged to use behavioral data, such as navigation recordings, to complement self-reported experiences and strengthen the validity of user experience research.

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