

Hooping into Spatial Computing: Hula Hoops as Embodied Visual Scaffolds for Teaching XR Design Concepts

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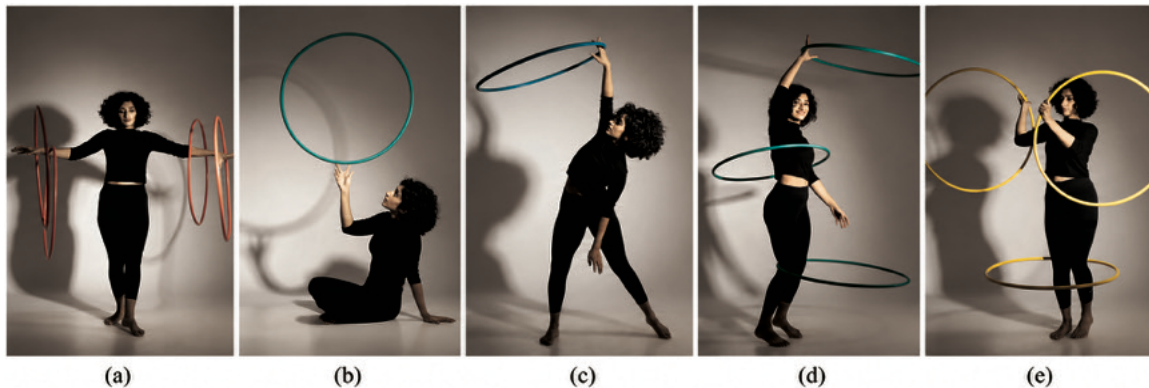


Figure 1: Hula hoops as embodied and visual scaffolds for XR design education. The five panels illustrate how hoops can act as visible and manipulable spatial artifacts: (a) body-centered boundaries, (b) focal framing, (c) oriented planes, (d) layered spaces, and (e) multiple spatial frames. Images adapted with permission from Hoop Flo/Eshna Kutty [1].

ABSTRACT

XR design education requires learners to develop spatial, embodied, and experiential ways of thinking that are not always supported by software-first instruction. This position paper explores hula hoops as low-cost pedagogical artifacts for introducing selected XR design concepts through bodily movement and visual-spatial demonstration. We present a hoop-based framework that identifies relevant XR concepts across Environment Design, Interaction and Navigation Design, and Experience Design; defines broad hoop activity families; and maps selected activities to learning outcomes in XR design. The mappings are classified through four criteria: embodiment, visualization, spatial manipulability, and XR design transferability. Rather than presenting an evaluated teaching method, the paper contributes a conceptual framework and research agenda for using play-based physical artifacts to support novice XR designers in reasoning about spatial understanding and spatial reasoning, coordinate systems, embodied interaction, spatial interfaces, navigation, attention, and perception.

Index Terms: Spatial Computing, Extended Reality, XR Design, Spatial Interfaces, Embodied Learning, Hula Hoop, Motor Skill Learning

1 INTRODUCTION

Extended Reality (XR) design requires learners to reason about bodies, objects, movement, and interaction in three-dimensional space. Unlike conventional interface design, XR experiences are shaped through spatial relationships, bodily movement, attention, comfort, and presence. For novice XR designers, including those entering from web, mobile, graphic design, computer science, game design, or other non-spatial design backgrounds, this shift toward designing for bodies in space can be difficult to understand through software

tools alone. While XR education often emphasizes headsets, game engines, and prototyping workflows, learners may also need low-cost ways to develop spatial intuition [2] before entering immersive environments. This is especially relevant in educational contexts where access to XR hardware, high-end computers, or dedicated labs may be limited.

This paper asks whether a familiar physical object, the hula hoop, can help make selected XR design concepts easier to see, feel, and discuss. Hoops are portable geometric artifacts that can act as visible planes, boundaries, reach zones, attention frames, and movable spatial references. Through activities such as lasso, waist hooping, arm hooping, isolations, folds, tosses, weaves, and balancing, learners can observe or enact spatial ideas before translating them into XR design decisions. We therefore propose a conceptual position and research agenda: embodied and visual scaffolds such as hula hoops may help novice XR designers move from screen-based, tool-centered, or abstract understandings of interaction toward designing for spatial interfaces.

2 RELATED WORK

Prior work suggests that XR design cannot be treated as a direct extension of screen-based interface design. Research on 3D user interfaces shows that immersive systems require attention to spatial input, manipulation, navigation, comfort, fatigue, and the alignment between interaction technique and task [3], [4]. At the same time, embodied cognition and spatial design research argue that spatial understanding is grounded in bodily movement, multisensory perception, and active exploration of environments [5], [6], [7]. Existing embodied design methods such as bodystorming similarly use bodily enactment to explore interaction possibilities [8]. Work on physical manipulatives, tangible learning, and diagrammatic representations further shows that external physical and visual artifacts can make abstract relationships easier to perceive, manipulate, and transfer [9], [10], [11], [12]. Finally, scaffolding research emphasizes that such supports are most effective when they are carefully framed, connected to learning goals, and gradually transferred to learners, as mentioned in [2]. Building on these strands, this paper positions

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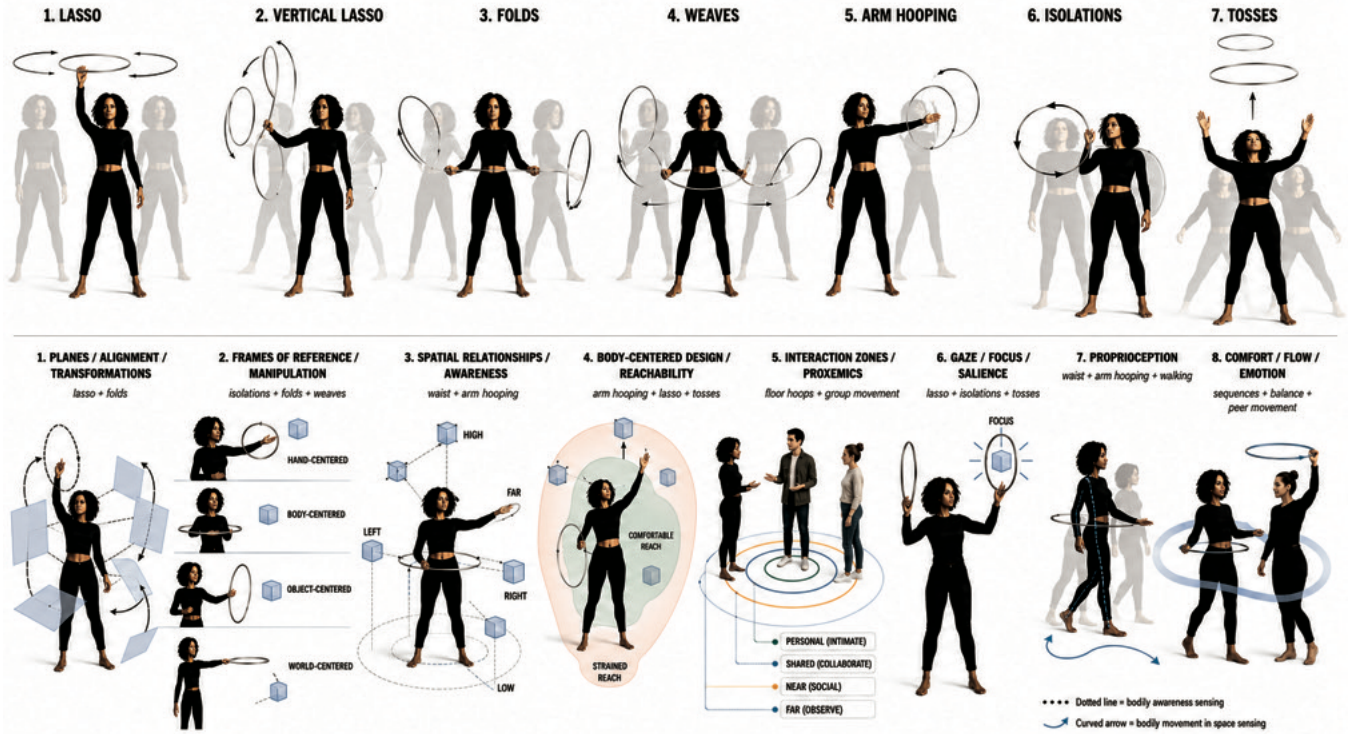


Figure 2: Hoop activity families and their mapping to XR design concepts. The top row illustrates selected hoop activity families using ghosted body positions and motion arrows to show movement over time. The bottom row translates these activities into XR design concepts.

hula hoops as low-cost embodied and visual scaffolds for introducing selected XR design concepts before or alongside headset-based prototyping.

3 HOOP-BASED PEDAGOGICAL FRAMEWORK

This section presents the proposed hoop-based pedagogical framework. The framework first identifies the XR design concepts considered in this paper, then defines the hoop activity vocabulary, mapping criteria, and concept-to-activity mappings used to connect hoop-based learning with XR design reasoning.

3.1 XR Design Concepts and Taxonomy

We propose a taxonomy of XR design concepts developed through an iterative synthesis of existing literature on XR design, human-computer interaction, interaction design, and user experience. During this synthesis, recurring concepts were identified and framed into three complementary dimensions: **Space, Action, and Perception**, because XR experiences are shaped not only by where digital content is placed, but also by how users move, act, attend, and feel within spatial environments. Based on this framing, we identify 36 XR design concepts across these design areas. Space, related to **environment design**, includes scale, depth, volume, orientation, spatial relationships, spatial awareness, frames of reference, transformations, alignment, and planes. Action, related to **interaction and navigation design**, includes proprioception, body-centered design, reachability, affordances, feedback, manipulation, mapping, mental models, conceptual models, interaction zones, proxemics, wayfinding, locomotion, and navigation orientation. Perception, related to **experience design**, includes gaze, focus, visual hierarchy, salience, immersion, presence, comfort, emotion, cognitive load, flow, agency, and discoverability. From this taxonomy, we identify 18 concepts that are strongly or partially mappable to hoop-based pedagogy.

3.2 Hoop Activities and Learning Modes

After reviewing existing hoop activity vocabularies and trick lists from online hooping resources [13], [14], we categorize hoop activities along four dimensions: **relationship to the body, movement through space, number of hoops, and number of participants**. Activities may be **on-body**, where the hoop rotates around or is sustained by a body part as shown in Fig. 1(a), (d), and (e), or **off-body**, where the hoop is manipulated away from the body using the hands, as shown in Fig. 1(b) and (c). They may be **stationary** or **travelling**, use a **single hoop** or **multiple hoops**, and involve **one learner** or **multiple participants**. We also distinguish between **embodied learner activities**, where students physically perform simplified hoop movements, and **instructor-led visual demonstrations**, where the hoop functions as an external spatial representation. **Hybrid activities** may combine both modes, providing learners with different ways to engage with the same spatial concept.

To keep the framework accessible to readers unfamiliar with hooping, we use broad hoop activity families rather than detailed trick names; these activity families are illustrated in Fig. 2. These include **lasso**, where the hoop spins around one hand above or beside the body; **vertical lasso**, where the hoop spins upright in front of or behind the body; **waist hooping**, where the hoop rotates around the waist or torso; and **arm hooping**, where the hoop rotates around the hand, wrist, forearm, or upper arm. They also include **isolations**, where the hoop appears visually fixed while the hand moves around or along it; **folds**, where the hoop is pivoted, flipped, or redirected across positions or planes; **tosses**, where the hoop is released and caught again; **weaves**, where the hoop repeatedly travels across the front or sides of the body; and **balancing**, where the hoop is stabilized on a body part without gripping it. These activity families are used in a mapping table as adaptable actions that can be performed, observed, or simplified for teaching.

Table 1: Mapping hoop activities to XR design learning outcomes. The table groups selected XR design concepts, corresponding hoop activity families, instructional modes, mapping criteria (Embodiment (E), Visualization (V), Spatial Manipulability (M), and XR Design Transferability (T)), and intended learning outcomes.

XR concept group (criteria satisfied)	Supporting hoop activities	Instructional mode	XR learning outcome
Planes, alignment, transformations (V, M, T)	Vertical lasso, folds, multi-hoop demonstrations	Instructor-led visual demo; stationary; single/multiple hoops	Learners understand spatial interfaces as orientable planes that can be positioned, tilted, aligned, or transformed relative to the user and environment.
Frames of reference, manipulation (E, V, M, T)	Isolations, folds, weaves, balancing	Hybrid demo + learner attempt; mostly stationary; single/multiple hoops	Learners compare body-centered, hand-centered, object-centered, and world-centered movement, and relate them to how virtual objects are anchored or manipulated in XR.
Spatial relationships, spatial awareness (E, V, M, T)	Waist hooping, arm hooping, floor-arranged hoops, multi-person movement	Embodied individual/group activity; stationary or travelling; single/multiple hoops	Learners understand how bodies, objects, boundaries, and movement paths relate to one another in shared three-dimensional space.
Body-centered design, reachability (E, V, M, T)	Arm hooping, lasso, hand-offs, simple tosses	Embodied individual activity; stationary or travelling; single hoop	Learners identify comfortable and strained reach zones, helping them reason about where XR objects or controls should be placed around the body.
Interaction zones, proxemics (E, V, M, T)	Different-sized hoops, floor hoops, multi-person activities	Floor-based spatial setup; embodied group activity; multiple colored hoops	Learners understand personal, shared, near, and far interaction spaces, including how distance affects comfort and social meaning.
Gaze (E, V, M, T), Focus (E, T), salience (V, T)	Vertical lasso, isolations, balancing, colored hoops, tosses	Instructor-led visual demo; optional learner attempt; single/multiple hoops	Learners understand how attention can be guided through framing, motion, contrast, and visible focal anchors.
Proprioception (E, T)	Waist hooping, arm hooping, balancing, walking with hoop	Embodied individual activity; stationary or travelling; single hoop	Learners recognize how body awareness, effort, rhythm, and movement control influence interaction comfort in XR.
Comfort, flow, emotion (E, T)	Simple hoop sequences, walking, balancing, peer movement activities	Embodied individual/group activity; stationary or travelling; single/multiple hoops	Learners reflect on how effort, rhythm, challenge, fatigue, frustration, delight, or calm can shape embodied XR experiences.

3.3 Mapping Criteria

We classify XR design concepts using four criteria: **Embodiment**, **Visualization**, **Spatial Manipulability**, and **XR Design Transferability**. The four criteria were chosen to capture complementary mechanisms through which hoop activities may support XR design learning. Embodiment (E) asks whether learners can physically experience the concept through bodily movement. Visualization (V) asks whether the hoop can make an abstract spatial idea visible. Spatial Manipulability (M) asks whether the concept can be communicated by varying the hoop's position, orientation, scale, layering, or movement in space. XR Design Transferability (T) asks whether the hoop activity can be connected to a concrete XR design concept and translated into a design decision. A concept is considered **strongly mappable** when it satisfies **T** and at least two of **E**, **V**, and **M**. A concept is considered **partially mappable** when the connection is useful but less direct, satisfies fewer criteria, or requires stronger instructor explanation. Since this paper focuses on XR design education, transferability is essential: a hoop activity may be embodied or visually engaging, but it is pedagogically relevant here only when it supports XR design reasoning.

3.4 Mapping

Building on the taxonomy, hoop activities, and mapping criteria introduced above, this section explains how selected activity families support related XR design concepts. The mappings were developed through reflective analysis, applying the four criteria to each hoop activity family and corresponding XR design concept. The mappings are grouped by conceptual similarity and summarized in Table 1.

1. *Planes, alignment, and transformations* are supported because a hoop makes an abstract plane visible and allows it to be tilted, rotated, aligned, and repositioned, linking bodily manipulation to spatial interface placement and orientation. For *frames of*

reference and manipulation, learners can observe and physically vary the relationship between the hoop, their body, and the surrounding space. Activities addressing *spatial relationships and spatial awareness* make boundaries, paths, distances, and relations between bodies and objects visible and changeable. This helps learners understand why XR interaction can become cognitively demanding when users must track their body, virtual objects, physical boundaries, and other people at the same time.

2. *Body-centered design and reachability* are explored through activities in which learners feel bodily limits, see reachable regions through hoop movement, and vary the action space around the body. These activities make reach, strain, comfort, and control tangible, helping learner-designers reason about where XR objects or controls should be placed for novice users managing headsets, controllers, unfamiliar gestures, and new interaction rules. *Interaction zones and proxemics* are supported through different-sized hoops and activities in which learners physically enter, leave, overlap, resize, and negotiate visible zones.
3. *Gaze, focus, and salience* operate differently within the framework. A hoop can act as a directional or moving frame for gaze, while focus is supported primarily through sustained attention to an activity. Salience is mainly visual, created through contrast, colour, motion, or framing without requiring the learner to physically embody the concept. *Proprioception* is only partially externalised and is not directly visualized in the same way as planes, zones, or boundaries. But waist hooping, arm hooping, balancing, and walking with the hoop enable learners to rely on body awareness, rhythm, effort, and movement control, which transfer to XR interactions involving headsets, controllers, hand tracking, and unfamiliar spatial

gestures. *Comfort, flow, and emotion* are explored through simple hoop sequences such as walking, balancing, and peer movement activities where learners experience effort, fatigue, rhythm, challenge, frustration, delight, calm, or loss of control. These felt experiences help learner-designers reflect on how embodied XR interactions can shape comfort, engagement, affect, and cognitive load for novice users.

4 DISCUSSION

4.1 Pedagogical Considerations

The use of hoops in XR design education should be guided by pedagogical fit rather than the visual impressiveness of a hoop activity. Since the goal is to support spatial design understanding, activities should be learnable, safe, accessible, demonstrable, and concept-specific. Learners do not need to become proficient hoop dancers; beginner-friendly actions such as holding, rotating, passing, balancing, walking with, or arranging hoops may be sufficient. More complex movements can be used as instructor-led visual demonstrations when they help externalize abstract concepts such as planes, transformations, alignment, gaze, or interaction zones. Hoop activities are pedagogically useful when they support reflection and help learners connect what they see or feel through the hoop to a concrete XR design decision.

4.2 Opportunities and Limitations

Hula hoops offer a low-cost way to introduce selected XR design concepts before learners enter headset-based environments. As movement-based artifacts, they may also support forms of flow-oriented, dance-like engagement that can amplify embodied learning, as suggested by related work on dance as embodied learning [15]. By making spatial ideas visible, movable, and bodily felt, hoop activities may support novice XR designers and learners transitioning from screen-based design to spatial design. In our current conceptual mapping, hoop activities strongly or partially support 18 of the 36 XR design concepts identified in the proposed taxonomy. This suggests that hoops can address a substantial portion of foundational spatial, embodied, interactional, and experiential concepts in XR design education. The variation in learning modes, hoop sizes, movement, and body involvement may support adaptation for different mobility needs through instructor-led demonstrations or stationary, upper-body activities.

This paper presents a conceptual framework linking hoop activities to selected XR design concepts; its educational effectiveness remains to be empirically evaluated. Because hoop activity names may not be self-explanatory to non-hoopers, additional visual references may be needed to make the movement patterns and spatial relationships in each activity easier to inspect [12]. Instructors must also carefully frame each activity so that the session remains focused on XR design rather than hoop technique. Future work should therefore examine these mappings through pilot workshops, learner reflections, design tasks, and teaching materials. Evaluating the specific contribution of hoop-based scaffolds will require careful study design to account for factors such as instructor guidance, peer interaction, and learners' prior experience, to better understand the contribution of hoop-based scaffolds to XR design learning.

5 CONCLUSION

We believe that the presented hoop-based pedagogical framework opens a research direction for using everyday movement artifacts as embodied and visual scaffolds in XR design education. By positioning hula hoops as low-cost, manipulable, and bodily engaging artifacts, this paper argues that learners may be supported in moving from designing for screens to designing for bodies in space. Further research should explore remote and low-resource XR education, since hoops are inexpensive, portable, and usable without headsets or high-end computers. Future work could develop activity cards,

concept maps, short demonstration videos, and reflection prompts to help instructors use hoop activities without advanced hooping knowledge, while keeping the focus on spatial design reasoning rather than performance.

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