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Pierce XRLab: A Two-Year Spiral Curriculum for Extended Reality in Middle School

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Abstract **Original Research Article**

Extended Reality (XR) is increasingly discussed in educational research as a medium for experiential learning, multimodal meaning-making, and creative engagement. School-based applications, however, often remain focused on individual activities or technologies. This chapter presents Pierce XRLab, a two-year XR curriculum for Grades 8–9 developed as a standalone middle school course for implementation within short lesson periods and shared device conditions. Sixteen units, eight in each grade, are organized in a spiral sequence that revisits key concepts under progressively more demanding interpretive, critical, and design conditions. XR is understood as a learning environment and as a representational and cultural medium that can shape perception, credibility, identity, and participation. The model draws on constructivist and constructionist learning, embodied cognition, experiential and pragmatist traditions, and critical media literacy. Four recurring spiral axes, developed through iterative curriculum organization and revision, make the conceptual progression explicit and focus on embodied engagement, representation and illusion, culture and identity, and experience design, critique, and ethics. Assessment is organized around three recurring evidence types, Experience Logs, Critical Briefs, and Design Artifacts. Implementation emphasizes repeatable instructional routines, resource-conscious technology choices, flexible substitution of technologies, classroom rotation, and explicit safety practices. The chapter contributes a curriculum-level model connecting longitudinal conceptual progression, recurring evidence of learning, and classroom enactment within routine school time and resource constraints. Empirical findings from the ongoing design-based research study fall outside the scope of the present chapter.

Keywords: Extended reality, immersive learning, middle school curriculum, curriculum design.

1. Introduction

Extended Reality (XR), encompassing virtual reality (VR), augmented reality (AR), and mixed reality (MR), has attracted increasing attention in educational research as a set of media that can support experiential learning, multimodal meaning-making, and engagement with complex concepts (Mills et al., 2022; Radianti et al., 2020). In K–12 education, XR has been used to support exploration, simulation, narrative-based learning, and creative production (Brunetti et al., 2024; Dunleavy et al., 2009). At the same time, research continues to highlight concerns regarding feasibility, safety, equity, and pedagogical coherence (Bexson et al., 2024; Maas & Hughes, 2020). These concerns have contributed to growing interest in curriculum-level approaches that move beyond isolated activities by making explicit how immersive experiences are sequenced, interpreted, and assessed within the practical constraints of schooling (Ireland & Mouthaan, 2020). In middle school contexts, this perspective can support explicit classroom inquiry into processes of perceptual mediation, narrative construction, identity formation, and social participation that may otherwise remain implicit in technology use (Hwang & Chien, 2022; Lombard & Ditton, 1997; Schroeder, 2011).

The literature documents substantial potential for engagement and conceptual learning. Reviews of K–12 XR also repeatedly identify implementation barriers related to infrastructure, cost, teacher readiness, and curricular alignment (Jiang et al., 2025; Maas & Hughes, 2020; Pellas et al., 2020, 2021). Teacher adoption intentions and opportunities for professional learning further shape whether XR can be sustained beyond short-term initiatives (Geriş & Kulaksız, 2025; Li et al., 2025). Across this literature, studies focusing on particular technologies, activities, or learning outcomes remain more prominent than curriculum-level accounts that explicitly address longitudinal progression, recurring evidence of learning, and routine classroom enactment (Schott et al., 2024; Ward et al., 2025). Within such designs, structured prompts and guided reflection may help make learning processes and evidence more visible over time (Thomann & Deutscher, 2025). This gap is significant in K–12 education because sustained use requires a coherent instructional model that can be repeated, adapted, and refined over time, alongside successful individual immersive experiences (Pellas et al., 2021; Schott et al., 2024). Iterative and participatory approaches to curriculum design similarly emphasize coherence among design intentions, implementation conditions, and evidence of learning (Design-Based Research Collective, 2003; Ireland & Mouthaan, 2020; Lazou & Tsinakos, 2025).

This chapter presents the design and development logic of Pierce XRLab, a two-year XR curriculum for Grades 8–9 at Pierce – The American College of Greece. The model combines a spiral conceptual structure with repeatable lesson routines, recurring student artifacts, and an implementation strategy responsive to common school constraints (Black & Wiliam, 1998; Ireland & Mouthaan, 2020; Udeozor et al., 2023). XR is approached as a delivery medium and a medium for meaning-making through which students examine representation, participation, credibility, and ethical responsibility (Madary & Metzinger, 2016; Mygdanis, 2026). The chapter contributes an integrated curriculum model organized around four elements, namely longitudinal conceptual progression, repeatable instructional routines, recurring evidence of learning, and resource-conscious classroom implementation. It extends the earlier practitioner-oriented account of Pierce XRLab (Mygdanis, 2026) through a more detailed examination of the curriculum development process, theoretical rationale, spiral progression, implementation logic, and assessment architecture. The chapter focuses on the curriculum rationale, architecture, and implementation model. Empirical evaluation remains part of the ongoing design-based research (DBR) process, and findings from that process will inform subsequent refinement of the program (Design-Based Research Collective, 2003; Mygdanis, 2025).

2. Design Context and Curriculum Development Rationale

Pierce XRLab was conceived as a distinct middle school course with a coherent curricular structure, extending beyond isolated XR activities embedded in other subjects. Its development was shaped by educational objectives, classroom constraints, assessment requirements, and the need for an instructional structure that could be sustained across the school year (Maas & Hughes, 2020; Udeozor et al., 2023). The resulting two-year sequence for Grades 8 and 9 progresses from guided encounters with immersive media toward interpretation, critique, and creative production. This orientation places classroom conditions and recurring evidence of learning at the center of curriculum design, integrating implementation considerations into the selection and organization of educational activities from the outset (Pellas et al., 2021; Schott et al., 2024).

Figure 1: *Pierce XRLab Logo*

2.1 Design Requirements and Development Logic

The immediate design context consisted of 45-minute weekly lessons, shared devices, limited time for setup and troubleshooting, and variation in students' prior familiarity with and comfort using immersive media (Jiang et al., 2025; Schott et al., 2024; Wang & Chan, 2024). These conditions called for short instructional cycles, predictable transitions, and activities that could remain meaningful when access to devices was limited. Within this context, the curriculum comprises 16 units, eight in each grade, with each unit unfolding across three weekly sessions. This rhythm supports a recurring progression from experience to interpretation and production. A brief student artifact in each unit makes learning visible for formative classroom discussion and feedback (Black & Wiliam, 1998; Kolb, 1984; Udeozor et al., 2023).

These classroom conditions informed a set of design requirements. The curriculum needed to support longitudinal progression, fit within 45-minute periods, accommodate limited device availability, generate assessable evidence of learning without extensive formal testing, provide safe and accessible opportunities for participation, remain adaptable to changing platforms, and be usable by teachers without specialist XR expertise. In the model presented here, these requirements serve as design criteria linking curricular intent to practical classroom enactment (Jiang et al., 2025; Maas & Hughes, 2020; McTighe & Wiggins, 2012; Schott et al., 2024).

These design criteria subsequently guided the development of Pierce XRLab, with curricular goals and classroom conditions shaping the selection and use of technologies. From the outset, the curriculum was conceived as a coherent two-year pathway in which units and activities were developed within an overarching curricular structure. The account presented here focuses on the developmental logic used to coordinate units, activities, forms of evidence, and technologies, without reconstructing every design decision chronologically. It presents the curriculum as a design model that can be examined and adapted, while classroom-based testing and subsequent refinement remain part of the ongoing design-based research (DBR) process (Design-Based Research Collective, 2003; Mygdanis, 2025).

2.2 Curriculum Development Process

The curriculum architecture was developed by the author as lead designer of Pierce XRLab. The 16-unit structure was organized into eight units in Grade 8 and eight in Grade 9, allowing the curriculum to fit the instructional time available within each school year while preserving a complete three-session cycle for every unit. The two grades were designed together as a coherent developmental pathway, with continuity across their conceptual and instructional structures.

Curriculum development proceeded iteratively. The overall two-year pathway and its constituent units were revised as the relationships among concepts, learning objectives, XR modalities, and grade-level expectations became clearer. Through this process, Grade 8 came to emphasize foundational encounters with immersive media, embodied experience, perception, and initial interpretation, whereas Grade 9 extended these foundations toward identity, critical analysis, ethical reasoning, and collaborative design. The distinction between the two grades therefore reflects a developmental progression across the curriculum, with greater conceptual, interpretive, and design demands over time.

The four spiral axes emerged during later stages of curriculum organization and revision. As the 16 units were reviewed in relation to one another, recurring conceptual concerns became more visible across activities and XR modalities. These concerns were subsequently organized into four axes comprising embodied engagement; representation and illusion; culture and identity; and experience design, critique, and ethics. Together, the axes make the curriculum's internal coherence explicit and provide a framework for tracing how key concepts recur across the two-year pathway under progressively more complex interpretive, critical, and design demands.

This iterative organization also informed curriculum sequencing. The placement of units was guided primarily by the conceptual role each was expected to play within the two-year pathway, supporting a progression from initial experience and conceptual orientation toward explicit interpretation, critique, ethical judgment, and design. Pierce XRLab revisits concepts such as presence, embodiment, perception, representation, and credibility across different units and modalities, with students engaging with them in progressively more interpretive, critical, and generative ways (Bruner, 1960; Ireland & Mouthaan, 2020). A concept may first be encountered through experience, later become an object of interpretation, and eventually serve as a criterion for critique or design. This spiral structure preserves the modular character of individual units, supports conceptual continuity, and allows flexibility in sequencing and local adaptation (Johnson-Glenberg, 2018; Lombard & Ditton, 1997; Slater, 2018).

A further design principle concerns the relationship between program-level architecture and unit-level enactment. At the program level, Pierce XRLab defines a two-year educational trajectory through recurring conceptual axes, progression goals, and a sustained commitment to critical and ethical inquiry (Madary & Metzinger, 2016). At the unit level, this trajectory is enacted through a stable lesson structure that specifies aims, intended outcomes, activity flow, reflection prompts, and anticipated student artifacts. Together, these levels align desired outcomes, evidence of learning, and learning activities, while preserving the capacity to revise individual units without disrupting the coherence of the overall program (McTighe & Wiggins, 2012).

Technology selection follows this curricular logic. The curriculum prioritizes a minimal-hardware configuration in which technologies can be substituted while preserving the intended learning activity and remaining manageable under school conditions (Jiang et al., 2025; Maas & Hughes, 2020; Wang & Chan, 2024). Educational aims and instructional needs guide the choice of platform or device, allowing specific technologies to change while the conceptual objective, instructional routine, and expected evidence of learning remain stable. Detailed infrastructure and classroom implementation choices are discussed in Section 6.2.

Safety, comfort, and equitable participation are integrated into the curriculum as core design requirements. Brief immersive exposure, planned rotation, and conceptually aligned non-headset tasks allow students to work toward the same learning objective through different modes of participation when devices are shared or immersive use is less suitable (Bexson et al., 2024; Cossio et al., 2025; McKenzie & Fegely, 2023). This approach connects operational feasibility with accessibility and maintains the instructional focus on the concept being studied, with device access treated as one component of participation.

Together, these decisions clarify the educational purpose of the curriculum. Pierce XRLab is designed to help students develop a more reflective relationship with immersive media by examining how XR shapes attention, representation, participation, and judgment (Hobbs, 2010; Ward et al., 2025).

3. Pedagogical Foundations and Instructional Perspectives

Pierce XRLab draws on several complementary learning traditions and classroom practices. XR is treated as a medium through which students engage with, interpret, construct, and reshape experience, with learning extending beyond the reception of information (Dewey, 1938; Kolb, 1984). Constructivist and constructionist approaches provide one foundation for this orientation, with students developing understanding through observation, description, comparison, problem-solving, and creation. Socially mediated activity and the production of shareable artifacts are central to this process (Papert, 1980; Vygotsky, 1978). In immersive and multimodal settings, design decisions, representational choices, and embodied responses become part of what students learn to notice, articulate, and discuss (Johnson-Glenberg, 2018; Papert, 1980).

A second foundation concerns the embodied nature of knowledge and learning. The curriculum approaches thinking and learning as processes connected to bodily action, spatial orientation, and sensory engagement with the environment (Barsalou, 2008). Students therefore attend explicitly to presence, shifts in attention, spatial anchoring, disorientation, and bodily response. These phenomena become resources for concept formation and reflection as students engage with immersive media (Johnson-Glenberg, 2018; Sanchez-Vives & Slater, 2005).

Experiential and pragmatist traditions provide a further foundation, particularly through the view that learning develops through cycles of experience, action, and reflective reconstruction (Dewey, 1938; Kolb, 1984). Within this logic, immersive activity is followed by interpretive and productive work that connects first-person experience with discussion, evidence, and decision-making.

These learning traditions are complemented by a cultural and interpretive perspective on immersive technologies. XR is understood as a representational and cultural medium that can shape perception, attention, narrative framing, credibility, and identity (Grau, 2003; Mills et al., 2022; Nowak & Fox, 2018). This perspective foregrounds questions of meaning-making and interpretation and connects XR education with critical media literacy (Gray et al., 2018; Hobbs, 2010). It also informs the curriculum's spiral organization. Concepts such as presence, identity, perception, credibility, and narrative recur across the two-year sequence under changing technological, aesthetic, and social conditions (Ireland & Mouthaan, 2020). Presence, for example, first appears as a felt quality of immersive experience and later becomes a lens for examining social participation and self-representation in avatar-mediated environments (Lombard & Ditton, 1997; Nowak & Fox, 2018). Credibility similarly develops from the interpretation of perceptual cues and illusion toward the critique of persuasion and media framing (Gray et al., 2018; Hobbs, 2010). In this way, the spiral supports conceptual deepening through repeated engagement with these ideas in increasingly complex interpretive contexts.

A sociocultural and historical perspective extends this orientation by locating XR within cultural practices, collective memory, narrative traditions, and everyday social experience. Students encounter examples from art, history, museums, and contemporary social life and use them to examine how perspective, authorship, and representation shape immersive meaning (Grau, 2003; Hobbs, 2010). This broadens the curriculum toward interdisciplinary interpretation and situates technical familiarity within a wider cultural and critical framework.

Critical and ethical inquiry forms another cross-cutting principle of the curriculum. Students examine privacy, psychological effects, bias, persuasive design, consent, and responsible participation as issues embedded in immersive experience and design (Gray et al., 2018; Madary & Metzinger, 2016; Southgate et al., 2026). These concerns are introduced early through questions of safety, permissions, and consent and become more explicit in later units addressing manipulation, representation, and ethical design. Reflective artifacts, Critical Briefs, and design planning provide recurring opportunities for students to articulate and apply ethical reasoning across the curriculum (Mygdanis, 2026; Udeozor et al., 2023). This sustained attention reflects the conditions of digital environments in which persuasive cues, trust, and identity already shape everyday participation (Gray et al., 2018; Nowak & Fox, 2018).

Figure 2: *Conceptual Pillars of Pierce XRLab*

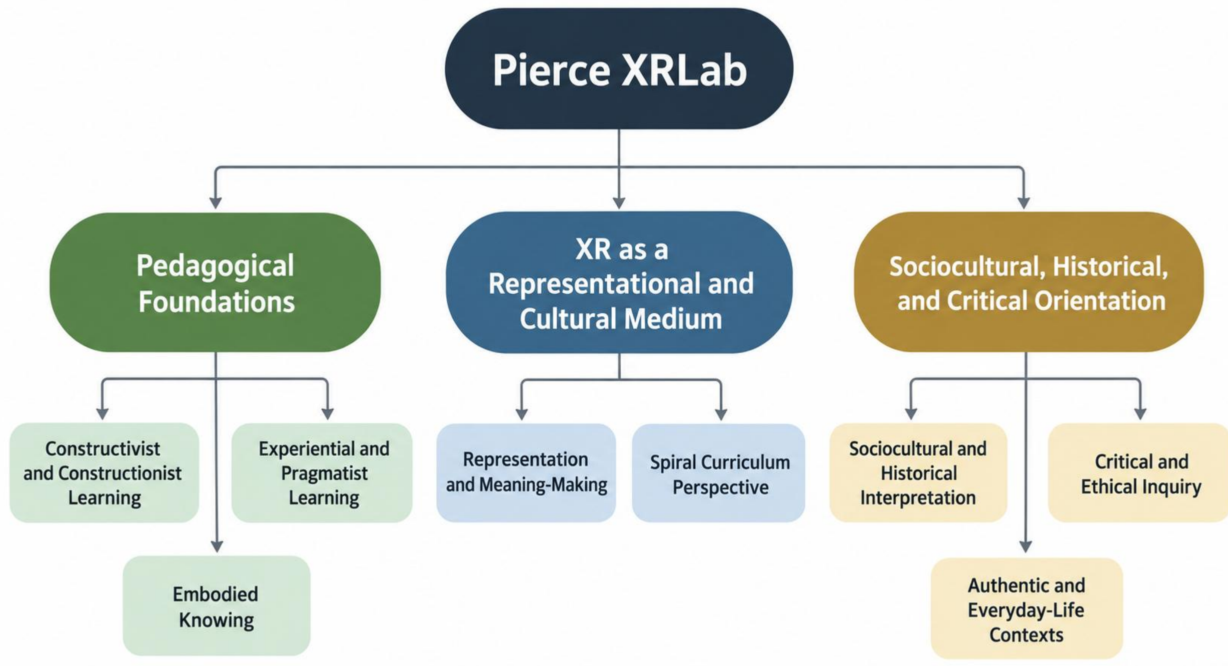

Figure 1 brings these commitments together within a coherent educational framework. Constructivist and constructionist learning, embodied accounts of knowing, and experiential and pragmatist traditions position XR learning as an active process of meaning-making through experience, reflection, and creation (Dewey, 1938; Papert, 1980). Recurring student artifacts make this learning visible and available for discussion and feedback (Udeozor et al., 2023). XR is also understood as a representational and cultural medium through which perception, narrative, trust, and participation can become objects of critical interpretation (Lombard & Ditton, 1997; Mills et al., 2022). Sociocultural, historical, and ethical inquiry adds contextual and critical depth, and the spiral structure revisits these commitments under progressively more demanding conceptual and interpretive conditions (Ireland & Mouthaan, 2020; Madary & Metzinger, 2016). Together, these foundations inform the spiral curriculum architecture described in the following section.

4. Curriculum Design and Spiral Structure

Pierce XRLab follows a two-year spiral sequence for Grades 8–9 comprising 16 units, eight in each grade. Each unit is delivered across three weekly sessions of approximately 45 minutes, creating a stable rhythm of experiential engagement, reflection, and artifact production. Recurring reflection and student artifacts provide formative evidence of learning throughout the sequence (Black & Wiliam, 1998; Udeozor et al., 2023). Progression is defined primarily by changes in how students engage with and interpret immersive media. Concepts are deliberately revisited under new pedagogical conditions, supporting movement from experience to interpretation and, eventually, to design and ethical inquiry (Bruner, 1960; Hobbs, 2010; Ireland & Mouthaan, 2020; Madary & Metzinger, 2016). Ideas first encountered through experience can later return as analytical lenses or inform design decisions that require justification (Slater, 2018).

The curriculum's inclusive design is informed by Universal Design for Learning and provides multiple pathways for participation. Multiple means of representation, engagement, and action and expression are reflected in multimodal resources, rotation structures, alternative non-headset routes, and varied forms of student artifacts (CAST, 2024). These choices are intended to reduce barriers associated with device availability, sensory comfort, and differences in how students engage with and express learning. The approach is consistent with research on embodiment and multimodal meaning-making, as well as with structured learning designs that connect engagement, sense-making, and production (Brunetti et al., 2024; Johnson-Glenberg, 2018; Mills et al., 2022).

4.1 Spiral Axes of the Curriculum

The four recurring spiral axes (SA) function as conceptual anchors that make the curriculum's progression explicit. Individual units may engage more than one axis; the designation used in Table 1 identifies the dominant pedagogical emphasis without implying an exclusive classification. This structure organizes the curriculum around recurring concepts and allows embodiment, representation, culture, identity, design, critique, and ethics to intersect across units (Ireland & Mouthaan, 2020; McTighe & Wiggins, 2012).

The first axis (SA1) centers on experiential engagement, presence, and embodied participation. It approaches XR as a situated experience in which attention, orientation, and bodily response are pedagogically meaningful (Barsalou, 2008; Johnson-Glenberg, 2018). This axis is prominent in the early sequence as students develop a vocabulary for describing immersion and continues to inform later units that connect presence with identity, design, and ethics (Lombard & Ditton, 1997; Madary & Metzinger, 2016).

The second axis (SA2) addresses representation, perception, and illusion. Students gradually recognize immersive media as designed representational systems shaped by perceptual and aesthetic choices (Lombard & Ditton, 1997). Visual cues, stereoscopic depth, framing, and related mechanisms become objects of analysis, providing a basis for critically interpreting how immersive effects are constructed (Grau, 2003; Mills et al., 2022).

The third axis (SA3) focuses on culture, sociality, and identity. XR is situated within cultural practices and social environments, allowing students to examine how immersive experiences relate to broader processes of representation and social interaction. Virtual museums, historical and cultural experiences, and socially mediated XR spaces provide contexts for examining perspective, participation, identity formation, and the ways in which immersive meaning is socially and culturally negotiated (Nowak & Fox, 2018; Schroeder, 2011).

The fourth axis (SA4) centers on experience design, critique, and ethics. It brings together the curriculum's constructionist and media literacy orientations by engaging students in the analysis and creation of XR-related experiences with attention to purpose, audience, credibility, and responsibility (Hobbs, 2010; Papert, 1980). Privacy, bias, persuasive influence, representation, and comfort are integrated into design reasoning as recurring considerations across the curriculum (Gray et al., 2018; Madary & Metzinger, 2016; Southgate et al., 2026).

5. Curriculum Content and Grade-Level Progression

Pierce XRLab proposes a two-year developmental progression within a modular curriculum structure that allows some reorganization in response to local conditions. This flexibility is supported by maintaining the developmental emphasis of each grade and the continuity of recurring concepts through the spiral structure (Ireland & Mouthaan, 2020; McTighe & Wiggins, 2012).

5.1 Grade 8: Foundations of Immersive Learning

Grade 8 establishes the experiential and conceptual foundations of the curriculum. The opening unit introduces XR through a guided encounter and establishes an expectation that immersive experiences will be observed, described, and reflected on as part of the learning process. Routine documentation supports interpretation and provides early evidence of learning (Black & Wiliam, 1998; Udeozor et al., 2023). The second unit extends this foundation into everyday contexts through AR. Students examine digital objects and augmentations in familiar settings and compare how AR alters use, meaning, and perception, situating XR within the broader media ecology of everyday life (Akçayır & Akçayır, 2017; Hobbs, 2010).

The third unit introduces historical and cultural interpretation through VR. Curated immersive environments provide contexts for examining viewpoint, framing, and meaning, connecting embodied experience with cultural analysis (Grau, 2003). The fourth unit focuses on visual illusion and the construction of reality. Students analyze perceptual cues and visual effects and begin to explain how immersive experiences can generate a sense of credibility, reinforcing their understanding of immersive media as authored and constructed (Lombard & Ditton, 1997). The fifth and sixth units return to embodiment and perception with greater conceptual precision. Presence, initially encountered through immersive activity, becomes an explicit object of analysis as students describe bodily and attentional cues during brief VR sessions (Sanchez-Vives & Slater, 2005; Slater, 2018). The sequence then broadens the conceptual frame by comparing AR, VR, and MR along a continuum (Jiang et al., 2025; Maas & Hughes, 2020).

The concluding units of Grade 8 bring cultural interpretation and design into closer relation. In the unit on virtual museums and digital exhibitions, students progress from engaging with curated content to making curatorial decisions, introducing an early form of design reasoning (Grau, 2003; Papert, 1980). In the unit on AR and artistic creation, students examine how augmentation can alter the perception and significance of an artwork and create a simple artifact accompanied by a brief statement of intent (Akçayır & Akçayır, 2017).

5.2 Grade 9: Critique, Identity, and Design

Grade 9 builds on this foundation by placing greater emphasis on critique, identity, and design. The opening unit on stereoscopic imagery and the history of immersion situates contemporary XR within a longer history of mediated depth and visual illusion, showing how immersive effects draw on representational practices that predate current XR technologies (Grau, 2003). The next unit revisits presence through questions of identity and participation in shared immersive social environments (Hwang & Chien, 2022). Students examine how avatar representation influences participation, how norms and responsibilities develop in shared spaces, and how social presence acquires cultural significance (Nowak & Fox, 2018; Schroeder, 2011).

This progression prepares students for more explicit critical analysis of XR as a medium of persuasion, framing, and potential manipulation. Using a structured critique process, students identify claims, design features, credibility cues, and implications related to privacy, data use, and user influence, while examining underlying assumptions, risks, and possible safeguards (Gray et al., 2018). The curriculum then extends this analytical orientation into collaborative world-building and narrative planning (Brunetti et al., 2024; Papert, 1980). Students engage with XR concepts as designers, negotiating coherence, representation, and communication with peers. The augmented schoolbook and handheld AR tasks continue this emphasis by requiring students to justify the educational purpose of immersive features and connect technical choices with intended learning outcomes (Hobbs, 2010; Maas & Hughes, 2020).

In the final phase, critique, design, and ethical reasoning converge. The ethics-centered unit asks students to address dilemmas involving comfort, privacy, representation, and responsible participation after developing a broader experiential and interpretive vocabulary (Cossio et al., 2025; Madary & Metzinger, 2016). Ethical reasoning is connected to specific design choices and user scenarios, grounding abstract principles in concrete decisions and consequences (Gray et al., 2018; Madary & Metzinger, 2016). The sequence culminates in immersive storytelling, where students consolidate earlier work on representation, presence, critique, and design through storyboard-based planning and AI-supported prompt development (Ursachi & Dascalu, 2025). They specify narrative flow, user perspective, and interaction decisions and refine these through a short revision cycle informed by guidance on the responsible educational use of generative AI (Miao & Holmes, 2023; Thomann & Deutscher, 2025).

Table 1 summarizes the 16 units, indicating the primary modality and dominant spiral axis for each.

Table 1: *Curriculum Units, Modalities, and Dominant Spiral Axes*

No	Unit title	M	A	No	Unit title	M	A
1	First encounter with XR	***XR***	1	9	Stereoscopic image and the journey toward immersion, from Victorian stereoscopes to VR	***VR***	2
2	Digital objects in everyday life through AR	***AR***	1	10	Presence and identity in the metaverse, from body to avatar	***XR***	3
3	Historical–cultural time travel through VR	***VR***	3	11	A critical view of XR in everyday life, narratives or manipulation tools	***XR***	4
4	Visual illusions and the construction of reality	***XR***	2	12	Building virtual worlds, narrative and collaboration in the metaverse	***XR***	4
5	Presence and embodiment in XR	***VR***	1	13	Designing an augmented AR schoolbook	***AR***	4
6	Exploring MR, extending immersion beyond AR and VR	***MR***	1	14	Merge Cube, creating AR experiences in the hands	***AR***	4
7	Culture and XR, virtual museums and digital exhibitions	***XR***	3	15	Limits, risks, and ethical dilemmas in XR experiences	***XR***	4
8	AR and artistic creation, from Myron Krueger to Artivive	***AR***	2	16	From idea to immersive storytelling, mapping an XR experience with storyboard and AI	***XR***	4

Note. M = modality; A = dominant spiral axis. Values 1–4 correspond to SA1–SA4, as defined in Section 4.1. Each unit may engage more than one axis; the value shown indicates its dominant pedagogical emphasis without implying an exclusive curricular connection.

Table 2: *Spiral Progression across Recurring Concepts*

Recurring concept	Earlier emphasis in Grade 8	Later emphasis in Grade 9
Presence and embodiment	Felt immersion, bodily and attentional cues, and comparison of XR modalities.	Social presence, avatar-mediated identity, participation, and responsibility in shared environments.
Representation and credibility	Visual illusion, perceptual cues, framing, and the construction of credibility.	Stereoscopic depth and the history of mediated illusion; persuasion, media framing, credibility cues, manipulation risks, and critical evaluation.
Culture and identity	Historical and cultural immersion, virtual museums, and early curatorial decisions.	Identity, social norms, avatar representation, and culturally situated participation.
Design and ethics	Simple AR artifacts, statements of intent, guided reflection, consent, comfort, and safe participation.	Collaborative world-building, augmented schoolbook and handheld AR design, ethical dilemmas, and immersive storytelling.

Table 2 makes the spiral progression more explicit by showing how recurring concepts change pedagogical function across the two grades. Earlier encounters emphasize noticing, describing, and comparing, while later encounters require students to interpret social and cultural implications, evaluate credibility and risk, and justify design choices. This movement from experience toward critique and design is the primary mechanism through which the curriculum increases cognitive and interpretive demand over time. The distribution of dominant axes reflects this developmental logic rather than a requirement for numerical balance. Grade 9 therefore contains a greater concentration of SA4 units, as critique, ethics, and design become the principal modes through which earlier concepts are revisited and extended. The next section explains how this progression is enacted within the classroom conditions identified earlier.

6. Implementation Model and Design Considerations

The implementation model connects the curriculum architecture with routines designed to function within the school conditions described in Section 2. Its main priorities are instructional continuity, equitable participation, manageable infrastructure demands, safety, and recurring evidence of learning (Jiang et al., 2025; Maas & Hughes, 2020).

6.1 Instructional Routine, Classroom Operations, and Teacher Role

Instructional continuity is supported through a stable routine across units. Each unit specifies objectives, intended outcomes, an ordered sequence of activities, reflection prompts, and an anticipated artifact or follow-up task (McTighe & Wiggins, 2012; Ward et al., 2025). Across the three-session rhythm, a typical pattern moves from encounter or experience to guided interpretation and reflection, followed by production or artifact development, with the balance adjusted according to the unit. Topics and modalities may vary, but the instructional rhythm remains recognizable. This consistency reduces organizational uncertainty and allows teachers to focus on framing the experience, supporting interpretation, and using student work as evidence for discussion and feedback.

Rotation is used when device availability is limited or immersive exposure needs to remain brief. As one group engages with the immersive component, others work on observation prompts, concept maps, comparison tasks, interpretive annotations, or design planning that prepare for or extend the same learning objective (McKenzie & Fegely, 2023). Non-headset participation provides an alternative route toward that objective through activities with their own pedagogical purpose. This supports participation among students with different levels of prior experience, sensory comfort, or familiarity with immersive media (Bexson et al., 2024; CAST, 2024; Cossio et al., 2025). The rotation model therefore responds to limited device availability while also supporting differentiation and accessibility.

Teacher usability is a deliberate feature of the model. The instructional structure is designed for teachers who may not have specialist expertise in XR systems. Their primary role remains pedagogical, encompassing the framing of experiences, facilitation of discussion, support for interpretation, monitoring of safety and participation, and guidance in helping students articulate the reasoning behind their observations and designs (McTighe & Wiggins, 2012). This emphasis is consistent with K–12 XR research identifying teacher preparedness, manageable routines, and clearly structured lessons as conditions that support sustained classroom use (Jiang et al., 2025; Maas & Hughes, 2020).

6.2 Infrastructure, Accessibility, and Safety Routines

Pierce XRLab adopts a resource-conscious, minimal-hardware infrastructure designed to operate within common school constraints. This characterization refers to the limited infrastructure demands of the model and does not constitute a formal analysis of economic efficiency. Smartphones provide the primary interface for AR viewing, QR-code activation, 3D-object interaction, avatar-related activities, and media capture, allowing several XR modalities to operate within a common classroom workflow (Akçayır & Akçayır, 2017; Maas & Hughes, 2020). Brief VR experiences can be delivered through low-cost smartphone-compatible viewers, while a basic Bluetooth controller and marker-based tools such as Merge Cube can support navigation and tangible forms of collaborative interaction where appropriate (Fehrmann, 2025; Gardeli & Vosinakis, 2025; Wang & Chan, 2024). Software selection prioritizes free or browser-based options where feasible. A further design principle is technological substitutability, allowing tools to be replaced in response to local resources while preserving the learning objective, instructional routine, and expected evidence of learning (Jiang et al., 2025; Maas & Hughes, 2020).

Safety and comfort routines are integrated into the instructional model. Immersive activities are kept brief, supervised, and deliberately paced, with planned transitions between users and explicit procedures for cleaning and equipment handling (Moore et al., 2021). Students have clear opportunities to discontinue immersive use if discomfort arises, and an aligned non-headset pathway remains available with the same conceptual objective. These practices reflect evidence that discomfort and cybersickness can occur during head-mounted display use and should be anticipated through supervision, breaks, and limits on exposure time (Bexson et al., 2024; Cossio et al., 2025; Marks et al., 2025). Commercial XR platforms may also collect interaction, movement, account, and other personal data. Their use therefore requires attention to platform privacy, informed permission and consent procedures, and data minimization in accordance with school policy and applicable requirements (Southgate et al., 2026).

6.3 Assessment Methods

Assessment is embedded in Pierce XRLab through an artifact-centered evidence model that is primarily formative and grounded in authentic tasks of interpretation and production. Objectives and intended outcomes are aligned with sequenced activities, reflection prompts, and specified student outputs so that evidence of learning is generated throughout each unit (Black & Wiliam, 1998; Rosenheck et al., 2021). The model uses three recurring evidence types comprising Experience Logs, Critical Briefs, and Design Artifacts. These provide recognizable structures through which students' thinking can be revisited, discussed, and compared across the spiral curriculum, while individual tasks retain their specific pedagogical purpose.

Experience Logs are most prominent when students are developing language for immersion, presence, augmentation, and embodied attention. They emphasize focused observation and conceptual description (Slater, 2018). Critical Briefs foreground interpretation, media critique, and ethical reasoning by asking students to examine constructed environments, credibility cues, design decisions, platform logics, and social implications (Gray et al., 2018). Design Artifacts require students to externalize and justify decisions about purpose, audience, representation, narrative, and interaction, connecting the assessment model with the curriculum's constructionist orientation (Papert, 1980; Udeozor et al., 2023).

These recurring evidence types also support progression across the curriculum. A student may begin with an Experience Log describing factors that contributed to a sense of immersion, later produce a Critical Brief examining persuasive design and credibility cues, and eventually create a storyboard that justifies narrative and interaction choices. Consistency across these tasks is supported by a small set of reusable criteria, including conceptual clarity, interpretive depth, quality of justification, and awareness of audience and responsibility (McTighe & Wiggins, 2012; Udeozor et al., 2023). These criteria provide common reference points across varied artifacts while preserving the distinct pedagogical purpose of each task. Table 3 summarizes the relationship between each evidence type, its primary purpose, and the dimensions of learning it makes visible.

Table 3: *Recurring Evidence Types and What They Make Visible*

Evidence type	Primary purpose	Typical evidence	Recurring criteria
Experience Log	Reflective noticing and vocabulary development	Perception, presence, embodiment, comparison of experiences	Conceptual clarity; specificity of observation
Critical Brief	Critical interpretation and ethical/media analysis	Claims, framing, credibility cues, privacy, bias, risk, and safeguards	Interpretive depth; quality of justification; responsibility awareness
Design Artifact	Application through creation and design reasoning	Storyboards, AR artifacts, world plans, augmented schoolbook elements, interaction choices	Purpose and audience fit; representation; interaction rationale; responsibility awareness

6.4 Adaptation and Implementation Flexibility

Pierce XRLab is designed to support adaptation across different school environments while preserving a common curricular logic. Its coherence rests on progression, recurring routines, and shared expectations for evidence of learning, reducing dependence on any single hardware ecosystem. This design also reduces reliance on specialized technical support and uninterrupted access to particular devices and aligns with implementation-oriented research emphasizing manageable routines, coordinated supports, and teacher capacity (Jiang et al., 2025; Maas & Hughes, 2020). Transferability is therefore framed as a design intention whose viability must be examined through implementation and evaluation.

Adaptation can occur at several levels. Schools may vary platforms, devices, and content sources while preserving attention to representational purpose, audience, and responsible participation (Hobbs, 2010; Madary & Metzinger, 2016). Cultural and historical units can draw on local museums, heritage, and community examples, and design tasks can be aligned with local subject priorities without altering the course's underlying progression. Although developed as a standalone course, Pierce XRLab may also inform subject-specific or interdisciplinary implementations through its progression, routines, and evidence model, provided that the coherence of the broader framework is maintained. Recurring evidence types remain useful across these variations because they allow teachers to review student thinking over time and adjust prompts, scaffolding, or pacing in response (Black & Wiliam, 1998; Mygdanis, 2025).

Scheduling can also be adapted. Conceptual continuity is carried by the spiral axes, allowing units to be regrouped into shorter thematic cycles, project periods, or interdisciplinary sequences when local timetables require greater flexibility (Ireland & Mouthaan, 2020). Repeatable routines and teacher-oriented materials are intended to support such adaptation without requiring specialist XR expertise. The effectiveness of these adaptations remains an empirical question to be addressed through subsequent implementation and evaluation.

7. Conclusion and Future Development

This chapter argues that the educational value of XR in middle school emerges through the structured movement from experience to reflection, interpretation, dialogue, and evidence of thinking (Black & Wiliam, 1998; Dewey, 1938; Kolb, 1984). Pierce XRLab addresses the gap between isolated immersive activities and sustained curriculum design by connecting longitudinal conceptual progression, repeatable instructional routines, recurring student artifacts, and resource-conscious classroom implementation (Maas & Hughes, 2020; Ward et al., 2025). Developed at Pierce – The American College of Greece, the model is designed to support adaptation across school contexts. Its initial architecture was developed by a single designer within one institutional setting, so its transferability and scalability require further empirical examination.

Empirical evaluation constitutes the current stage of development. A segment of Pierce XRLab has already been implemented and is being examined through a design-based research methodology across twenty middle school classes. This phase marks a transition from initial curriculum development to evidence-informed refinement through classroom implementation. Findings from this work fall outside the scope of the present design chapter and will inform revisions to educational materials, unit content, pacing, and classroom practices. This process follows design-based research principles that connect theory-informed design with iterative testing and revision in real-world settings (Design-Based Research Collective, 2003; Mygdanis, 2025). Planned refinement will focus on concepts that may require more gradual development, points where critical and ethical routines may require reinforcement, and opportunities for interdisciplinary co-teaching that preserve the curriculum's core structure.

A longer-term objective is to extend the program through additional units and a possible third year in Grade 10. Expansion will proceed iteratively so that new content remains aligned with the existing conceptual axes, evidence model, and implementation principles. Continued implementation across different contexts will provide opportunities to examine the transferability and scalability of the framework and to refine its design accordingly (Design-Based Research Collective, 2003; Mygdanis, 2025).

More broadly, XR can support meaningful forms of learning when immersive experiences are deliberately sequenced, interpreted, and integrated into classroom practice (McTighe & Wiggins, 2012; Schott et al., 2024). Curriculum models of this kind can help keep pedagogical purpose, critical interpretation, and evidence of learning in view as immersive technologies continue to evolve.

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