

LOOP: A Transversal Framework for Game-based Learning Analysis and Design

Jérôme Legrix-Pagès

Unicaen Gaming Lab, University of Caen Normandy, France

Homo Ludens Research Group, Université du Québec à Montréal (UQAM), QC, Canada

jerome.legrix-pages@unicaen.fr

Abstract: Despite the proliferation of models addressing serious game design and learning outcomes, educators and designers struggle to articulate gameplay structures, learner experience, pedagogical intentions, and ethical considerations within a unified framework. Existing approaches focus on specific dimensions—systemic mechanics through the Mechanics-Dynamics-Aesthetics (MDA) framework, learning-mechanics alignment through the Learning Mechanics-Game Mechanics (LM-GM) model, or pedagogical context through CEPAJe—yet rarely enable both analysis and iterative design across heterogeneous ludic situations. This paper introduces LOOP, a transversal framework developed since 2017 at the Gaming Lab, University of Caen Normandy. It structures game-based learning analysis and design through seven dimensions: Ludicity, World, Mechanics, Experience, Values, Accessibility, and Transformation. Transformation examines what a game produces beyond itself, including its intended pedagogical effects. Rather than prescribing success criteria, LOOP functions as a reflective scaffold making explicit the choices and trade-offs inherent in ludopedagogical situations. Three exploratory applications are reported. A qualitative thematic alignment analysis of 372 eligible games from an initial corpus of 458 identified patterns across LOOP dimensions: alignment was more frequent for structural dimensions (84–93%) than for Transformation (51%); these figures are not chance-corrected reliability estimates. A diagnostic study of 24 support-seeking educator-led projects identified recurring weaknesses alongside limited benchmarking and self-reported game exposure. A generative study documented 47 games created through LOOP-structured game jams across board, digital, virtual-reality, and live-action formats and educational domains including engineering, urban planning, law, and healthcare. LOOP provides an operational bridge between theoretical models and game-based learning design practice. The paper discusses contributions, limitations, and future research.

Keywords: Game-based learning, Educational game design, Game analysis, Design framework, Ludopedagogy, Transformation

1. Introduction

Game-based learning (GBL) has gained significant traction across educational contexts, from primary schools to higher education and professional training (Connolly et al. 2012; Boyle et al. 2016; Barz et al. 2024). Games promise engagement, immediate feedback, experiential learning, and meaningful contexts for skill development (Gee, 2003).

Yet a persistent challenge remains: how can educators, designers, and researchers systematically analyse existing games for pedagogical potential, design new educational games with coherent learning objectives, and evaluate implemented ludopedagogical situations (Vincent, 2026)?

This paper introduces LOOP, a transversal framework developed since 2017 within the Gaming Lab at the University of Caen Normandy, with support from the French Ministry of Higher Education and Research, and iteratively refined across diverse contexts: higher education, professional training, secondary education, and science mediation (Legrix-Pagès, 2024).

2. Theoretical Background

The development of LOOP responds to a fragmented landscape of analytical and design frameworks in game-based learning. This section reviews major approaches, identifies their contributions and limitations, and positions LOOP as a complementary transversal framework.

2.1 Systemic Approaches

The Mechanics-Dynamics-Aesthetics (MDA) framework (Hunicke et al. 2004) remains foundational in game studies and design education. MDA conceptualises games as systems where designed mechanics give rise to emergent dynamics, which produce aesthetic experiences for players.

Subsequent systemic models have extended this foundation. Schell's (2008) elemental tetrad adds technology and story as design lenses. Fullerton's (2008) framework distinguishes formal, dramatic, and dynamic elements, offering comprehensive vocabulary for design analysis. The Design-Dynamics-Experience (DDE) model (Walk et

al. 2017) and the Design-Play-Experience (DPE) framework (Winn, 2009) foreground player experience, particularly relevant for serious games.

These approaches provide powerful vocabularies for describing game structures, yet they were not developed specifically for educational contexts—their aesthetic categories do not map directly onto pedagogical intentions, and they remain silent on values, ethics, accessibility, and situated deployment.

2.2 Learning-centred Frameworks

A second tradition links game structures to learning processes. The Learning Mechanics-Game Mechanics (LM-GM) framework, developed by Lim et al. (2008) and elaborated by Arnab et al. (2015), proposes mappings between game mechanics (action points, role-playing, resource management) and learning mechanics (exploration, experimentation, reflection, collaboration). This enables designers to select mechanics supporting intended learning processes.

The Activity Theory-based Model for Serious Games (ATMSG) (Carvalho et al. 2015), the Game Object Model II (GOM II) (Amory, 2007), and more recent work on the representational role of game mechanics in socio-ecological systems (Bécu et al., 2025) extend this perspective by incorporating activity context, system dynamics, and social dimensions, foregrounding pedagogical intention. However, the same mechanic can serve different learning purposes depending on context—a variability these mappings do not fully address.

2.3 Contextual and Pedagogical Frameworks

A third tradition emphasises deployment context rather than game structure alone. De Freitas and Oliver (2006) proposed a four-dimensional framework considering learner, pedagogy, context, and representation. CEPAJe (*Contexte*–Context, *Enseignant*–Teacher, *Pédagogie*–Pedagogy, *Apprenant*–Learner, *Jeu*–Game; Alvarez and Chaumette, 2017) similarly situates game analysis within the pedagogical environment, considering teaching context, target audience, learning activities, and game characteristics as interdependent elements. Research on pedagogical integration emphasises that effectiveness depends on how games are introduced, facilitated, and debriefed (Proulx et al. 2017; Crookall, 2010; Sanchez, 2023).

These contextual approaches provide essential corrections to game-centric analyses. However, by foregrounding deployment context, they may underspecify game structures themselves, making cross-game comparison difficult.

2.4 Critical and Ethical Perspectives

A growing body of work addresses values and ideologies embedded in games. Flanagan and Nissenbaum's (2014) *Values at Play* demonstrates how games encode assumptions about competition, fairness, and social relations in their mechanics. Bogost's (2007) procedural rhetoric highlights how rules make arguments about systems. Sicart (2014) examines how games position players as moral agents.

Accessibility research (Hassan, 2024) has also highlighted how design choices include or exclude players with different abilities and cultural backgrounds—considerations salient where games should serve diverse learner populations.

Methodologically, the Digital Game Analysis Protocol (DiGAP; Daneels et al. 2022) provides structured procedures for empirical game study, addressing analytical rigour and replicability.

The frameworks reviewed each illuminate important dimensions of game-based learning, yet practitioners face a fragmented landscape—a persistence recently confirmed by scoping work on serious game design frameworks, which identifies limited integration across learning-oriented, design-oriented, and user-centred approaches (Maxim and Arnedo-Moreno, 2025). A transversal protocol integrating these perspectives is needed.

3. The LOOP Framework and its Seven Dimensions

As shown in Figure 1, LOOP structures inquiry through seven interrelated dimensions, each formulated as a guiding question. These dimensions form a coherent grammar: each informs and shapes the others. Rather than prescribing success criteria, LOOP functions as a reflective scaffold—making explicit the choices and trade-offs inherent in ludopedagogical situations.

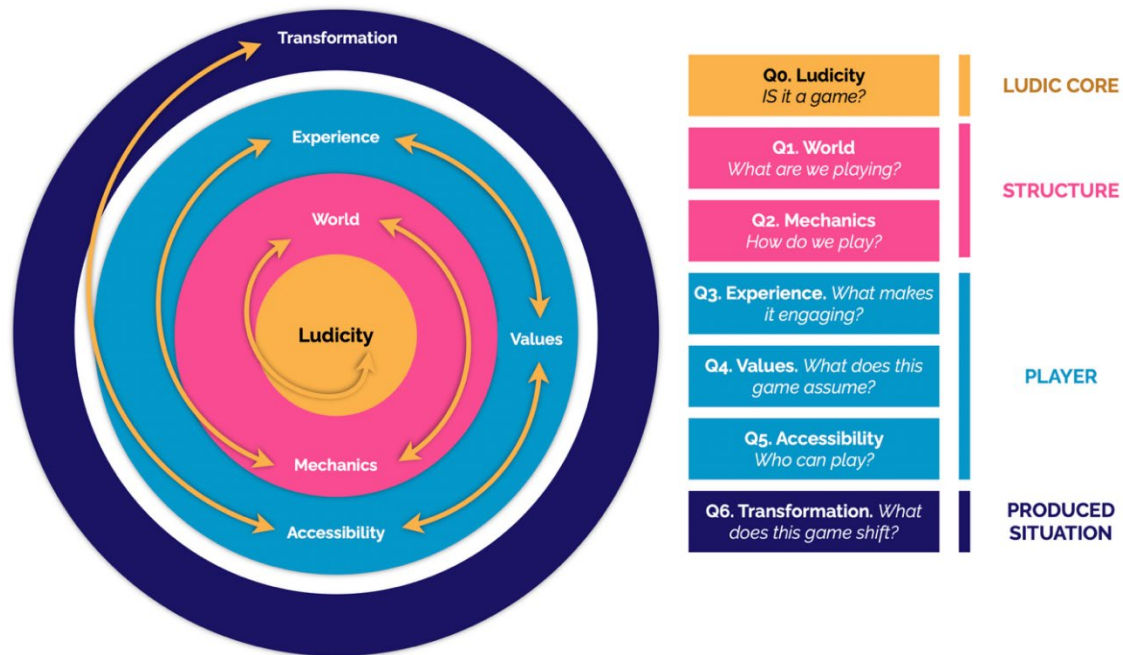


Figure 1: The LOOP framework

3.1 Q0. Ludicity: Is This a Game?

Q0 establishes the ludic nature of the activity. Following Suits (1978), LOOP identifies four constitutive elements: rules structuring possible actions; forms of progression or closure; genuine player agency; and a lusory attitude—willing acceptance of arbitrary constraints for the sake of play (Huizinga, 1938; Caillois, 1958; Henriot, 1989; Brougère, 2005).

This question is diagnostic: when elements are weak or absent, LOOP helps qualify the activity differently (gamified workshop, simulation, interactive narrative). The question also situates the game along descriptive axes: material form, dominant genre, degree of structure (ludus versus paidia), and primary intention.

3.2 Q1. World: What are we Playing?

Q1 concerns the representational world and narrative structures the game proposes. Diegesis concerns the inhabitable world—not the story itself, but the universe making stories possible (Jenkins, 2004; Wolf, 2012). What system or domain does the game model? A political conflict, an ecosystem, an organisation? Game artefacts (boards, tokens, visual design) function as diegetic operators conveying relational structures—interpersonal, social, economic—within which narratives unfold.

Narrative concerns how stories emerge. LOOP distinguishes embedded narrative (pre-authored) from emergent narrative (generated through play). Focalisation is essential: from what perspective do players perceive and act? What information is available, hidden, or asymmetric (Genette, 1972; Fernández-Vara, 2015)?

3.3 Q2. Mechanics: How do we Play?

Q2 examines mechanical structure: resources, actions, turn sequence, information architecture, conflict resolution, feedback systems. The protocol examines gameplay loops—cycles of action, feedback, and adaptation creating engagement and learning opportunities.

Following the LM-GM framework (Arnab et al. 2015), this dimension explicitly maps game mechanics to learning mechanics: how do specific choices (resource management, negotiation, time pressure) support or hinder exploration, experimentation, reflection, collaboration? This mapping is not deterministic; the same mechanic serves different purposes depending on context and facilitation.

3.4 Q3. Experience: What Makes it Engaging?

Moving from structure to experience, this dimension addresses player motivation and engagement. Drawing on Self-Determination Theory (Ryan and Deci, 2000), LOOP examines how game structures support autonomy,

competence, and relatedness. Player typologies (Bartle, 1996; Hamari and Tuunanen, 2014) inform consideration of diverse engagement modes.

Emotional safety is also addressed, relevant for role-play, sensitive topics, or competitive dynamics: phenomena such as bleed—emotional transfer between player and character (White, 2020)—require careful design attention, and challenge levels should support flow without frustration (Chen, 2007).

3.5 Q4. Values: What Does This Game Assume?

Values are embedded not only in themes but in mechanical logic: every rule encodes assumptions about rationality, fairness, cooperation, causality (Flanagan, 2009). A resource-management game models assumptions about scarcity; a voting mechanic embeds assumptions about democratic process.

For educational games, intended objectives may conflict with implicit lessons encoded in structures. A game teaching environmental awareness might reinforce instrumental relationships with nature through its mechanics. LOOP prompts examination of tensions between pedagogical intentions and procedural rhetoric.

3.6 Q5. Accessibility: Who can Play?

Accessibility encompasses sensory and ergonomic dimensions of game experience: visual design, sound, physical materials, interface, and their accessibility implications. Following Hassan (2024), LOOP examines how choices include or exclude players with different abilities, learning needs, and cultural backgrounds.

Accessibility extends beyond disability accommodation to cognitive load, cultural familiarity with conventions, language requirements, and space demands. Aesthetic choices also affect perceived seriousness and tone, influencing how players frame engagement and learning stances (Hodent, 2017).

3.7 Q6. Transformation: What Does This Game Shift?

Where Q0-Q5 examine the game as an artefact and an experience, Q6 turns to the changes a game may produce in players, groups, and deployment settings. This dimension forms an autonomous fourth level, looking at the game from the outside rather than from within its rules.

Transformation operates at individual (knowledge, skills, attitudes), collective (group dynamics, shared culture), and systemic (practices, norms, representations) scales. In educational contexts, the intended pedagogical effect is a central—but not the only—case of transformation: LOOP examines the fit between game characteristics and educational purpose, including introduction, facilitation, and debriefing strategies. The same game can serve different transformational purposes depending on deployment (Bonenfant, 2015), and LOOP prompts explicit articulation of intended shifts and their connection to broader educational trajectories. Transformational interpretation therefore requires explicit assumptions about target populations, purposes, and deployment conditions.

3.8 LOOP as Integrated Protocol

The seven dimensions form an integrated protocol: mechanical choices (Q2) affect values (Q4) and experience (Q3); representation (Q1) shapes accessibility (Q5) and learning mechanics (Q2). Analysis proceeds iteratively across dimensions, and choices throughout Q1-Q5 ultimately bear on what the game can shift (Q6).

4. Methodology

The paper reports a multi-study design comprising three exploratory applications, each addressing a distinct research question (RQ) and a distinct use of the framework:

- *RQ1 (thematic alignment): What patterns of thematic alignment and divergence emerge when analysts independently apply LOOP to the same analog games?*
- *RQ2 (diagnostic utility): Which recurring design weaknesses does LOOP render visible in educator-led game projects, and how do these patterns inform remediation?*
- *RQ3 (generative utility): How was LOOP used to structure game-design processes across heterogeneous formats and educational domains?*

These questions differ deliberately in epistemological status: RQ1 examines LOOP as a descriptive and exploratory instrument, RQ2 and RQ3 as diagnostic and generative scaffolds. Findings from one phase are not used to support claims about another: alignment results (RQ1) are limited to the analog corpus on which they were obtained, whereas the creation study (RQ3) documents the use of LOOP across analog, digital, virtual-

reality (VR), and live-action formats. It does not test cross-format equivalence or extend the findings of RQ1 beyond analog games.

4.1 Study 1: Qualitative Thematic Alignment Analysis (RQ1)

Study 1 examined patterns of thematic alignment when analysts independently applied LOOP to the same analog games. It was designed as an exploratory qualitative alignment study rather than as a psychometric validation or formal inter-rater reliability study. Of 458 analog games initially screened, 372 retained at least two comparable analyses across all seven dimensions and were included in the final analysis. The retained corpus was analysed by 28 trained analysts, with two to six independent written analyses available for each game. For each game, analysts worked independently based on the complete rules and direct examination of the game materials, complemented by play or observation when available. Before analysing games, analysts completed a structured introduction to the seven LOOP dimensions, examined illustrative examples, and applied the protocol to a shared training game. The resulting analyses were collectively discussed to clarify the scope of each dimension and the expected level of justification.

The unit of comparison was the analyst pair within a game and LOOP dimension. All possible analyst pairs were compared. Responses were classified as thematically aligned when they identified the same central feature and attributed the same primary function or implication to it; lexical similarity alone was insufficient. Partial overlap, focus on different central features, or incompatible interpretations was classified as non-alignment. Pairwise classifications followed an explicit thematic-equivalence rule established before comparison. Ambiguous cases were conservatively classified as non-aligned whenever substantive equivalence could not be established.

For each game and dimension, a pairwise alignment proportion was first calculated across all available analyst pairs. Dimension-level values were then calculated as the mean of the game-level proportions, giving each game equal weight regardless of the number of analysts. Missing or non-interpretable responses were excluded dimension by dimension, and the denominator was adjusted to include only eligible analyst pairs.

No chance-corrected coefficient was calculated because no fixed categorical scheme had been specified in advance (McDonald et al. 2019; O'Connor and Joffe 2020). The resulting proportions are descriptive summaries of thematic alignment in this corpus; they are not estimates of inter-rater reliability, evidence for construct validity, or measures of learning effectiveness.

4.2 Study 2: Diagnostic Remediation of Educator-Led Projects (RQ2)

To assess LOOP's diagnostic utility, the framework was applied to 24 educator-led game development projects between 2018 and 2025. Projects typically arrived through individualised pedagogical support requests—often initially framed as needs for graphic improvement, production assistance, or digital implementation. Data collection followed a consistent procedure: systematic application of the framework dimension by dimension, followed by cross-dimensional coherence analysis; documentation tracked initial state, identified weaknesses, interventions, and outcomes. Projects spanned higher education, professional training, and science mediation, in formats including board games, card games, role-playing scenarios, and hybrid digital-physical games.

4.3 Study 3: LOOP-Structured Game Creation (RQ3)

To examine LOOP's generative utility, the framework structured 47 game creation projects through game jams and design workshops between 2017 and 2025. These events brought together interdisciplinary teams—educators, subject matter experts, game designers, students—to create educational games within constrained timeframes. LOOP guided teams through the seven dimensions as a design sequence, requiring explicit address of each dimension and making design rationales visible for discussion and critique; documentation covered design decisions per dimension and project completion. Created games spanned board games, digital games, VR experiences, live-action role-playing, and hybrid formats, across educational domains including engineering, urban planning, law, healthcare, and science mediation. Participants included university students, professional trainers, secondary school teachers, and international participants from 36 nationalities.

5. Results

5.1 Study 1: Thematic Alignment Patterns

Study 1 produced different descriptive patterns of thematic alignment across LOOP dimensions, summarised in Table 1. Mean game-level alignment was higher for Q0 (93%), Q1 (84%), Q2 (88%), and Q5 (85%), which primarily concern observable rules, representations, mechanical structures, and accessibility features.

Alignment was less frequent for Q3 (69%) and Q4 (65%). Divergences in Q3 primarily concerned assumptions about target players and anticipated engagement, while divergences in Q4 concerned which values were treated as mechanically salient. Q6 showed the lowest descriptive alignment (51%). Q6 responses differed particularly in the anticipated target, scale, and conditions of transformation.

These patterns describe thematic alignment within the analog-game corpus and under the procedure reported in Section 4.1. They do not generalise to digital, VR, or hybrid formats.

Table 1: Descriptive thematic alignment by LOOP dimension in the analog-game corpus

Dimension	Alignment
Q0. Ludicity	93%
Q1. World	84%
Q2. Mechanics	88%
Q3. Experience	69%
Q4. Values	65%
Q5. Accessibility	85%
Q6. Transformation	51%

5.2 Study 2: Remediation Patterns

Analysis of the 24 remediation projects revealed recurring weakness patterns in educator-developed games.

Weaknesses were identified across all dimensions with varying frequency, as shown in Table 2. Q0 weaknesses (6/24) corresponded to cases where submitted projects were not games but pedagogical puzzles or gamified exercises.

Table 2: Frequency of identified weaknesses across remediation projects (Study 2), by LOOP dimension

Dimension	Projects with identified weakness (n=24)
Q0. Ludicity	6/24
Q1. World	17/24
Q2. Mechanics	23/24
Q3. Experience	3/24
Q4. Values	15/24
Q5. Accessibility	24/24
Q6. Transformation	15/24

The most frequent mechanical issues (Q2) involved over-reliance on chance-based mechanics reminiscent of *Monopoly*, *Trivial Pursuit*, or *Snakes and Ladders*—roll-and-move progression, quiz-based advancement, and elimination mechanics reducing meaningful player agency. Q1 weaknesses typically involved weak narrative integration: educational content overlaid onto generic structures without meaningful thematic connection to the represented system. Q4 issues emerged through misalignment between intended learning objectives and embedded mechanical values—games designed for collaboration featuring competitive victory conditions, or games addressing complex systems rewarding optimisation of oversimplified metrics. Q5 issues, present in all projects, concerned legibility, cognitive load, language, or ancillary skill demands.

In this support-seeking sample, 20/24 educators acknowledged conducting no benchmark of existing games before designing their own, and 18/24 reported limited game exposure, playing less than monthly.

Following LOOP-based diagnosis, targeted interventions replaced chance-based with decision-based progression, connected activities to represented systems, realigned victory conditions with learning objectives, and reduced ancillary skill barriers. Informal practitioner feedback indicated greater clarity and confidence in prototype iteration.

5.3 Study 3: Documented Game Creation

The 47 completed games document LOOP's use as a generative design scaffold across heterogeneous formats and domains. Not all initiated projects reached completion; the 47 documented games are those successfully finalised.

Notable examples illustrate the diversity of formats and educational applications. *La Formule d'Askiar*, a VR game addressing carbon footprint reduction in concrete production for engineering education, required explicit alignment between VR affordances (Q5), mechanical choices (Q2), represented system accuracy (Q1), and learning objectives (Q6). *Gestion de Crise*, a real-time remote serious game on cooperation in extreme situations for healthcare professional training, focused design attention on Q2 (time pressure mechanics), Q3 (stress and engagement), and Q6 (professional learning transfer). Other completed games include *4 Rue aux Fromages*, a cooperative board game on urban resilience to climate change where Q4 analysis was used to align the mechanics with the message of collective action, and *Consensus*, a live-action role-playing game on collective decision-making for law education, where Q3 considerations guided emotional safety design.

Some LOOP-developed games integrated assessment markers enabling subsequent evaluation: *Gestion de Crise*, for instance, includes decision-logging and structured debriefing prompts enabling post-game analysis of coordination patterns and decision rationales.

6. Discussion

6.1 Contributions

LOOP makes three primary contributions to game-based learning research and practice.

First, it provides theoretical synthesis by integrating systemic (MDA, DDE), learning-centred (LM-GM), contextual (CEPAJe), and critical (Values at Play) perspectives within a unified procedural framework. Rather than replacing existing models, LOOP offers a protocol that mobilises their insights as appropriate to specific analytical or design needs.

Second, LOOP offers operational utility as a practical tool for analysis, design, diagnosis, and remediation. The three applications document LOOP's analytical, diagnostic, and generative uses. The structured question sequence provides shared vocabulary for interdisciplinary teams who might otherwise struggle to integrate game design, pedagogical, and subject matter expertise. The remediation findings highlight LOOP's diagnostic value: surface-level concerns (graphics, production) frequently masked deeper structural issues that LOOP revealed.

Third, Study 1 shows how thematic alignment varied across dimensions within this analog corpus. Alignment was higher for Q0, Q1, Q2, and Q5 (84–93%) than for Q3, Q4, and Q6 (51–69%), suggesting dimensions where assumptions vary more across analysts. The higher alignment observed for Q0, Q1, Q2, and Q5 suggests that structural prompts were applied more similarly across analysts, whereas lower alignment for Q3, Q4, and especially Q6 reflects greater sensitivity to assumptions about player experience, values, and deployment context. These findings indicate areas where the protocol would benefit from clearer prompting and further refinement.

6.2 Limitations

Five limitations warrant acknowledgment. First, Study 1 reports descriptive alignment proportions rather than chance-corrected reliability coefficients, a choice consistent with the open-ended nature of LOOP responses (see Section 4.1) but one that limits direct comparability with quantitative reliability literature. Future work could examine whether specific dimensions—particularly the more categorical Q0—can be operationalised for formal reliability assessment without sacrificing the interpretive flexibility that gives LOOP its practical utility.

Second, the primary corpus consisted of analog games. While LOOP has been used with tabletop role-playing games, live-action role-playing games, video games, and esports contexts, systematic evaluation across these formats remains to be conducted. Digital games introduce considerations—interface complexity, technical accessibility, real-time dynamics—that may require supplementary protocols or dimension elaboration.

Third, the author developed LOOP and conducted its evaluation, raising potential self-validation concerns. Although the source analyses were independent, retrospective mapping and pairwise classification were performed by the framework developer, preserving a risk of interpretive dependence. However, independent replication by researchers outside the Gaming Lab would strengthen evidence of transferability.

Fourth, outcome assessment relied on process indicators—alignment proportions, weakness identification, project completion—and practitioner feedback rather than learning outcome measurement. This paper accordingly makes no claim regarding learning effectiveness: findings document LOOP's use as a design scaffold and a process evaluation instrument, not a predictor of measurable student outcomes.

Fifth, while LOOP game jams have involved participants from 36 nationalities, the framework's core development occurred in a French higher education context. Cultural assumptions about pedagogy, play, and game conventions may influence the framework in ways that limit cross-cultural generalisability.

6.3 Future Directions

This work suggests five priorities: format-specific extensions elaborating LOOP for digital, virtual and augmented reality, live-action, and hybrid forms; independent replication outside the development context, addressing developer-related bias and testing transferability across institutional and cultural settings; learning outcome research comparing LOOP-structured designs with designs developed without structured frameworks; training and dissemination tools facilitating adoption by educators without game design expertise; and longitudinal tracking of deployment beyond initial development.

7. Conclusion

Three findings emerge from this work. First, within this analog corpus, structural dimensions showed higher descriptive alignment than experiential, value-related, and transformational dimensions. Second, within the support-seeking sample, recurring weaknesses co-occurred with limited benchmarking and self-reported game exposure, leading to recurring weakness patterns that structured frameworks can help address. Third, transversal protocols like LOOP appear to support interdisciplinary dialogue by making design tensions explicit rather than prescribing solutions.

These findings point toward a broader shift: from seeking universal criteria for "good educational games" toward developing shared vocabularies for examining the trade-offs any ludopedagogical situation involves. LOOP contributes one such vocabulary—provisional, open to refinement, and examined through three exploratory applications.

Ethics Declaration: This research involved voluntary participants in game analysis, game jams, and educational game development. No sensitive data were collected. The author declares no conflict of interest.

AI Declaration: Claude (Anthropic) was used to support referencing-style compliance. The author takes full responsibility for all content.

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