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Gamified Media Design for Sustainable Campus Participation: A Two-Phase Evaluation of a Digital Recycling Communication Platform

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Abstract

Sustainable behaviour systems in higher education are increasingly delivered through mobile digital platforms, yet their role as media artefacts remains under-examined in media and communication research. This study addresses this gap by analysing a gamified WeChat Mini Program for campus recycling as a creative media design artefact that mediates user attention, feedback, identity, and participation. The study is motivated by a documented attitude–behaviour gap at a university campus in Jiangsu Province, China: 84.48% of surveyed students (N = 406) understood waste-sorting rules, while only 19.21% consistently practised correct sorting. Guided by Design Science Research, seven evidence streams were translated into the Evidence-Driven Dual-Engine Recycling Engagement Framework (EDRF), which was operationalised as a deployed WeChat Mini Program and evaluated across two field phases. Phase 1 confirmed operational reliability with 234 registered users, 446 verified submissions, 1,291.03 kg of recyclables, and 100% settlement success. Phase 2 activated the full gamified experience and produced positive expert evaluation (n = 14, M = 4.05/5.00) and student usability evaluation (n = 40, M = 4.00/5.00). Supplementary backend records further indicated continued operational activity after the structured evaluation window. The findings support the interpretation of gamified sustainability platforms as behaviour-mediating media artefacts, where feedback visibility, identity narrative, and institutional trust are central to sustained participation.

Keywords: creative media design, gamified media, WeChat Mini Program, campus recycling, environmental communication, Design Science Research

1. Introduction

1.1 Mobile Media Platforms and Mediated Pro-Environmental Participation

A growing share of everyday pro-environmental routines—sorting domestic waste, monitoring household electricity, paying for transit—now passes through mobile media platforms before it becomes a recorded behaviour. The platform is no longer a peripheral aid to the environmental act; it is the medium through which the act becomes visible, accountable, and socially shareable. For media and communication research, this shift raises a question that has not yet been examined systematically: how does the design of such platforms—their feedback architecture, identity cues, interaction flow, and visible operational reliability—shape whether users return to them again and again, particularly when the underlying action (such as recycling) is itself low in immediate reward and high in friction?

University campuses are an instructive setting in which to study this question. Campuses contain dense, repeated, and routinised participation patterns; they have shared institutional rules; and in the Chinese higher education context, they are highly mediated through WeChat-based services. Yet continued recycling participation on Chinese university campuses remains difficult to achieve. At a university campus in Jiangsu Province, China, 84.48% of surveyed students (N = 406) reported being clear or fairly clear about waste sorting rules, while only 19.21% reported consistent sorting practice—a 65.27 percentage-point divergence. Existing research has typically explained such divergences through psychological constructs (Kollmuss & Agyeman, 2002) or institutional barriers. This study examines a complementary but under-explored layer: the mediation layer itself. Where the digital platform fails to make the action visible, credible, and continuous, attitudes do not translate into behaviour—not because students do not care, but because the medium does not carry the action well.

1.2 Gamification: From Mechanic Stacks to Mediated Experience

Gamification—the use of game design elements in non-game contexts (Deterding et al., 2011)—has been the dominant design response to behavioural participation gaps in sustainability research. Reviews report that points, badges, leaderboards, and progress bars can increase short-term participation in pro-environmental routines (Douglas & Brauer, 2021; Boncu et al. 2022). However, once novelty fades, mechanic-driven engagement decays, and external rewards may undermine the intrinsic motivation that sustains long-term practice (Ryan & Deci, 2020). Bogost (2014) describes mechanic-only gamification as a category error that confuses scoring with meaning. Nicholson (2015) and Deterding (2015) argue that what distinguishes effective from ineffective gamification is not the presence of mechanics but their integration into a coherent designed experience in which feedback, narrative, identity, and trust align. This reframing is what the present article develops: a gamified WeChat Mini Program for campus recycling treated not as a behavioural intervention layered over a recycling device, but as a designed media artefact whose features function together as a communicative whole.

1.3 A Media Design Perspective on Gamified Sustainability Platforms

The analytical perspective adopted here draws on three converging lines of scholarship. Persuasive design and behaviour-change technology (Fogg, 2002; Oinas-Kukkonen & Harjumaa, 2009) have shown that digital systems shape behaviour through how their logic is presented to users. Interaction and experience design research (Hassenzahl, 2010; Norman, 2016) has established that perceived usefulness and felt experience are produced through visual, temporal, and interactive composition. Mobile media research has begun to treat platforms such as WeChat not as neutral conduits but as active media environments that organise everyday participation (de Seta, 2018; Plantin & de Seta, 2019). Bringing these threads together, this article advances the following position: a gamified sustainability platform is best understood as a behaviour-mediating media artefact in which four design layers—incentive feedback, identity narrative, interface clarity, and operational reliability—must align for continued user engagement to be possible.

1.4 Research Questions

RQ1. What stakeholder requirements, participation barriers, and interaction challenges must be identified to inform the design of a gamified media artefact for continued campus recycling participation?

RQ2. How can these requirements be translated, through an evidence-driven design architecture, into a deployable gamified WeChat Mini Program that integrates incentive feedback, identity narrative, interface clarity, and operational reliability as aligned media design layers?

RQ3. How do expert assessment, student usability evaluation, and post-evaluation operational records jointly evidence the engagement-supporting capacity of the deployed media artefact across structured and post-evaluation deployment windows?

1.5 Contribution and Article Structure

The article contributes to media and communication scholarship in three ways. Theoretically, it reframes gamified sustainability platforms as behaviour-mediating media artefacts. Methodologically, it demonstrates how Design Science Research can move from multi-stream stakeholder evidence to a deployed and temporally extended, field-observed digital artefact. In terms of design knowledge, it offers the EDRF—whose seven design rules can be read as transferable principles for gamified media products in adjacent participation domains. The remainder reviews the literature (Section 2), details the methodology and evaluation design (Section 3), presents the EDRF (Section 4), reports deployment and evaluation (Section 5), and discusses the findings and conclusions (Sections 6–7).

2. Literature Review: From Gamification Mechanics to Mediated Sustainability Participation

2.1 Gamification and Pro-Environmental Behaviour: From Mechanic Effects to Mediation Effects

Gamification is conventionally defined as the use of game design elements in non-game contexts (Deterding et al., 2011). Within sustainability research, gamification has been operationalised primarily through extrinsic mechanics—points, badges, leaderboards, progress bars, and material rewards. Systematic reviews report that such mechanics can produce statistically observable improvements in short-term participation (Douglas & Brauer, 2021;Boncu et al. 2022). The same body of work, however, identifies a recurring limit: once novelty fades and external incentives lose salience, mechanic-driven participation tends to decay, and intrinsic motivation may be displaced by reward-contingent compliance (Hamari et al., 2014; Ryan & Deci, 2020). Self-Determination Theory (Deci & Ryan, 2000) attributes the decay to the over-justification effect; the Theory of Planned Behaviour (Ajzen, 1991) frames the residual attitude–behaviour gap as a problem of perceived behavioural control; the Hook Model (Eyal, 2014) describes how trigger–action–reward–investment cycles can produce habituated return. These constructs illuminate parts of the engagement puzzle but do not address the question that has become increasingly visible: even when mechanics are present and motivationally well-formed, whether a user perceives a reward as credible, whether progress is rendered legibly, whether the institutional promise behind a points balance is trusted—these are properties of the medium, not the mechanic.

Recent reviews register this shift: Boncu et al. (2022) report that mechanically identical interventions diverge according to how they are presented and embedded in everyday routines. The analytical centre of gravity is shifting from which mechanics work toward how the platform mediates the action—the movement this study takes as its starting point.

2.2 Persuasive Design, Experience Design, and the Media Turn in Gamification

Three closely related design research traditions provide the conceptual resources for a media-artefact framing. Persuasive systems design (Fogg, 2002; Oinas-Kukkonen & Harjumaa, 2009) treats the system as a communicative actor whose compositional features must align for behavioural influence to occur. Experience design (Hassenzahl, 2010; Norman, 2016) treats user engagement as an emergent property of how a system orchestrates attention, action, feedback, and meaning over time. Game studies and HCI have made parallel arguments specifically about gamification: Bogost (2014) critiques mechanic-stacking as confusing scoring with meaning; Nicholson (2015) proposes meaningful gamification requires deliberate composition of reflection, choice, information, and play; Deterding (2015) specifies how gameful design must align goals, actions, feedback, and challenge; Sicart (2014) reframes play itself as a designed cultural form. Across these contributions, a consistent thesis emerges: gamification effectiveness is a property of design composition, not mechanic presence. When brought into contact with media and communication scholarship, a further implication becomes visible: the platform is not merely the container of game design; it is itself a medium with its own communicative logic. Figure 1 visualises this conceptual progression. The three framings are not mutually exclusive; they represent an expansion of analytical scope from discrete mechanics, to composed user experience, and finally to the platform as a behaviour-mediating media artefact. The present study adopts Framing 3, in which gamified sustainability platforms are analysed through incentive feedback, identity narrative, interface clarity, and operational reliability. Table 1 summarises the three analytical framings.

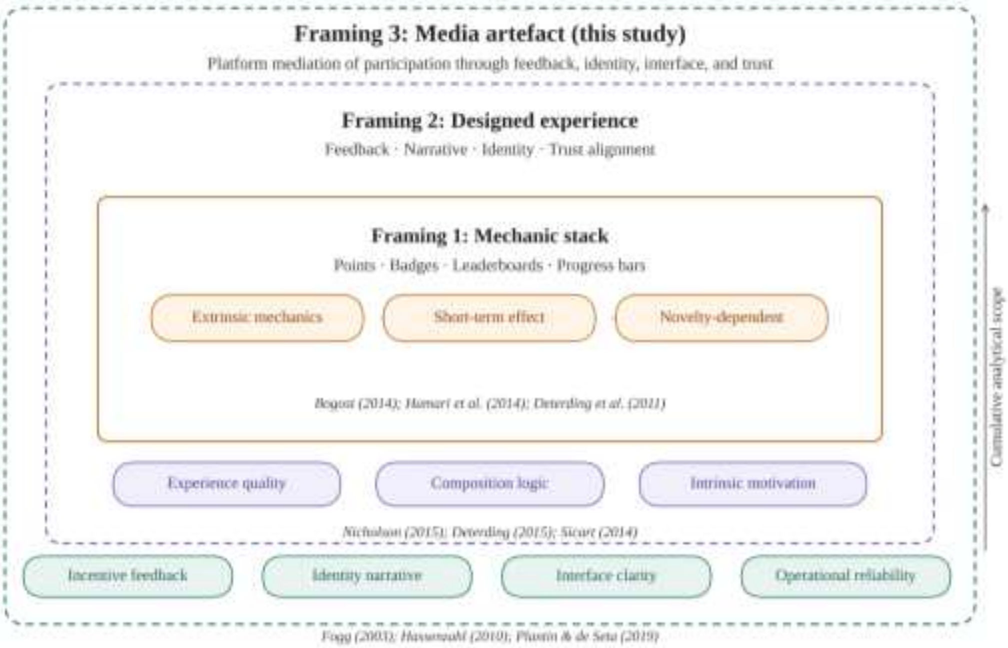

Figure 1. Conceptual evolution from gamification mechanics to media artefact framing

Table 1. Three Analytical Framings of Gamified Sustainability Platforms

Analytical framing	Unit of analysis	Core claim	Representative literature
Mechanic stack	Individual game mechanics (points, badges, leaderboards) treated as discrete motivators.	Adding mechanics increases participation; effect is generally short-term.	Hamari et al. (2014); Douglas & Brauer (2021); Boncu et al. (2022)
Designed experience	Integrated user experience produced by aligned mechanics, narrative, and feedback.	Mechanics become effective only when composed into a meaningful, intrinsically satisfying experience.	Bogost (2014); Nicholson (2015); Deterding (2015); Sicart (2014)
Media artefact (this study)	Mediation of action: how the platform makes participation visible, credible, and continuous.	Platforms support continued pro-environmental action by aligning incentive feedback, identity narrative, interface clarity, and operational reliability as a communicative whole.	Fogg (2002); Hassenzahl (2010); Oinas-Kukkonen & Harjumaa (2009); Plantin & de Seta (2019)

Note. The three framings are cumulative analytical lenses. Representative literature is illustrative, not exhaustive.

2.3 WeChat Mini Programs as a Media Environment for Campus Participation

Most gamification–sustainability research has been developed on Western platforms or in stand-alone application contexts. WeChat operates not as a single product but as a layered platform integrating messaging, payment, identity verification, location services, and a Mini Program ecosystem within one persistent user environment (Plantin & de Seta, 2019). Mini Programs do not require independent installation, are launched through QR codes embedded in physical infrastructure, inherit the host platform's identity layer, and operate within an established trust frame. A media-studies framing makes the communicative role of this infrastructure analytically visible: WeChat is not the channel through which a recycling app reaches students; it is part of the medium in which the action takes place. Emerging work on Chinese platform infrastructures (de Seta, 2018; Plantin & de Seta, 2019) has begun to articulate this perspective at the platform-architecture level. The present study extends it to the artefact level.

2.4 Design Science Research as a Methodology for Media Design Knowledge

Design Science Research (DSR) suits this study because the goal is not merely to describe a phenomenon but to construct and evaluate a purposive artefact whose properties contribute to design knowledge (Hevner et al., 2004; Peffers et al., 2007). DSR is increasingly recognised in media and communication research, where knowledge is often embodied in interfaces, interaction flows, and platform configurations rather than in propositional theory alone (Vaishnavi & Kuechler, 2015). The study adopts a pragmatist stance: the design contribution is judged by whether the artefact performs usefully under real-world conditions and whether the resulting design knowledge transfers to adjacent settings.

2.5 Research Gaps and Contribution Positioning

Three gaps in the existing literature jointly motivate the present study. First, the mediation layer of gamified sustainability platforms is under-theorised. Second, WeChat and other Chinese super-apps are rarely analysed as media environments in pro-environmental research. Third, post-evaluation operational evidence from authentic institutional deployments of gamified media artefacts is uncommon. Table 2 summarises these gaps and the corresponding contributions of the present study.

Table 2. Research Gaps and Contributions of the Present Study

Gap	State of the literature	Contribution of this study
G1. Mediation layer of gamified sustainability platforms is under-theorised.	Existing reviews catalogue mechanics and motivational effects but rarely analyse how the platform communicates action back to users, or how visual, interactive, and narrative composition shapes participation.	Reframes gamified sustainability platforms as behaviour-mediating media artefacts, identifying four mediation layers (incentive feedback, identity narrative, interface clarity, operational reliability) whose alignment is necessary for continued engagement.
G2. WeChat as a media environment is rarely analysed in pro-environmental research.	Most sustainability-gamification studies are developed on Western platforms or stand-alone apps. The communicative affordances of super-app Mini Programs — embedded identity, low-friction entry, payment continuity — are seldom examined.	Treats WeChat not as a neutral container but as an active media environment that shapes how a gamified sustainability artefact is encountered, trusted, and returned to.
G3. Few studies provide post-evaluation operational evidence of a gamified media artefact in real deployment.	Empirical evaluations tend to rely on short-term experiments, single questionnaires, or simulated use. Multi-stream evidence collected across structured and post-evaluation windows in an authentic institutional setting is uncommon.	Provides three-stage operational and evaluation evidence — Phase 1 (23 active days), Phase 2 (structured March–April 2026 evaluation), and supplementary backend records (April–May 2026) — from an authentic university deployment.

Note. The contributions are stated at the level of the article's analytical claim; their empirical and design substance is developed in Sections 4 and 5.

3. Methodology: Design Science Research and Two-Phase Evaluation

The study follows Design Science Research (DSR), generating knowledge through the purposeful design, development, and evaluation of artefacts (Hevner et al., 2004; Peffers et al., 2007). A pragmatist epistemological stance grounds the sequential mixed-methods design: qualitative evidence identifies design constraints, quantitative survey and operational data characterise participation patterns, and evaluation evidence provides formative design knowledge (Creswell & Plano Clark, 2007). These evidence streams are integrated through systematic triangulation.

3.1 Pre-Development Evidence Collection

The pre-development stage integrated seven evidence streams through twelve instruments. Several streams advanced in parallel; the December 2025 student survey served as a late-stage quantitative validation layer before Phase 1 deployment. Table 3 summarises the streams, scope, timing, and design knowledge contribution.

Table 3. Pre-Development Evidence Streams

Evidence Stream	Sample / Scope	Period	Design Knowledge Contribution
Literature synthesis	145 sources	Ongoing	Theoretical grounding: gamification, persuasive design, behaviour change
Comparative case analysis	6 campus cases	Ongoing	Operational precedents and participation failure modes
Field observation (I1)	n = 385 instances	Oct 2025	Interaction barriers and recycling behaviour patterns
Student survey (I2)	N = 406	Dec 2025	Participation barriers, gamification preferences, TAM dimensions (Davis, 1989)
Stakeholder & expert interviews (I3–I6)	n = 14; 524 min; κ = 0.82	Jul–Oct 2025	Operational, governance, hardware, and gamification design constraints
Pilot device evaluation (I7)	n = 40	Oct–Dec 2025	Interaction friction points and prototype failure modes
Interface preference survey (I8)	n = 64	Oct–Dec 2025	Visual design preferences and feature attractiveness

Note. Expert interview transcripts (I3–I6, 524 min total) were coded through NVivo-assisted keyword frequency and dimensional categorisation, producing 247 coded segments with inter-rater reliability Cohen's κ = 0.82 (threshold κ ≥ 0.75; Landis & Koch, 1977). Student survey (I2) and student usability form (I11) were content-validated using the Index of Item-Objective Congruence (IOC ≥ 0.67) and piloted for internal consistency (Cronbach α ≥ 0.70). Expert evaluation form (I10) was validated through face validity review by two independent academics. Back-end records (I12) were cross-verified against operator physical clearance logs.

3.2 Data Analysis

Qualitative data from observation (I1) and interviews (I3–I6) were analysed using thematic analysis (Braun & Clarke, 2006) with NVivo-assisted coding. Quantitative survey data (I2, N = 406) were analysed using descriptive statistics, t-tests, one-way ANOVA, and Pearson correlation. Expert evaluation data (I10) and student usability data (I11) were analysed using descriptive statistics; SD thresholds guided consensus interpretation (SD < 0.50 = strong consensus). Triangulation followed a five-step procedure: within-source coding, cross-source comparison, convergence and divergence identification, synthesis into design mandates, and translation into EDRF rules and modules.

3.3 Two-Phase Evaluation Design

The evaluation followed two structured phases with supplementary post-evaluation tracking. The phased design separated operational reliability confirmation from full gamified experience assessment, recognising that reliability failure in early deployment undermines the trust foundation required for engagement features to function as intended. Table 4 presents the full evaluation design.

Table 4. Two-Phase Evaluation Design

Phase	Period	Purpose	Data Sources
Phase 1: Operational reliability	25 Dec 2025–16 Jan 2026 (23 days)	Confirm core-loop function and trust foundation	Back-end transaction records (I12): registration, submissions, weight totals, 100% settlement success
Phase 2: Full gamified experience	Mar–Apr 2026 (~60 days)	Evaluate full media experience with expert and student assessment	Expert evaluation (I10, n = 14, FUT1–FUT4, M = 4.05/5.00); student usability (I11, n = 40, FES1–FES6, M = 4.00/5.00); back-end records (I12)
Post-evaluation tracking	Apr–May 2026 (supplementary)	Track continued engagement beyond structured window	Back-end records (I12): Apr 2026 (775 submissions, 1,321.93 kg); 1–13 May 2026 (321 submissions, 765.93 kg; 1–5 May = Labour Day holiday)

Note. Expert evaluation (I10, n = 14) is positioned as formative design assessment; student usability testing (I11, n = 40) addresses user experience rather than behavioural change attribution. No control group was included; causal claims about specific features are not made.

3.4 Ethical Considerations

All participants provided informed consent. Expert interviewees are pseudonymised (E1–E5); student data were collected anonymously. The study complied with institutional ethics requirements at a university campus in Jiangsu Province, China. All personally identifiable information was removed from the analytical dataset before analysis; back-end records contain only anonymised transaction entries (timestamp, weight, device ID, points allocated). WeChat OAuth authentication was implemented in compliance with China's Personal Information Protection Law (Standing Committee of the National People's Congress, 2021).

AI Assistance Disclosure. The preparation of this manuscript involved the use of Claude (Anthropic) as an AI writing assistant. AI assistance was used in the following capacities: structuring and drafting sections of the manuscript text, reformulating arguments for clarity and academic register, and organising reference lists. All empirical data, research design, theoretical arguments, analytical interpretations, and conclusions are the original work of the author. The author takes full responsibility for the accuracy, integrity, and originality of the content of this manuscript.

4. Design Model: From EDRF to Gamified Creative Media Design

This section presents the Evidence-Driven Dual-Engine Recycling Engagement Framework (EDRF) as a gamified creative media design model. Its purpose is to reinterpret the framework's architecture through a creative media design lens, demonstrating how its four layers, dual-engine structure, and seven design rules together constitute a behaviour-mediating media artefact.

4.1 The EDRF as a Four-Layer Media Design Architecture

The EDRF was constructed through the systematic translation of seven evidence streams into decision rules, configurable parameters, and deployable modules. Its architecture comprises four vertically connected layers: Behavioural Logic (L1), Rule Layer (L2), Configuration Layer (L3), and Functional Module Layer (L4). Table 5 presents the four-layer structure with both its original function and its creative media design role.

Table 5. Four-Layer EDRF Structure and Creative Media Design Interpretation

EDRF Layer	Original Function	Creative Media Design Role	Key Components
L1 Behavioural Logic	Dual-Engine motivation core: Engine A (extrinsic) + Engine B (intrinsic)	Defines the participation logic and emotional experience of the media artefact	Engine A: points, rewards, leaderboards, challenges. Engine B: Eco-Garden, levels, badges, mascot, identity narrative
L2 Rule Layer	Seven evidence-derived decision rules (DR1–DR7)	Creative media design constraints governing interaction, feedback, and trust	DR1 Low-friction entry; DR2 Failure-first recovery; DR3 Information priority; DR4 Penalty transparency; DR5 Incentive-loop visibility; DR6 Weak-network resilience; DR7 Governance–operations coupling
L3 Configuration Layer	Default strategies and configurable parameters for each DR	Interface, feedback, and operational parameters that shape the media experience	Home-screen priority; SLA visibility; appeal/audit logic; offline sync; adaptive verification mode
L4 Functional Module Layer	Deployable modules M1–M8 covering interaction, social, trust, and operations	The deployable media features through which engagement is experienced by users	WeChat Mini Program, smart recycling device, Eco-Garden, leaderboard, reward centre, disposal log, admin dashboard

Note. L = Layer; DR = Decision Rule; M = Functional Module.

4.2 Dual-Engine Architecture as Dual Media Experience

The central architectural innovation of the EDRF is its dual-engine gamification design. Engine A constitutes the extrinsic incentive chain—points, weight-based rewards, leaderboards, challenges, and redemption—that provides immediate material confirmation of the recycling action. Engine B constitutes the intrinsic engagement layer—Eco-Garden cultivation, level progression, badges, mascot interaction, and environmental contribution visualisation—that converts repeated recycling from a transaction into a personal progress narrative. The EDRF resolves the risk of motivational crowding-out (Ryan & Deci, 2020) by decoupling the two engines structurally. This separation also serves a financial function: gamification experts recommended incentive levels of CNY 0.80–1.20/kg while recycling operators reported a price ceiling of CNY 0.60–0.70/kg. Engine B bridges this gap by substituting ecological narrative, identity progression, and social recognition for the monetary shortfall—making the system financially sustainable within market-determined cost constraints. Table 6 presents the dual-engine architecture interpreted as dual media experience layers.

Table 6. Dual-Engine Architecture as Dual Media Experience

Engine	Original EDRF Function	Creative Media Design Interpretation	Key Media Elements
Engine A: Extrinsic Incentive Chain	Initial participation trigger through points, weight-based settlement, leaderboard, and redemption	Incentive-feedback media layer: makes user actions visible, quantified, and materially meaningful	Points display, reward centre, leaderboard, challenge tasks, settlement confirmation
Engine B: Intrinsic Engagement Layer	Long-term engagement through Eco-Garden, levels, mascot, environmental contribution, and social identity	Identity-narrative media layer: converts recycling into cumulative progress story and social meaning	Eco-Garden growth, level progression, badges, mascot states, environmental impact visualisation
Operational Reliability (prerequisite)	100% settlement success and zero anomalous submissions as trust foundation	Trust-building experience: confirms that the media promise is credible and the institution is accountable	Disposal records, one-click appeal, SLA notifications, audit log, penalty evidence requirement

Note. Operational reliability is included as a prerequisite layer because the media experience of both engines depends on the user's trust that rewards are settled correctly and that system judgements are contestable.

4.3 Seven Design Rules as Creative Media Principles

The EDRF's Rule Layer formalises seven evidence-derived decision rules (DR1–DR7) that translate the empirical constraints identified in the pre-development stage into operational requirements. This article interprets them as creative media design principles governing how the media experience is composed, presented, and sustained. Table 7 presents the full set with their original labels, creative media interpretation, and primary evidence sources.

Table 7. EDRF Decision Rules (DR1–DR7) as Creative Media Design Principles

Rule	Original Label	Creative Media Design Principle	Primary Evidence Source
DR1	Low-Friction Entry	Interaction simplicity: the deposit path must remain cognitively light and immediately understandable	Pilot evaluation (55% Passive Compliant type; 4 P0 flow failures); survey (N = 406, 48.52% cite inconvenience as primary barrier)
DR2	Failure-First Recovery	Reliability as trust-building: failure modes must be resolved before engagement features are activated	Pilot P0 issues (touchscreen, weighing, door); operator interviews (contamination >15% triggers rejection)
DR3	Evidence-Based Information Priority	Visual hierarchy: interface emphasis follows empirically validated user priority (Visual 4.61 > Scan 4.53 > Points 4.48)	Interface preference survey (n = 64; feature attractiveness matrix)
DR4	Trust and Penalty Transparency	Feedback credibility: all system judgements must be visible, explainable, and contestable before acting on users	Survey (12.32% lack-of-faith finding); pilot P0 (unexplained penalty deductions cause trust collapse)
DR5	Incentive-Loop Visibility	Real-time feedback: reward status, review progress, and delay notifications must remain continuously visible	Expert interviews (E1–E5: instant feedback as core gamification principle); pilot P1 (withdrawal delays erode enthusiasm)
DR6	Weak-Network and Outdoor Resilience	Experience continuity: outdoor and low-connectivity conditions are normal operating contexts, not edge cases	Field observation (campus coverage gaps, night lighting); pilot P2 (offline degradation issues); supplier interviews (T1–T3)
DR7	Governance–Operations Coupling	Institutional alignment: incentive intensity, verification, and responsibility must match real operational capacity	Case analysis (bin overflow → trust erosion loop); operator price ceiling (CNY 0.60–0.70/kg) vs. expert recommendation (CNY 0.80–1.20/kg)

Note. DR1–DR5 are more directly associated with the gamification and media experience dimensions of the model. DR2, DR6, and DR7 extend the model toward failure recovery, outdoor resilience, and governance alignment.

Three rules deserve particular attention. DR4 (Trust and Penalty Transparency) is structurally critical because penalising users without visible explanation destroys the credibility of the feedback architecture itself. DR5 (Incentive-Loop Visibility) treats reward communication as a media design problem: whether users return depends on whether they can see their actions being processed. DR7 (Governance–Operations Coupling) recognises that a media promise is only as credible as the institutional capacity behind it.

4.4 Expert Refinement of the EDRF

The initial model was refined through evaluation by the 14-member expert panel spanning campus administration, recycling operations, gamification and design, and technical equipment. Key refinements made the Phase 1/Phase 2 boundary explicit, strengthened the resilience and governance layer to reflect operator-confirmed constraints, and added mascot state triggers aligned with Engine B. The refined model preserved the four-layer structure and DR1–DR7 rule set and governed all subsequent prototype development and deployment decisions.

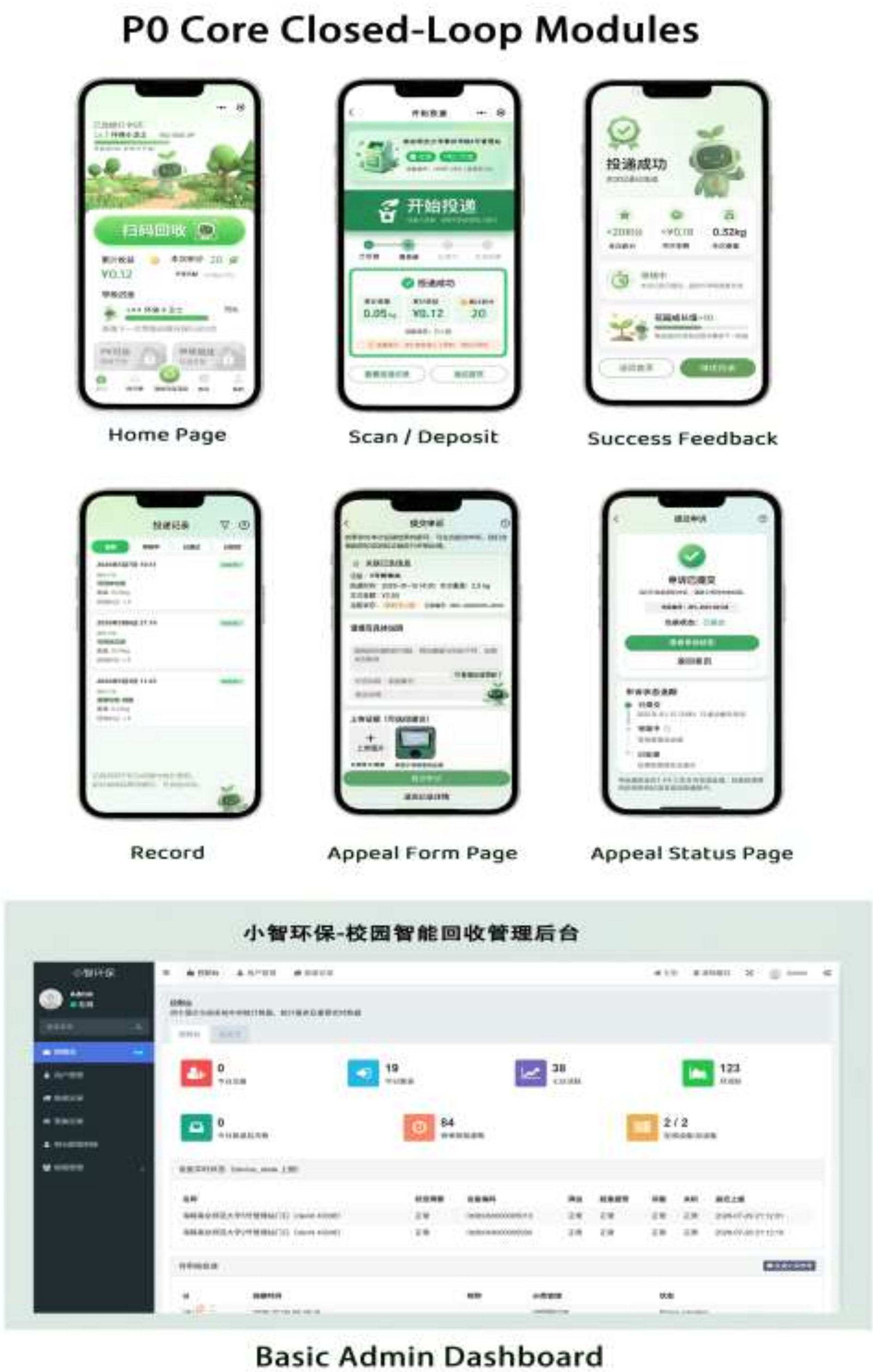

Figure 2. User-facing Media Features of the Gamified Mobile Recycling Artefact

5. Prototype Deployment and Evaluation

This section reports the two-phase campus deployment of the gamified WeChat Mini Program and its evaluation through operational records, expert assessment, and student usability testing. The deployment context was a university campus in Jiangsu Province, China, with two smart recycling stations operated by a local smart recycling equipment provider. The phased design separated operational reliability confirmation (Phase 1) from full gamified experience evaluation (Phase 2).

5.1 Study Context and System Features

The WeChat Mini Program translated the EDRF architecture into a coordinated set of media features rather than isolated functional tools. As shown in Figure 2, the user-facing interface combined four interrelated media layers. First, scan-to-recycle entry operationalised DR1 by reducing participation friction through a simple QR-based interaction. Second, the points display, reward centre, disposal record, and SLA-visible settlement status operationalised DR4 and DR5 by making the incentive process transparent, continuously visible, and accountable. Third, the Eco-Garden, level progression, badges, mascot interaction, and environmental contribution display operationalised Engine B, transforming repeated recycling into a cumulative identity and progress narrative. Fourth, leaderboards and dormitory PK competition—activated only after per-building active-user thresholds (DR7)—introduced peer comparison and collective recognition. Together, these features demonstrate that the prototype functioned as a behaviour-mediating media artefact: it did not merely record recycling behaviour but communicated each action back to users through feedback visibility, identity cues, and trust-building interface structures.

5.2 Phase 1: Operational Reliability Evidence

Phase 1 ran for 23 active days from 25 December 2025 to 16 January 2026, activating only the core scan-deposit-audit-points loop with Phase 2 gamification features held in locked-state display. This configuration established that the system's functional reliability was not contingent on gamification design quality. Table 8 summarizes the Phase 1 operational indicators alongside their design rule implications.

Table 8. Phase 1 Operational Indicators and Design Rule Implications

Indicator	Value	Design Rule Implication
Active deployment days	23 days (25 Dec 2025–16 Jan 2026)	Real campus deployment over examination and holiday period, without experimental scaffolding
Registered members (deduplicated)	234 users	DR1 validated: 38 users self-registered on Day 1 at both stations through organic discovery, with no promotional campaign
Verified submissions	446	DR5 validated: daily submission weight grew from 0.42 kg (1 Jan) to 285.51 kg (11 Jan) — compounding re-engagement driven by visible incentive loop
Total recycling weight	1,291.03 kg	January monthly total (1,123.70 kg) was 6.7× December total (167.33 kg), indicating deepening rather than declining engagement
Payment settlement success rate	100% (56 transactions; ¥282.89 total)	DR4 validated: uninterrupted incentive chain with full traceability (per-record timestamps, weights, credits)
Collection-to-submission weight ratio	96.4% (161.37 kg collected / 167.33 kg submitted in Dec)	DR7 validated: physical recycling chain confirmed operational — media artefact linked to genuine environmental outcome

Note. All figures are sourced from administrator backend records without modification. RMB settlement figures reflect vendor-side operational records; the user-facing prototype adopted a points-based feedback and redemption model.

Three Phase 1 patterns are particularly significant. First, the Day 1 self-registration of 38 users through organic discovery—without any promotional campaign—provides direct behavioural evidence that the DR1 low-friction entry functioned as intended. Second, the January submission trajectory (0.42 kg to 285.51 kg over ten days) demonstrates compounding re-engagement consistent with DR5. Third, the 100% payment settlement rate and 96.4% collection-to-submission weight-matching ratio address the pre-development ‘black hole effect’, linking user action to verifiable physical outcome and thereby establishing trust (DR4).

5.3 Phase 2: Full Gamified Experience Evaluation

Phase 2 activated the complete gamification architecture from 2 March 2026, including the leaderboard-growth subsystem, dormitory PK competition, structured task system, knowledge challenge, Eco-Garden supply interactions, and rewards redemption store. The evaluation integrated three evidence streams: expert assessment (I10, n = 14); student usability testing (I11, n = 40); and supplementary back-end operational records. All 40 student participants completed a three-task interaction protocol device deposit, Mini Program navigation, and engagement with at least one Phase 2 gamification feature with no task abandonments recorded. As illustrated in Figure 3, the Phase 2 interface extended the core scan-deposit-points loop into a broader participation environment through Eco-Garden growth, mascot states, level progression, badges, reward access, and ranking-based social comparison. These components operationalised Engine B by converting repeated recycling actions into a cumulative identity narrative, extending the system from a transaction-based tool into a continuing participation experience. The evaluation therefore assessed not only whether users could complete recycling tasks, but whether the media artefact could sustain attention, feedback recognition, and willingness to return.

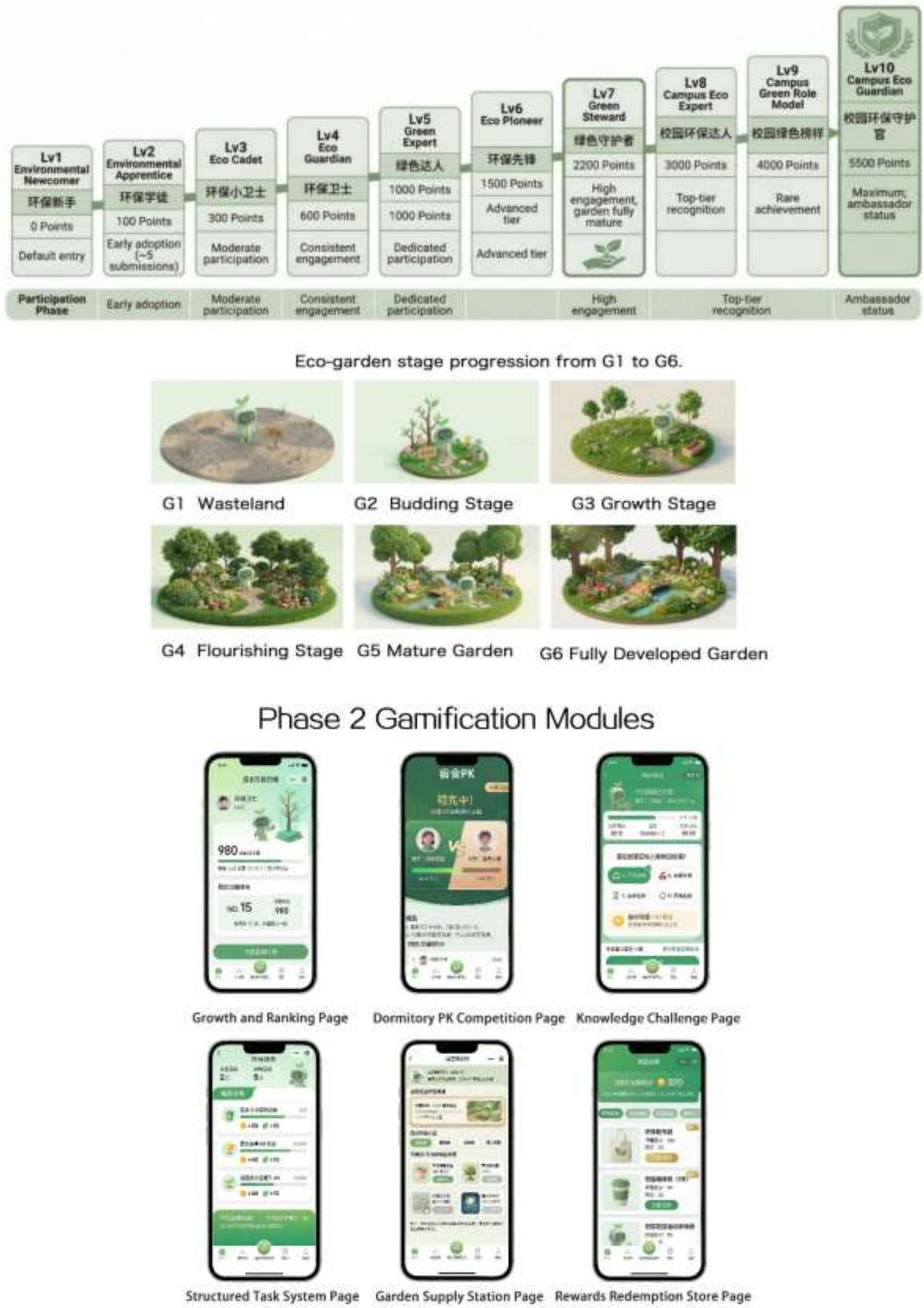

Figure 3. Phase 2 Gamified Media Features for Sustained Campus Recycling Participation

5.4 Expert Evaluation Findings

The 14-member expert panel assessed the deployed prototype across four FUT dimensions on a 100-point scale. The overall mean was 81.07/100 (SD = 5.14, M/5 = 4.05). All 14 experts gave a unanimous forward recommendation. Table 9 presents the dimension-level results with creative media design interpretations.

Table 9. Phase 2 Expert Evaluation Results (I10, n = 14)

Dimension	Label	M/5 (SD)	Creative Media Design Interpretation
FUT1	Interaction Efficiency	3.91 (0.51)	Entry discoverability and low-friction flow confirmed; error-state communication identified as primary refinement target (S1-4, M = 3.79; S1-5, M = 3.79)
FUT2	Platform Functional Performance	4.17 (0.48)	Highest-rated dimension; S2-3 (progress/ranking visibility) was the top-scoring item across the entire instrument (M = 4.57), validating DR3 and DR5
FUT3	Incentive and Governance Design	4.00 (0.55)	S3-3 (anomaly detection, M = 3.50) was the lowest-rated item — fraud prevention flagged as the most critical structural refinement priority
FUT4	Long-Term Engagement Potential	4.12 (0.50)	S4-3 (growth-based non-monetary engagement, M = 4.36) was the highest within this dimension, confirming Engine B's value as an identity-narrative media layer
Composite	Overall Expert Evaluation	4.05/5.00 (SD 5.14/100)	All 14 experts recommended proceeding ("Ready for wider deployment" or "Ready with minor revisions"); unanimous forward assessment

Note. M/5 = dimension mean per item on the 1–5 Likert scale. SD is reported at the total-score level across 14 experts. The composite row reflects the overall mean score of 81.07/100 recalculated as M/5. All 14 experts selected either 'Ready for wider campus deployment' (E group) or 'Ready with minor revisions' (A, R, and T groups).

The two poles of the expert instrument were S2-3 (progress and ranking visibility, M = 4.57), the single highest-scoring item and a direct validation of DR3 and DR5, and S3-3 (anomaly detection and fraud prevention, M = 3.50), the lowest-rated item, which identified backend rule enforcement as the most critical structural refinement priority.

5.5 Student Usability Evaluation Findings

Forty student participants completed supervised interaction sessions and the FES usability instrument. The overall mean was 119.95/150 (M/5 = 4.00), placing the system in the upper-adequate-to-good range. Table 10 presents the six-subscale results with creative media design interpretations.

Table 10. Phase 2 Student Usability Evaluation Results (I11, n = 40)

Subscale	Label	M/5 (SD)	Creative Media Design Interpretation
FES1	Reward Effectiveness	4.10 (2.48)	Points and reward visibility perceived as meaningful incentive; highest SD — individual variation in reward valuation expected
FES2	Leaderboard Motivation	3.95 (2.20)	Competitive mechanics positive but contextually dependent on peer participation; privacy preferences reinforce anonymous-default design (DR4)
FES3	Social Engagement	3.81 (2.02)	Dormitory PK and sharing features require critical user-base threshold before becoming effective (DR7)
FES4	Participation Continuity	3.75 (2.23)	Students cautious about long-term engagement; one-session interaction cannot confirm habitual behaviour
FES5	Sorting Accuracy Support	4.18 (1.96)	Guidance and error feedback highly valued; directly addresses the 65.27 pp attitude–behaviour gap
FES6	Retention Intention	4.21 (1.69)	Highest-rated subscale and lowest SD — post-interaction willingness to use regularly was the most consensually positive finding
Composite	Overall Student Evaluation	4.00/5.00 (SD 8.37/150)	119.95/150 overall mean (79.97% of maximum); no participant scored below 70.7% of maximum; 5 participants scored ≥ 130/150

Note. M/5 = subscale mean per item on the 1–5 Likert scale. FES = Field Engagement Scale. SD is reported at the total-score level (150-point scale) across 40 participants and at the subscale level for FES1–FES6. Gender differences across all six subscales were less than 0.12 SD units and are not treated as analytically significant. All 40 participants completed all 30 items.

FES6 Retention Intention (M/5 = 4.21, lowest SD = 1.69) was the most consensually endorsed finding, and FES5 Sorting Accuracy Support (M/5 = 4.18) confirms that guidance and error feedback reduced sorting uncertainty, directly relevant to the 65.27 pp attitude–behaviour gap. FES3 (M/5 = 3.81) and FES4 (M/5 = 3.75) were the lowest-rated subscales, indicating that social and competitive mechanics need larger active user bases and longer deployment to reach their potential. A supplementary user feedback survey (n = 52) identified physical friction—weather (50%) and walking distance (36.54%)—as the primary churn driver, far outweighing gamification-related factors (3.85%).

5.6 Supplementary Operational Evidence and Post-Evaluation Continuity

To examine whether user engagement persisted beyond the structured evaluation window, supplementary backend records were reviewed for April and early May 2026. Table 11 presents the results.

Table 11. Supplementary Post-Evaluation Operational Records (April–May 2026)

Indicator	April 2026	1–13 May 2026
Submission records	775	321
Total recycling weight	1,321.93 kg	765.93 kg
Average weight per submission	1.71 kg	2.39 kg
Approved records	599	248
Issued points	61,248 pts	35,487 pts
Contextual note	Post-evaluation tracking indicates continued operational activity beyond the structured Phase 2 window	1–5 May = Labour Day holiday; reduced activity reflects campus absence, not system decline

Note. April data are based on backend monthly and order-level operational statistics. May data cover 1–13 May 2026. The Labour Day holiday (1–5 May) caused a campus absence period; the May submission volume should be interpreted in relation to this contextual factor rather than as evidence of system decline. Issued points are based on the fixed conversion of 1 kg = 60 exchange points.

The April 2026 monthly recycling weight (1,321.93 kg) exceeded the entire Phase 1 total (1,291.03 kg over 23 days) within a single calendar month, indicating that the full gamification architecture sustained and extended the participation baseline. A post-deployment complaint that the withdrawal mechanism was unclear after audit completion prompted an update supporting instant settlement after approval and improved reward visibility—concrete evidence of feedback-driven iteration aligned with DR4, DR5, and DR2.

5.7 Triangulated Summary

Across the three Phase 2 evidence sources, convergence is strongest on four findings: (1) functional reliability of the core recycling loop was affirmed at all stakeholder levels (experts FUT2 = 4.17/5; students FES5–FES6 ≥ 4.18; 90.4% same-window audit completion); (2) Engine B growth-based mechanics generated qualitatively distinct engagement recognised by both experts (S4-3, M = 4.36) and students; (3) reward and penalty transparency requires UX refinement; and (4) physical accessibility, not gamification design, remains the primary participation friction. The principal limitation is the absence of a control group and the restricted deployment duration, so the findings support deployment readiness and early engagement capacity rather than long-term behavioural maintenance.

6. Discussion: Gamification as Behaviour-Mediating Media Design

6.1 Gamification as Integrated Media Experience, Not Mechanic Stack

The deployment evidence supports the media artefact reframing on two levels. At the functional level, the Phase 1 data show that the system's primary participation driver was the integrity of the incentive-feedback loop as a whole: organic Day 1 self-registration and the compounding January submission growth were driven by returning users deepening their engagement with a visible, trustworthy reward system rather than by new-user acquisition. These outcomes were achieved before the full gamification suite was activated, implying that the media experience of reliable, visible, and credible feedback was already sufficient to generate compounding engagement. At the experiential level, the Phase 2 evaluation shows that Engine B produced qualitatively different engagement: expert item S4-3 (growth-based non-monetary engagement, M = 4.36) was the highest-rated item within the long-term engagement dimension, and student responses characterised the Eco-Garden and level progression as providing a sense of personal investment that per-kilogram monetary reward did not generate. This is consistent with the media-studies position that a platform shapes participation through how its logic is presented, sequenced, and experienced (Fogg, 2002; Hassenzahl, 2010).

6.2 Four Media Design Layers and Their Empirical Performance

The first layer, incentive-feedback visibility, was validated most strongly: FUT2 Platform Functional Performance was the highest-rated expert dimension (M/5 = 4.17), S2-3 (progress and ranking visibility) the single highest-scoring expert item (M = 4.57), and FES5 (M/5 = 4.18) and FES6 (M/5 = 4.21) the strongest student subscales. The second layer, identity narrative, received positive but more differentiated support: expert S4-3 (M = 4.36) and student responses affirm genuine growth-based engagement, yet FES4 Participation Continuity (M/5 = 3.75) and the finding that only 3.85% cited gamification as the primary reason for continued use indicate that identity mechanics function as sustained-engagement rather than acquisition drivers—the role the EDRF assigns to Engine B. The third layer, interface clarity, was confirmed through the 100% task completion rate (0 abandonments across 40 three-task sessions). The fourth layer, operational reliability, received the most direct validation: 100% payment settlement over 56 Phase 1 transactions, 96.4% collection-to-submission weight matching, and 90.4% same-window audit completion. When the media promise is not fulfilled—as illustrated by the post-deployment withdrawal complaint—the user experience degrades not as a technical failure but as a credibility failure.

6.3 The Financial Sustainability Logic of Dual-Engine Design

One finding of particular practical significance is the financial-sustainability role of Engine B. Pre-development evidence established a structural tension: gamification experts recommended incentive levels of CNY 0.80–1.20/kg while recycling operators reported a price ceiling of CNY 0.60–0.70/kg—a gap that cash incentives alone cannot bridge without eroding operator margins. Engine B addresses it by substituting ecological narrative, growth visualisation, and social recognition for monetary compensation at the margin. The April 2026 records (1,321.93 kg) were generated within the same operator cost structure as Phase 1, suggesting the dual-engine architecture can sustain and extend participation without requiring reward escalation. This reframes engagement mechanics not only as a motivational question but as an economic one: how much participation value can a media artefact generate at a given cost of operation?

6.4 Implications for Campus Sustainability Practice

Three practical implications emerge. First, sustainable behaviour systems should be designed as media experiences, not only as environmental infrastructure: the 65.27 pp knowledge–action gap is less an awareness deficit than a mediation deficit—the system does not carry students' compliance back to them in a form that feels meaningful, credible, and worth repeating. Second, operational reliability is a creative media design requirement; universities should prioritise incentive-chain integrity and operational transparency before investing in richer gamification, since without this foundation the Eco-Garden cannot function as an identity-narrative layer. Third, social and competitive mechanics require critical user-base thresholds and privacy-respecting defaults: FES2 Leaderboard Motivation (M/5 = 3.95) and FES3 Social Engagement (M/5 = 3.81) were rated positively but with greater individual variation, and peer participation ranked among the top three barriers to continued use (30.77%).

6.5 Limitations and Future Research

Four limitations bound the scope of the findings. First, the study was conducted at a single institution, limiting generalisability. Second, the deployment window does not support claims about long-term behavioural maintenance across a full academic year. Third, the study did not include a control group; observed participation outcomes cannot be attributed to gamification design specifically rather than to monetary incentives, novelty, or seasonal factors. Fourth, the creative media design dimensions were operationalised through FUT and FES items not purpose-designed to measure them as independent variables; the convergent interpretation requires validation through instruments that directly measure visual hierarchy, feedback architecture, and identity narrative as separable constructs. Future research should pursue multi-campus longitudinal deployment studies, develop dedicated measurement instruments for the creative media design dimensions (drawing on established persuasive-design and experience-design scales), and test whether the EDRF rules and dual-engine financial logic transfer across governance contexts and operator cost structures.

7. Conclusion

This study examined a gamified WeChat Mini Program for campus recycling as a behaviour-mediating media artefact. Its starting point was a documented 65.27 percentage-point gap between stated recycling knowledge (84.48%, N = 406) and consistent sorting practice (19.21%)—interpreted not as an awareness deficit but as a mediation failure, in which the recycling act was not carried back to users in a form that made it visible, credible, and worth repeating. Developed through Design Science Research, the Evidence-Driven Dual-Engine Recycling Engagement Framework (EDRF) translated seven evidence streams into seven design rules (DR1–DR7), a dual-engine gamification architecture, and a four-layer deployable model. Phase 1 established operational reliability; Phase 2 produced positive expert (n = 14, M = 4.05/5.00) and student (n = 40, M = 4.00/5.00) evaluations; and post-evaluation tracking confirmed continued activity into April–May 2026.

Three contributions emerge. Theoretically, the study advances the position that gamified sustainability platforms are a class of behaviour-mediating media artefacts in which the design of feedback visibility, identity narrative, interface clarity, and operational reliability—not the underlying environmental action—constitutes the primary analytical object. Methodologically, it demonstrates how Design Science Research can move from multi-stream stakeholder evidence to a deployed, temporally extended, field-observed digital artefact. In terms of design knowledge, it offers the EDRF and its seven decision rules as a field-tested, transferable architecture for gamified media products in adjacent participation domains.

The most transferable practical insight is alignment: a gamified sustainability system functions as an effective media artefact only when its interface promises are matched by operational delivery. Hidden rewards, opaque penalties, inaccessible stations, and unverifiable environmental outcomes each sever the connection between user action and meaningful feedback—and it is that connection, not the game mechanics themselves, that sustains participation. Sustainable campus behaviour systems should therefore be designed as creative media experiences from the outset, with operational reliability and incentive transparency treated as media design requirements rather than as background infrastructure.

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Data sharing statement

No additional data are available.

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