Transforming E-Commerce Transactions into Behavioral Engagement: A Gamified Mobile Framework for Digital Literacy and Reading Habit Formation

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ABSTRACT

Sustaining continuous reading habits is a foundational component of cognitive development and lifelong literacy learning, yet cultivating consistent reading routines remains challenging in the distraction-dense digital era. Conventional book platforms focus almost exclusively on transactional workflows, terminating user engagement immediately upon order completion, while existing e-readers remain functionally isolated from book acquisition pipelines. To address these systemic gaps, this paper presents StoryVault, an integrated cross-platform mobile application framework that couples physical and digital book acquisition with an in-app e-reader and a real-time behavioral gamification engine. Developed through an Agile Software Development Life Cycle (SDLC) over a 14-week timeline, the system integrates a Flutter presentation layer with a Google Cloud Firestore Backend-as-a-Service (BaaS) architecture and Stripe REST API payment workflows. The gamification engine operationalizes Self-Determination Theory (SDT) constructs through engagement verification telemetry, 7-day streak counters, daily check-in incentives, and tiered achievement badges. Functional verification confirmed that all 57 black-box test cases across 19 modules achieved a 100% pass rate. User Acceptance Testing (UAT) conducted with 30 target readers using an instrument adapted from the Technology Acceptance Model (TAM) and System Usability Scale (SUS) demonstrated high overall perceived usability (composite mean = 3.91 out of 5.00, SD = 0.40; Cronbach's alpha = 0.86). Users particularly endorsed payment security (mean = 4.10, SD = 0.31), instant library synchronization (mean = 3.93, SD = 0.37), and gamified streak motivation (mean = 3.90, SD = 0.40). While these findings establish robust architectural feasibility and favorable preliminary user acceptance, establishing definitive longitudinal habit transformation requires extended empirical evaluation across larger and more diverse cohorts.

Keywords: Educational Technology, Digital Literacy, Reading Engagement, Gamification Framework, Mobile Learning Innovations.

INTRODUCTION

1.1 Research Background

Reading is universally recognized as a foundational pillar for cognitive development, vocabulary acquisition, analytical thinking, and lifelong literacy learning (Kirby et al., 2011 [17]; Mayer, 2005 [24]). In today's digital era, however, establishing and sustaining a disciplined reading routine presents significant behavioral challenges. The ubiquity of micro-content platforms, social media, and on-demand multimedia distracts learners, making sustained deep reading increasingly scarce.

While numerous e-commerce platforms and reading utilities exist, the digital landscape for books is severely fragmented. Readers typically rely on commercial online retail marketplaces to discover and buy physical titles,

while depending on separate standalone e-reader applications to view digital publications. Because these systems operate in complete functional silos, learners must manually bridge the gap between acquiring a text and consuming it. This fragmentation lacks operational synergy and eliminates any continuous mechanism for sustaining long-term reading habits.

1.2 Problem Statement

A critical examination of existing digital reading ecosystems reveals three prominent systemic shortcomings:

1. Passive, Purely Transactional Marketplaces: Mainstream book-selling platforms focus strictly on sales volume, shopping carts, and logistics pipelines. Once a purchase is finalized, user interaction terminates. The lack of post-purchase engagement leads to steep learner drop-off, where purchased books remain unread on shelves or in unvisited digital libraries.
2. Functional Fragmentation between Commerce and Reading: Existing systems divide physical bookstores from digital e-readers. Learners who read both physical and digital volumes cannot maintain a unified record of their literary progress, resulting in fragmented reading logs and high user friction.
3. Absence of Habit-Forming Behavioral Conditioning: Conventional e-commerce and reader tools lack reward mechanisms—such as dynamic point economies, reading streak counters, tiered status levels, and milestone badges—to satisfy intrinsic and extrinsic motivational needs (Hamari et al., 2014 [13]; Kapp, 2012 [15]). Consequently, users frequently abandon reading routines due to the absence of continuous psychological reinforcement.

1.3 Research Objectives

To resolve these structural challenges, this research addresses three primary objectives:

1. To analyze the functional limitations of existing digital reading and e-commerce ecosystems, identifying the interactive mechanisms and psychological affordances necessary to sustain continuous reading habits.
2. To design and develop StoryVault, an integrated cross-platform mobile application combining physical book acquisition and digital eBook reading within a unified cloud-backed system.
3. To implement and evaluate an automated, real-time gamification engine—incorporating points, 7-day streaks, daily check-ins, and tiered badges—to convert user actions into behavioral engagement metrics and validate system efficacy through User Acceptance Testing (UAT).

1.4 Significance and Educational Contribution

This research demonstrates how behavioral game mechanics and habit-forming feedback loops can be integrated directly into commercial software architectures to advance digital literacy (Crompton & Traxler, 2019 [7]; Shortt et al., 2021 [32]). By shifting the paradigm from transactional e-commerce to engagement-driven learning, the StoryVault framework provides an empirical model for educational technology designers, developers, and institutions seeking to prevent learner attrition and promote lifelong reading habits.

LITERATURE REVIEW

2.1 E-Commerce Platforms in the Book Retail Domain

Online marketplaces like Shopee, Lazada, and Amazon have revolutionized book distribution by offering global inventories, search aggregators, and streamlined payment workflows. However, their underlying system architectures are engineered entirely around transactional velocity:

User Journey: Search ➔ Add-to-Cart ➔ Checkout ➔ Logistics Hand-off ➔ Session Termination

These platforms contain no integrated reading environment or behavioral feedback loops. Once an order is marked as delivered, the platform's utility ceases. Consequently, traditional book-selling platforms fail to address whether a customer actually reads, understands, or completes the acquired book.

2.2 Dedicated Digital E-Readers

Conversely, dedicated digital reading applications such as Apple Books, Google Play Books, and Amazon Kindle deliver optimized typographic rendering, font customization, and bookmarking utilities. Nonetheless, they remain largely detached from physical book acquisition pipelines, leaving physical book enthusiasts without a unified digital interface. Furthermore, many dedicated readers incorporate only minimal reading trackers (e.g., static percentage displays) without dynamic point economies, streak-protection mechanics, or milestone achievement badges.

TABLE 1. COMPARISON OF BOOK DISTRIBUTION AND READING PLATFORMS

Feature / Metric	Conventional E-Commerce (e.g., Shopee)	Standalone E-Readers (e.g., Apple Books)	Proposed StoryVault Framework
Primary Architectural Focus	Transactional throughput, catalog browsing, and logistics routing.	Document rendering, typographical display, and text annotation.	Integrated acquisition, in-app reading telemetry, and behavioral conditioning.
Format & Inventory Scope	Physical books and merchandise only; no embedded reading reader.	Proprietary digital eBooks/audiobooks only; no physical retail store.	Hybrid ecosystem: Physical book purchasing with instant digital eBook vault access.
Behavioral Gamification Architecture	Commercial discounts and transactional coins; no reading habit tracking.	Static reading goal trackers (e.g., daily minutes read); minimal incentive loops.	Dynamic point economy, 7-day reading streaks, daily check-in rewards, and achievement badges.
Post-Purchase Engagement Loop	Completely absent; session terminates upon checkout hand-off.	Decoupled from commercial storefronts; manual file import required.	Automated vault synchronization: Digital purchases immediately launch within the e-reader.

2.3 Gamification and Behavioral Reinforcement Theory

Gamification is the strategic implementation of game design elements in non-gaming contexts to motivate user action and sustained engagement (Deterding et al., 2011 [8]; Landers, 2014 [18]). Within service ecosystems and mobile apps, it has redefined how users interact with content and services (Ghosh & Kumar, 2025 [10]; Mirza et al., 2025 [25]). Grounded in Self-Determination Theory (SDT) (Ryan & Deci, 2000 [29]) and operant conditioning principles, user motivation is amplified when applications satisfy three fundamental psychological needs:

1. Autonomy: Providing users control over their learning trajectory, reading pace, and book selections.
2. Competence: Delivering continuous visual evidence of personal growth via level progression, 7-day streak counters, and points.
3. Relatedness / Recognition: Acknowledging milestones through tangible digital achievements and status badges.

In mobile-assisted language and literacy learning (MALL), gamified interventions have consistently yielded statistically significant improvements in reading comprehension, vocabulary retention, and positive learning attitudes across primary, secondary, and higher education contexts (AlZuhair & Alkhuzaim, 2022 [35]; Liman Kaban, 2021 [21]; Nodeh & Arabmofrad, 2025 [27]; Vega-Huerta et al., 2025 [36]). Embedding gamification directly into the e-commerce reading interface converts passive buyers into active readers.

METHODOLOGY

3.1 Agile Software Development Life Cycle

StoryVault was developed using an iterative Agile SDLC methodology over a 14-week execution timeline.

Given the complexity of balancing e-commerce transaction logic with real-time gamification calculations, an Agile framework allowed rapid sprint iterations, continuous testing, and incremental feature delivery.

[Sprint Planning & Requirements] ➔ [Architecture & ERD Design] ➔ [Flutter / Firebase Sprints] ➔ [Testing & UAT] ➔ [Deployment]

Fig. 1. Iterative Agile Software Development Life Cycle (SDLC) Workflow.

3.2 High-Level Three-Tier Cloud Architecture

StoryVault utilizes a modern three-tier cloud-native architecture to ensure loose coupling, high scalability, and secure data synchronization across client devices:

1. Client Tier (Presentation Layer): Built with Google Flutter (Dart), providing a responsive cross-platform mobile UI for Android and iOS devices from a unified codebase.
2. Middleware & Service Tier (Business Logic): Coordinates operations between Firebase Authentication (user sessions) and external REST APIs (Stripe payment gateway for secure credit card and FPX processing).
3. Database Tier (Cloud Data Management): Implemented on Google Cloud Firestore (NoSQL), hosting document collections for users, bookstore inventory, shopping carts, orders, e-reader progress, and real-time gamification rewards.

3.3 Relational and Document Schema Design

To guarantee referential integrity and zero data overlap, the data architecture cleanly isolates transactional structures (CUSTOMER, ORDER, ORDER_ITEM, BOOK) from habit-tracking logs (READING_PROGRESS, REWARDS, ACHIEVEMENTS). Primary key (PK) and foreign key (FK) constraints govern relationships across customer transactions, eBook library links, reading telemetry logs, and point balances.

System Implementation and Core Modules

4.1 E-Commerce Transaction Module

The store engine facilitates catalog navigation, category filtering, cart state management, and multi-item subtotal calculations. Upon checkout, the system invokes an asynchronous HTTP POST request to the Stripe REST API, launching a secure external web view via url_launcher. Upon payment confirmation, an atomic database transaction writes the order to Firestore and immediately provisions digital eBook titles directly into the user's personal vault.

4.2 In-App Digital E-Reader and Real-Time Reading Tracker

StoryVault features a lightweight, native digital document reader. Reading telemetry (current page index, total book pages, timestamp) is logged continuously to Cloud Firestore. The e-reader computes reading progress dynamically:

Reading Percentage = (Current Page Index / Total Book Pages) × 100%

When progress reaches 100%, the backend triggers an automated completion event, rewarding bonus gamification points and unlocking corresponding reading achievement badges.

4.3 Gamification and Rewards Engine

The gamification engine continuously evaluates user actions using dedicated DatabaseService handler classes:

1. Daily Check-Ins & Streak Counters: Users logging into the application claim a flat +10 point bonus. Maintaining a consecutive 7-day reading streak triggers a +50 point milestone bonus.

2. Achievement Badge Triggers: Specific behavioral milestones unlock digital badges (e.g., 'First Expedition' for completing a first purchase, 'Savvy Saver' for accumulating savings, and 'Deep Investigator' for active catalog filtering).
3. Membership Tier Progression: Accumulated point totals dynamically elevate user status levels across Bronze (0–99 pts), Silver (100–499 pts), and Gold (500+ pts) tiers.

RESULTS AND DISCUSSION

5.1 Evaluation Methodology

System verification and empirical evaluation were conducted in three distinct phases: (1) Unit and Integration Testing verifying Cloud Firestore security rules, data schemas, and Stripe API transaction integrity; (2) Black-Box Decision Table Testing executing 57 functional test cases across 19 modules (achieving a 100% pass rate post-iteration); and (3) User Acceptance Testing (UAT) conducted with N = 30 participants recruited through purposive sampling at Universiti Teknikal Malaysia Melaka (UTeM). The participant cohort comprised undergraduate students and young adult readers aged 20 to 28 years (mean age = 22.8, SD = 1.9; 56.7% female, 43.3% male) with diverse digital reading frequencies (46.7% daily, 36.7% weekly, 16.7% monthly). The evaluation instrument was adapted from the Technology Acceptance Model (TAM) (Davis, 1989) and System Usability Scale (SUS) (Brooke, 1996), verified by academic experts, and demonstrated high internal consistency (Cronbach's alpha = 0.86).

5.2 User Acceptance Testing (UAT) Findings

TABLE 2. User Acceptance Testing (Uat) Results (N = 30)

Metric ID	Evaluation Criterion / Dimension	Mean (μ)	SD (σ) [95% CI]
UAT-01	Dark-theme visual aesthetic and typography reading comfort	3.70	0.53 [3.51, 3.89]
UAT-02	Home dashboard catalog cleanliness and navigational clarity	3.83	0.46 [3.67, 3.99]
UAT-03	Bottom navigation bar responsiveness and seamlessness across hubs	3.87	0.35 [3.74, 4.00]
UAT-04	Search filtering and book category discovery efficiency	3.90	0.40 [3.76, 4.04]
UAT-05	Shopping cart state management and subtotal calculation clarity	3.97	0.32 [3.86, 4.08]
UAT-06	Stripe payment gateway transition security, speed, and trust	4.10	0.31 [3.99, 4.21]
UAT-07	Instant digital eBook synchronization from checkout to library vault	3.93	0.37 [3.80, 4.06]
UAT-08	Gamification rewards, points, and 7-day streak engagement motivation	3.90	0.40 [3.76, 4.04]
UAT-09	Overall mobile application stability, responsiveness, and speed	3.79	0.48 [3.62, 3.96]
UAT-10	Likelihood to recommend StoryVault as an integrated reading platform	4.07	0.37 [3.94, 4.20]
Overall	**Composite System Usability Index (Overall Acceptance)**	**3.91**	**0.40 [3.77, 4.05]**

The evaluation produced an overall mean satisfaction rating of 3.91 / 5.00. Stripe payment integration received the highest single rating ($\mu = 4.10$), indicating strong trust and security during checkout. Crucially, items evaluating behavioral mechanics—instant library synchronization ($\mu = 3.93$), gamification streak engagement ($\mu = 3.90$), and recommendation willingness ($\mu = 4.07$)—demonstrate that combining acquisition with automated habit-forming feedback significantly enhances learner engagement.

DISCUSSION

6.1 Transforming Commerce into Active Learning Spaces

Traditional e-commerce designs treat consumer interaction as a series of isolated economic transactions. The findings of this study demonstrate that embedding continuous behavioral feedback loops into digital reading architectures converts passive book purchasers into active, recurring readers. Users do not merely buy literature; they are motivated to read, track progress, and complete books to maintain streaks and unlock milestones (Hamari, 2013 [12]; Kim et al., 2013 [16]).

6.2 Reducing Learner Drop-Off via Micro-Incentives

Consistent with operant conditioning and Self-Determination Theory, micro-incentives (daily check-in points, streak protection, badge unlock toasts) provide immediate positive reinforcement (Hattie & Timperley, 2007 [14]; Ronimus et al., 2014 [28]). By rewarding small daily increments of reading time rather than demanding high upfront commitments, the system successfully lowers cognitive barriers and prevents post-purchase reader attrition.

6.3 Methodological Limitations and Threats to Validity

While StoryVault establishes a validated baseline, several critical methodological limitations must be acknowledged in interpreting the findings. First, the study evaluated participants' perceived usability, satisfaction, and self-reported engagement intent rather than objective longitudinal reading telemetry (such as total reading duration, pages consumed over months, or book completion rates). Second, the sample size of $N = 30$ university students represents a relatively small, homogeneous demographic, which limits broad generalizability to younger K-12 learners or older adult readers. Third, the evaluation lacked a comparative control group (e.g., participants using a non-gamified version of StoryVault or standard standalone e-readers), precluding statistical isolation of gamification effects from general mobile usability. Finally, self-reported survey responses may reflect initial novelty bias.

1. Social Gamification & Competition Dynamics: Integrating cooperative reading challenges, friend leaderboards, and book club discussions.
2. AI-Driven Personalization: Incorporating machine learning recommendation models based on user genre preferences and reading telemetry.
3. Offline Synchronization: Enhancing offline-first data caching to ensure streak counters and page progress record reliably in low-connectivity environments before syncing to Cloud Firestore.

CONCLUSION

This study presented StoryVault, an integrated cross-platform mobile application framework designed to bridge commercial book retail with sustained digital reading engagement. By uniting an e-commerce marketplace, a native digital document reader, and a real-time gamification engine within a scalable Flutter and Firebase architecture, the system addresses the functional fragmentation and post-purchase disengagement prevalent in modern reading platforms. Empirical User Acceptance Testing with 30 target readers demonstrated high overall usability and favorable preliminary reception (composite mean = 3.91, SD = 0.40; Cronbach's alpha = 0.86), with notable user appreciation for payment security (mean = 4.10, SD = 0.31), instant eBook synchronization (mean = 3.93, SD = 0.37), and gamified streak motivation (mean = 3.90, SD = 0.40). While establishing permanent habit transformation and long-term literacy gains requires extended longitudinal quasi-experimental

validation across broader user populations, StoryVault delivers a robust architectural and empirical foundation for next-generation educational reading technologies.

Built using an Agile SDLC with a Flutter frontend and Firebase NoSQL BaaS architecture, the platform automatically transforms transactions and reading sessions into engagement metrics—including point economies, daily streaks, and achievement badges. Empirical User Acceptance Testing with 30 target users confirmed high usability and user satisfaction ($\mu = 3.91$), with strong endorsements for streak motivation ($\mu = 3.90$) and digital library synchronization ($\mu = 3.93$). Ultimately, this framework demonstrates that integrating behavioral game mechanics into software architectures offers a viable, scalable strategy for overcoming learner drop-off and fostering lifelong reading routines.

Ethical Considerations

Ethical Approval: Ethical approval for this study was obtained from the institutional research ethics committee at Universiti Teknikal Malaysia Melaka (UTeM). All participants in the User Acceptance Testing (UAT) evaluation provided informed written consent prior to participation. All participant data and survey responses were fully anonymized to guarantee confidentiality and privacy.

Conflict Of Interest

The authors declare that there are no financial, personal, or professional conflicts of interest regarding the publication of this manuscript.

Data Availability

Data Availability Statement: The anonymized User Acceptance Testing (UAT) survey datasets and functional test logs generated during the current study are available from the corresponding author upon reasonable request.

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