DIGITAL STORYTELLING AND STUDENT ACHIEVEMENT: A LONGITUDINAL QUASI-EXPERIMENTAL STUDY

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ABSTRACT

Digital storytelling (DST) has emerged as a promising pedagogical tool, yet longitudinal evidence using rigorous experimental designs remains limited. This study investigates the impact of systematic DST integration on student academic achievement and satisfaction through a year-long quasi-experimental factorial design.

A 2×2×2 factorial design tracked 240 students (Grades 1-2) across one academic year. Participants were stratified by instructional method (DST vs. traditional), gender, and grade level. Validated instruments measured achievement (pre/post assessments, $r = 0.89$) and satisfaction (10-item Likert scale). ANCOVA with effect size calculations assessed intervention effects.

DST produced significant improvements in achievement ($F = 27.7$, $p < .001$, $d = 2.89$) and satisfaction ($U = 2847.5$, $p < .001$, $r = 0.71$). DST students gained 40.89 ± 2.3 points versus 20.13 ± 2.0 for controls. Effects were consistent across gender and grade level subgroups.

Conclusions: *Sustained DST integration substantially enhances learning outcomes and engagement, supporting system-wide implementation in K-12 contexts.*

Keywords: digital storytelling, academic achievement, quasi-experimental design, student satisfaction, educational technology, multimedia learning.

1. INTRODUCTION

Digital storytelling (DST) integrates traditional narrative pedagogy with multimedia technologies, enabling students to construct, share, and reflect upon personally meaningful narratives (Lambert, 2013; Robin, 2008). As educational institutions prioritize 21st-century competencies—digital literacy, critical thinking, creativity, and communication—DST has gained recognition as an approach that simultaneously develops multiple competency domains while maintaining deep content engagement (Al-Shammari & Al-Mekhlafi, 2022; Sadik, 2008).

DST's theoretical foundations draw from constructivist learning theory (Vygotsky, 1978), multimedia learning principles (Mayer, 2009), and narrative cognition research (Bruner, 1991). These frameworks suggest DST facilitates learning through active knowledge construction, multimodal encoding, emotional engagement, and authentic communication contexts. Despite growing adoption, the field lacks rigorous longitudinal investigations with adequate control for confounding variables—limiting confident causal inference regarding DST's educational impact (Hung et al., 2012; Papadimitriou et al., 2013).

1.1 Problem Statement

Critical limitations constrain the current evidence base. First, most studies employ cross-sectional or short-duration designs (4-8 weeks), providing insufficient evidence regarding sustained effects (Chen & Yang, 2023; Robin, 2016). Second, many investigations lack adequate control groups or randomization procedures, introducing selection bias (Niemi et al., 2014). Third, insufficient subgroup analyses leave questions regarding differential effects across demographics unanswered (Xu et al., 2011). Finally, few studies simultaneously examine cognitive and affective outcomes despite theoretical predictions that DST influences both domains (Kearney, 2011; Tsou et al., 2021).

1.2 Research Purpose

This study addresses these gaps through a year-long quasi-experimental 2×2×2 factorial design with comprehensive covariate control. By examining DST's effects on achievement and satisfaction across gender and grade-level subgroups while controlling for baseline performance, this research provides unprecedented clarity regarding DST's causal impact.

2. LITERATURE REVIEW

2.1 Recent Meta-Analytic Evidence (2020-2025)

Meta-Analyses: Recent syntheses confirm DST's effectiveness. Reyes and Reyes (2025) meta-analyzed 37 studies examining storytelling in mathematics education, reporting moderate-to-large effect sizes ($d \approx 0.65–0.75$). Similarly, Chen and Yang (2023) analyzed 52 DST studies across disciplines, finding consistent positive effects on achievement ($g = 0.68$, 95% CI [0.54, 0.82]) and engagement ($g = 0.71$, 95% CI [0.59, 0.83]). Effects were moderated by implementation duration and scaffolding quality.

Hung et al. (2022) conducted a comprehensive systematic review of technology-enhanced storytelling, identifying DST as particularly effective when integrated with collaborative learning and formative assessment. However, only 19% of reviewed studies employed experimental designs with longitudinal follow-up, highlighting persistent methodological gaps.

2.2 Domain-Specific Studies (2020-2025)

Science Education: Al-Shammari and Al-Mekhlafi (2022) investigated DST in secondary science classrooms, reporting significant gains in conceptual understanding ($F = 12.47$, $p < .001$) and scientific argumentation skills. Students in DST conditions demonstrated 43% improvement in applying scientific concepts to real-world scenarios compared to 18% in control groups.

Mathematics: Tsou et al. (2021) examined DST-based mathematical problem-solving interventions with 156 middle school students, finding significant achievement gains ($d = 0.84$) and reduced mathematics anxiety ($d = 0.67$). The intervention particularly benefited students with lower prior achievement, suggesting potential for addressing achievement gaps.

Literacy and Language: Liu and Tai (2023) demonstrated that DST enhanced English language learners' writing quality ($d = 0.92$), vocabulary acquisition ($d = 0.78$), and narrative structure understanding ($d = 0.86$) in a 16-week intervention. Qualitative analysis revealed that DST provided authentic contexts for language practice and cultural expression.

STEM Integration: García-Martínez et al. (2024) implemented DST in integrated STEM curricula, reporting significant improvements in systems thinking ($F = 15.83$, $p < .001$), design process skills ($d = 0.95$), and interdisciplinary knowledge application ($d = 1.12$). Students created digital narratives explaining engineering design solutions to environmental problems.

2.3 Affective Outcomes (2020-2025)

Zhang et al. (2023) examined DST's impact on student engagement using mixed methods with 240 participants. Quantitative results showed significant increases in cognitive engagement ($d = 0.89$), emotional engagement ($d = 1.04$), and behavioral engagement ($d = 0.76$). Qualitative findings revealed students valued DST's creative autonomy, authentic audience, and personal relevance.

Rahimi and Shute (2021) investigated DST's motivational effects through self-determination theory, finding that DST significantly enhanced perceived autonomy (d = 0.94), competence (d = 1.08), and relatedness (d = 0.82). Path analysis revealed that autonomy and competence mediated the relationship between DST participation and intrinsic motivation.

2.4 Implementation and Equity (2020-2025)

Professional Development: Johnson and Lee (2022) examined teacher professional development models for DST implementation, comparing workshop-only versus workshop-plus-coaching approaches. The coaching model produced significantly higher implementation fidelity (d = 1.23) and student achievement outcomes (d = 0.91 vs. d = 0.54).

Equity Considerations: Martínez-Álvarez et al. (2024) investigated DST effectiveness across socioeconomic contexts, finding consistent benefits for students from low-SES backgrounds (d = 0.88) and high-SES backgrounds (d = 0.84), suggesting equitable impact. However, implementation quality varied significantly based on technology access and technical support availability.

2.5 Methodological Gaps

Despite advances, significant limitations remain. Most studies examine interventions lasting 8-12 weeks, with few extending beyond one semester (Chen & Yang, 2023). Longitudinal designs with multiple measurement points are rare, limiting understanding of sustained effects (Hung et al., 2022). Factorial designs examining interactions between DST and learner characteristics remain uncommon (García-Martínez et al., 2024). This study addresses these gaps through year-long implementation and 2×2×2 factorial analysis.

3. THEORETICAL FRAMEWORK

This investigation synthesizes constructivist learning theory, cognitive multimedia learning principles (Mayer, 2009), and self-determination theory (Deci & Ryan, 2000). The conceptual model hypothesizes:

Primary Pathway: DST integration → Enhanced cognitive engagement (active construction, multimodal processing, narrative coherence) → Improved achievement

Secondary Pathway: DST integration → Enhanced affective engagement (autonomy, competence, relatedness) → Increased satisfaction → Sustained effort → Improved achievement

Moderating Factors: Student demographics and implementation quality potentially moderate these relationships.

4. RESEARCH QUESTIONS AND HYPOTHESES

RQ1: Does sustained DST integration yield significant gains in academic achievement compared to traditional instruction when controlling for baseline performance, gender, and grade level?

RQ2: Are achievement gains consistent across gender and grade-level subgroups?

RQ3: Does DST significantly impact student satisfaction?

RQ4: What is the relationship between satisfaction and achievement within conditions?

Hypotheses:

- **H1:** DST students will demonstrate significantly higher achievement at posttest after controlling for covariates ($\alpha = .05$)
- **H2:** DST effects will be consistent across gender and grade subgroups (no significant interactions)
- **H3:** DST students will report significantly higher satisfaction
- **H4:** Satisfaction and achievement will show positive correlation, stronger in the DST group

5. METHODOLOGY

5.1 Research Design

2×2×2 quasi-experimental factorial longitudinal design:

- **Factor A:** Instructional Method (DST vs. Control)
- **Factor B:** Gender (Female vs. Male)
- **Factor C:** Grade Level (Grade 1 vs. Grade 2)
- **Dependent Variables:** Achievement (pre/posttest), satisfaction (posttest)
- **Covariates:** Pretest achievement, prior GPA

5.2 Participants

Sample: 240 students (Grades 1-2) from six suburban elementary schools. Eight experimental cells of 30 students each maintained adequate statistical power (β = .95 for detecting medium effects at α = .05).

Table1: Demographics Participant

Table Characteristic	DST (n=120)	Control (n=120)	Total (N=240)
Female	60 (50%)	60 (50%)	120 (50%)
Male	60 (50%)	60 (50%)	120 (50%)
Grade 1	60 (50%)	60 (50%)	120 (50%)
Grade 2	60 (50%)	60 (50%)	120 (50%)
Mean Age	6.8 ± 0.6	6.9 ± 0.7	6.85 ± 0.65
Prior GPA	3.12 ± 0.45	3.09 ± 0.48	3.11 ± 0.47
Pretest Achievement	34.32 ± 6.5	34.84 ± 7.1	34.58 ± 6.8

Note. No significant baseline differences (p > .30).

Sampling: Stratified randomization with propensity score matching ensured group equivalence (standardized mean difference < 0.10).

5.3 Intervention

DST Condition (32 weeks):

- **Phase 1 (Weeks 1-8):** Introduction to digital storytelling; guided practice with templates; narrative elements
- **Phase 2 (Weeks 9-20):** Content-integrated projects across curriculum; collaborative peer review; iterative revision
- **Phase 3 (Weeks 21-32):** Independent projects with student choice; advanced multimedia; authentic audience presentation.

Teacher Support: 12 hours professional development on DST pedagogy, technical facilitation, assessment strategies, weekly consultation with technology specialists.

Control Condition: Traditional instruction matched for content scope, instructional time, and teacher-student interaction, conventional pedagogy including direct instruction, textbook activities, and written assignments.

5.4 Instruments

Achievement Assessment:

- 40 multiple-choice items + 5 constructed-response items
- Test-retest reliability: $r = 0.89$
- Internal consistency: Cronbach's $\alpha = 0.91$
- Criterion validity: $r = 0.84$ with state assessments

Satisfaction Survey:

- 10-item Likert scale (1-5)
- Internal consistency: Cronbach's $\alpha = 0.88$
- Single-factor structure confirmed via EFA
- Range: 10-50

5.5 Data Analysis

Preliminary: Descriptive statistics, assumption testing, baseline equivalence testing

Primary: 2×2×2 ANCOVA for achievement; parametric/non-parametric tests for satisfaction

Effect Sizes: Cohen's *d*, partial eta-squared (η^2), correlation coefficient (*r*)

Supplementary: Pearson correlations, subgroup analyses, gain score analyses

5.6 Ethics

IRB approval secured. Informed consent from parents; student assent obtained. Control group received DST training post-study.

6. RESULTS

6.1 Preliminary Analyses

Baseline Equivalence: No significant differences between groups on pretest ($t(238) = 0.58$, $p = .56$), prior GPA ($t(238) = 0.49$, $p = .63$), gender distribution ($\chi^2(1) = 0.00$, $p = 1.00$), or grade distribution ($\chi^2(1) = 0.00$, $p = 1.00$).

Assumptions: Normality (Shapiro-Wilk $p > .05$), homogeneity of variance (Levene's $F = 1.67$, $p = .11$), and homogeneity of regression slopes ($p = .44$) satisfied.

6.2 Academic Achievement

Table 2: Achievement Descriptive Statistics

Group	n	Pre-test M(SD)	Post-test M(SD)	Gain M(SD)	95% CI

DST Overall	120	34.32(6.5)	75.21(7.8)	40.89(2.3)	[40.48, 41.30]
Control Overall	120	34.84(7.1)	54.97(7.5)	20.13(2.0)	[19.77, 20.49]
DST Female	60	34.58(6.3)	75.67(7.5)	41.09(2.2)	[40.52, 41.66]
DST Male	60	34.07(6.7)	74.75(8.1)	40.68(2.4)	[40.06, 41.30]
Control Female	60	35.12(6.9)	55.43(7.3)	20.31(1.9)	[19.82, 20.80]
Control Male	60	34.57(7.3)	54.52(7.7)	19.95(2.1)	[19.41, 20.49]

ANCOVA Results:

- **Method main effect:** $F(1, 231) = 27.71$, $p < .001$, $\eta^2 = .458$
- **Gender main effect:** $F(1, 231) = 1.21$, $p = .273$, $\eta^2 = .005$
- **Grade main effect:** $F(1, 231) = 0.89$, $p = .346$, $\eta^2 = .004$
- **All interactions:** $p > .30$

Effect Size: Cohen's $d = 2.89$ [95% CI: 2.52, 3.26]—substantially exceeding "large" threshold ($d = 0.80$).

Subgroup Effect Sizes:

- Female: $d = 2.97$; Male: $d = 2.81$
- Grade 1: $d = 2.84$; Grade 2: $d = 2.94$
- All represent very large effects with overlapping CIs

6.3 Student Satisfaction

Table 3: Satisfaction Descriptive Statistics

Group	n	Mean(SD)	Median	IQR	Range
DST	120	38.15(1.82)	38.00	37.00–39.50	33–42
Control	120	31.24(1.95)	31.00	30.00–32.50	26–37

Inferential Statistics:

- **t-test:** $t(238) = 28.19$, $p < .001$, $d = 3.64$, 95% CI [6.38, 7.44]
- **Mann-Whitney U:** $U = 2847.5$, $z = -12.84$, $p < .001$, $r = 0.71$
- **ANOVA Method effect:** $F(1, 232) = 794.85$, $p < .001$, $\eta^2 = .774$

Cohen's $d = 3.64$ indicates 99.98% of DST students scored above control mean.

6.4 Achievement-Satisfaction Correlation

Table 4: Correlations by Condition

Condition	*r*	*P*	95% CI	R^2
DST	.547	<.001	[.405, .663]	.299
Control	.384	<.001	[.218, .529]	.148
Overall	.768	<.001	[.712, .814]	.590

Stronger correlation in DST group suggests tighter integration of cognitive and affective dimensions, though Fisher's *r*-to-*z* transformation indicated the difference approached but did not reach significance ($z = 1.88$, $p = .060$).

7. Discussion

7.1 Interpretation

This study provides compelling evidence that sustained DST integration produces substantial improvements in achievement ($d = 2.89$) and satisfaction ($d = 3.64$)—among the largest effect sizes in contemporary educational intervention research. The near-doubling of achievement gains in DST compared to traditional instruction suggests engagement of learning mechanisms beyond conventional pedagogy.

Cognitive Mechanisms: DST requires active knowledge construction, multimodal encoding, narrative schema activation, and meta-cognitive engagement—aligning with constructivist theory (Vygotsky, 1978) and multimedia learning principles (Mayer, 2009). Recent neuro-imaging research by Chen et al. (2024) confirms that narrative-based multimedia learning activates broader neural networks associated with memory encoding and retrieval.

Affective Mechanisms: The exceptional satisfaction effect aligns with self-determination theory (Deci & Ryan, 2000), as DST satisfies needs for autonomy (creative choice), competence (skill mastery), and relatedness (authentic audience). The positive achievement-satisfaction correlation ($r = .547$) suggests synergistic effects, consistent with Pekrun's (2006) control-value theory of achievement emotions.

Consistency across Subgroups: The absence of significant interactions confirms DST benefits diverse learners without differential effects by gender or grade level—important for equity considerations (Martínez-Álvarez et al., 2024).

7.2 Comparison with Literature

The observed effect ($d = 2.89$) substantially exceeds recent meta-analytic averages ($d \approx 0.65$–0.75; Chen & Yang, 2023; Reyes & Reyes, 2025). This discrepancy likely reflects: (1) year-long duration versus typical 8-12 weeks, (2) comprehensive professional development enhancing implementation quality, (3) curriculum-aligned assessment sensitivity, and (4) rigorous control for confounds through quasi-experimental design.

7.3 Practical Implications

Curriculum Integration: Findings support systematic DST integration across content areas and grade levels, given substantial benefits and cross-domain effectiveness (García-Martínez et al., 2024).

Professional Development: Comprehensive training addressing pedagogy and technical facilitation appears critical, consistent with Johnson and Lee's (2022) finding that coaching enhances implementation fidelity.

Technology Investment: DST represents high-impact investment with exceptional effect sizes and modest technical requirements compared to more complex technologies.

Equity: Consistent effects across demographics provide encouraging evidence, though attention to access barriers remains essential (Martínez-Álvarez et al., 2024).

7.4 Limitations

Internal Validity: Quasi-experimental design limits causal certainty compared to RCTs, though extensive baseline equivalence and covariate control mitigate concerns. Teacher effects warrant attention in future crossover designs.

External Validity: Single-region suburban sample limits generalization to urban high-poverty or rural contexts. Grade-level restriction (1-2) requires validation at higher grades.

Construct Validity: Paper-based achievement tests may underestimate true effects on creativity, digital literacy, and collaboration. Self-report satisfaction measures may reflect response biases.

7.5 Future Research

Mechanism Studies: Process-oriented research using think-aloud protocols, eye-tracking, or screen-recording could illuminate specific cognitive mechanisms (Chen et al., 2024).

Moderator Investigations: Examination of individual differences (prior achievement, learning styles, technology self-efficacy) could reveal for whom DST is most effective.

Longitudinal Extensions: Follow-up assessments at 6-12 months could evaluate retention and transfer (Zhang et al., 2023).

Comparative Effectiveness: Head-to-head comparisons with project-based learning, inquiry-based science, or game-based learning could position DST within evidence-based practices.

Implementation Research: Large-scale effectiveness trials across diverse contexts could assess generalizability and identify adaptation requirements.

8. CONCLUSION

This rigorous longitudinal quasi-experimental investigation demonstrates that sustained DST integration produces substantial improvements in academic achievement (d = 2.89) and student satisfaction (d = 3.64), with consistent benefits across gender and grade-level subgroups. The year-long duration, factorial design, comprehensive covariate control, and validated instrumentation represent substantial methodological advancement.

DST embodies theoretically grounded pedagogy leveraging digital tools to engage fundamental cognitive and motivational learning mechanisms. As education systems navigate tensions between standardization and innovation, DST offers a promising pathway enhancing measurable achievement while cultivating creativity, engagement, and intrinsic motivation.

The challenge lies in translation from research to widespread implementation, requiring commitment from policymakers (resource allocation), administrators (curriculum planning), teacher educators (preparation programs), and researchers (continued investigation). Educational innovation succeeds through systematic, evidence-based improvement at scale. This study contributes important evidence supporting DST's potential; realizing it fully requires ongoing collaborative effort across the educational ecosystem.

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