Digital storytelling and students' motivation towards learning genetics: A quasi-experimental study

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ABSTRACT

This study investigated the effect of digital storytelling on Senior High School students' academic performance and motivation towards learning genetics. The study employed a quasi-experimental non-equivalent control-group pretest-posttest design. A total of 121 SHS 3 Biology students from selected Senior High Schools in the Sekyere South District participated in the study, comprising 70 students in the experimental group and 51 students in the control group. The experimental group was taught genetics using digital stories incorporating narratives, text, diagrams, animations, videos and recorded explanations, while the control group was taught using the conventional teaching method. Data were collected using the Students' Performance in Genetics Test and the Students' Motivation towards Learning Genetics Questionnaire. Academic-performance data were analysed using descriptive statistics and Analysis of Covariance, while motivation data were analysed using a mixed-design Analysis of Variance. The findings revealed that students taught through digital storytelling obtained significantly higher adjusted posttest performance scores than those taught conventionally, $F(1, 118) = 164.85$, $p < 0.001$, partial $\eta^2 = 0.583$. The mixed-design ANOVA also showed a significant interaction between time and instructional group, $F(1, 119) = 39.20$, $p < 0.001$, partial $\eta^2 = 0.248$, indicating that the digital-storytelling group experienced a greater increase in motivation. The study concluded that digital storytelling was more effective than conventional instruction in improving students' academic performance and motivation in genetics. It was recommended that Biology teachers integrate scientifically accurate, curriculum-aligned and well-scaffolded digital stories into genetics instruction.

Keywords: *Academic performance, Biology education, Digital storytelling, Genetics, Motivation, Senior high school.*

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Highlights of this paper

- Digital storytelling significantly improved Senior High School students' academic performance in genetics, with the experimental group achieving substantially higher posttest scores than the control group (partial $\eta^2 = 0.583$).
- Students exposed to digital storytelling showed a significantly greater increase in motivation towards learning genetics compared to those taught through conventional methods (partial $\eta^2 = 0.248$).
- The study provides empirical evidence that integrating scientifically accurate, curriculum-aligned digital stories into genetics instruction can enhance both cognitive and affective learning outcomes in Ghanaian Senior High Schools.

1. INTRODUCTION

Digital storytelling combines traditional narrative techniques with multimedia elements to engage learners in researching, organising and communicating their understanding, making it a constructivist approach that enhances academic learning while developing critical thinking and digital literacy (Başar, 2022; Bilici & Yilmaz, 2024; Tamimi, 2024). This approach is particularly relevant to genetics, a conceptually challenging subject requiring students to establish relationships among abstract concepts: DNA, genes, alleles, chromosomes, meiosis and inheritance—across molecular, cellular and organismal levels. When taught through conventional methods, students frequently develop fragmented knowledge and misconceptions. Within the Ghanaian SHS context, students face persistent difficulties in genetics, including inability to distinguish among DNA, genes and chromosomes; confusion between genotype and phenotype; and challenges applying Mendelian principles (Attipoe, 2015; Gyamfi & Agyei, 2025; Quainoo, Otami, & Owusu, 2021). Digital storytelling addresses these challenges by transforming abstract genetics information into visual, sequential narratives that promote active knowledge construction, reflection and conceptual understanding (Bilici & Yilmaz, 2024; Karakoyun & Yapici, 2016). Additionally, it enhances students' motivation, interest, self-efficacy and persistence by providing opportunities for creativity, autonomy and collaboration through culturally relevant narratives (Başar, 2022; Mnisi, 2015). Despite its educational value, direct experimental evidence on digital storytelling's combined effect on SHS students' academic performance and motivation in genetics remains limited in Ghana. This study therefore investigated the effect of digital storytelling on students' academic performance and motivation towards learning genetics, comparing it with the conventional teaching method among Ghanaian SHS Biology students.

2. LITERATURE REVIEW

2.1. Theoretical Framework

This theoretical framework integrates Vygotsky (1978). Social Constructivist Learning Theory with Smeda, Dakich, and Sharda (2014) e-Learning Digital Storytelling (eLDiSt) framework to explain how digital storytelling influences students' academic performance and motivation in genetics education.

2.2. Vygotsky's Social Constructivist Learning Theory

Vygotsky (1978) theory posits that learning is socially mediated through interaction with teachers, peers, cultural tools, and existing experiences. Three foundational principles guide this framework: Social mediation, Cultural mediation and the Zone of Proximal Development (ZPD).

In social mediation, knowledge construction occurs first on the social plane (between people) and then on the psychological plane (within the individual). Students develop advanced understanding through meaningful activities, idea exchange, feedback, and appropriate assistance within their ZPD (Vygotsky, 1978).

In cultural mediation, higher mental functions develop through internalization of culturally produced sign systems: language, symbols, and artifacts (Vygotsky, 1978). Digital storytelling provides multiple sign systems—linguistic, visual, auditory, spatial—to represent genetic knowledge. Students employ scripts, visual representations, animations, and narration to explain genetic concepts (Bilici & Yilmaz, 2024; Mosia & Egara, 2025). This multi-modal mediation addresses the challenge of genetics being "abstract, invisible and complex" (Machová & Ehler, 2023; Ojo, 2024).

The Zone of Proximal Development (ZPD) represents the distance between independent and assisted performance. Digital storytelling creates multiple ZPD opportunities through distributed scaffolding from teachers, peers, and digital tools (Smeda et al., 2014). Teacher feedback helps correct misconceptions about chromosome behavior and inheritance patterns (Karakoyun & Yapici, 2016). Through this process, students move from assisted to independent performance (Bilici & Yilmaz, 2024; Vygotsky, 1978).

2.3. Smeda et al. (2014) e-Learning Digital Storytelling Framework

The eLDiSt framework identifies seven key elements of effective digital storytelling: (1) point of view, (2) dramatic question, (3) emotional content, (4) voice, (5) soundtrack, (6) economy, and (7) pacing. When applied to genetics education, these elements translate into scientifically accurate narratives, engaging problems, relevant family scenarios, clear explanations, appropriate multimedia integration, and structured learning sequences.

2.4. Conceptual Framework

The conceptual framework proposes that the instructional method is the independent variable with two conditions: digital storytelling for the experimental group and the conventional teaching method for the control group. Digital storytelling involves researching genetics concepts, developing scripts and storyboards, integrating text, narration, pictures, diagrams, animations and videos, collaborating with peers, receiving feedback and presenting completed digital stories. The conventional method involves teacher explanations, textbook use, note-taking, question-and-answer sessions and routine classroom exercises.

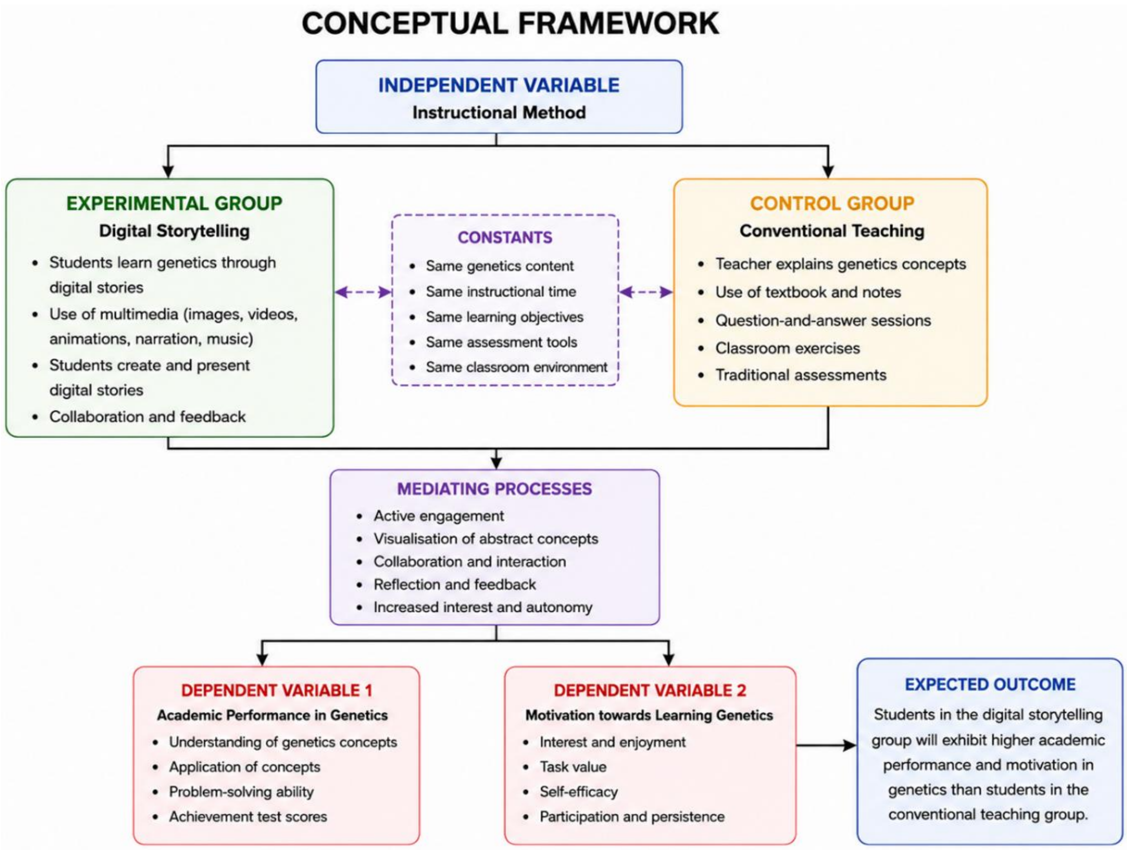

Figure 1. Conceptual framework of the study.

The framework assumes that digital storytelling promotes active participation, visualisation, collaboration, autonomy, reflection and feedback, which help students construct coherent relationships among abstract genetics concepts. These learning processes influence the dependent variables: students' academic performance and motivation towards learning genetics. The framework predicts that students exposed to digital storytelling will obtain higher posttest academic-performance and motivation scores than students exposed to the conventional teaching method.

2.5. Concept and Principles of Digital Storytelling in Education

Digital storytelling combines traditional storytelling with digital and multimedia resources such as written text, images, graphics, animations, videos, music, sound effects and recorded narration. It presents information through a short, coherent narrative developed around a particular educational objective, message and audience. Unlike an ordinary slideshow, a digital story connects multimedia elements through a meaningful storyline.

Digital storytelling may be teacher-created or student-created. Wu and Chen (2020) found that educational digital storytelling has been used across primary, secondary and higher education to support cognitive, affective, social and technological learning outcomes. Recent studies describe it as a learner-centred approach connecting narrative, multimedia and technology-supported knowledge construction (Başar, 2022; Bilici & Yilmaz, 2024; Büyükkarci & Müldür, 2022; Tamimi, 2024).

Development of a digital story involves planning, production, revision and presentation. Mosia and Egara (2025) organised the process into five phases: curriculum alignment and story planning, orientation to digital tools, story development and scaffolding, classroom implementation, and peer presentation and feedback.

2.6. Use of Digital Storytelling in Biology and Genetics Instruction

Biology contains numerous abstract concepts, invisible processes and complex relationships. Genetics is particularly challenging because learners must establish relationships among DNA, genes, alleles, chromosomes, proteins, meiosis, inheritance and variation across molecular, cellular and organismal levels (Machová & Ehler, 2023; Mussard & Reiss, 2022; Ojo, 2024).

In genetics instruction, digital stories can be developed around family resemblance, inherited disorders, blood groups, sex-linked characteristics, variation, mutation, meiosis and trait transmission. A digital story may follow a family attempting to understand why a genetic condition appears in some members but not others, integrating pedigree diagrams, photographs, animations and recorded narration to demonstrate inheritance patterns.

Digital storytelling may be used as teacher-developed instructional resources or student-generated learning activities. Karakoyun and Yapici (2016) found that digital storytelling was perceived as visual, attention-grabbing, enjoyable and capable of promoting learning by doing in biology education. Bilici and Yilmaz (2024) reported that collaborative digital storytelling in a tenth-grade cell-division unit improved academic achievement, critical-thinking disposition, co-regulation and narrative skills.

2.7. Digital Storytelling and Students' Academic Performance

Academic performance refers to the extent to which students acquire and demonstrate knowledge, understanding and skills after instruction. Digital storytelling may improve academic performance because it requires active interaction with subject matter rather than passive reception. When students create digital stories, they research information, identify important ideas, organise concepts, construct explanations, connect evidence with conclusions and communicate their understanding—promoting elaboration, reflection, application, creativity and higher-order thinking.

Empirical evidence indicates that students exposed to digital storytelling outperform those instructed through conventional methods. Bilici and Yilmaz (2024) found that the posttest academic-achievement mean of students who created collaborative digital stories was significantly higher than that of students in the control group. Başar (2022) reported improvements in students' achievement, attitudes and motivation. Kabaran (2022) meta-analysis of 13 science-education studies involving 913 participants found a high overall effect of digital-story applications on academic achievement.

Digital storytelling may also influence retention and problem-solving because stories organise information into meaningful and memorable sequences. Mosia and Egara (2025) found that senior secondary learners taught circle geometry through digital storytelling performed better in both achievement and delayed-retention assessments. Tamimi (2024) reported positive effects on students' academic outcomes and critical thinking. However, positive performance should not be assumed automatically; inaccurate information, poor story structure, irrelevant multimedia, inadequate digital skills, limited equipment and insufficient time may reduce effectiveness (Bilici & Yilmaz, 2024; Büyükkarci & Müldür, 2022; Mosia & Egara, 2025).

2.8. Digital Storytelling and Students' Motivation towards Learning Genetics

Motivation influences students' willingness to begin learning activities, maintain effort, participate and persist when encountering difficult concepts. Important dimensions include interest, enjoyment, task value, self-efficacy, participation and persistence. Digital storytelling strengthens these dimensions by transforming learning into an active, creative and personally meaningful process. Students make decisions about characters, storylines, images, narration and presentation styles, experiencing greater autonomy and ownership.

Several empirical studies report positive motivational outcomes. Başar (2022) found that students exposed to digital stories demonstrated improvements in achievement, attitudes and motivation. Tamimi (2024) reported significant motivational differences between students who experienced digital storytelling and those taught through comparison methods, particularly in task value and self-efficacy. Al-Jabri (2024) and Kılıç Mocan (2021) found that using digital stories increased learners' attention, concentration, achievement and motivation.

The motivational potential is particularly relevant to genetics because students may perceive the subject as abstract, difficult and overloaded with unfamiliar terminology. Negative perceptions and persistent misconceptions reduce confidence, interest and willingness to engage (Machová & Ehler, 2023; Ojo, 2024). Narratives based on family inheritance, variation and genetic conditions make genetics more relevant, while diagrams, animations and recorded explanations make difficult concepts more understandable.

2.9. Genetics Misconceptions among Secondary School Students

Misconceptions are scientifically inaccurate ideas that learners confidently consider correct. Genetics is particularly susceptible because many processes occur at molecular and cellular levels and cannot be directly observed. Students must connect concepts across DNA molecules, genes, chromosomes, cells, organisms, families and populations (Machová & Ehler, 2023; Mussard & Reiss, 2022).

One common group of misconceptions concerns relationships among DNA, genes, alleles and chromosomes. Some students use the terms interchangeably, while others believe genes and chromosomes are separate materials. Students may believe a gene is a small organism, visible particle or complete characteristic rather than a DNA segment. Machová and Ehler (2023) found students often possessed general ideas about genetic information but struggled to combine them coherently.

Misconceptions are also evident in inheritance understanding. Some learners believe children receive traits directly from grandparents rather than alleles from biological parents. Others assume offspring inherit more genetic information from the parent they resemble. A related misconception is that the mother determines child sex, although the father's sperm provides X or Y chromosomes.

Students frequently misunderstand dominance, recessiveness, genotype and phenotype. A dominant allele may be interpreted as physically stronger, more common or more likely to increase in a population. Some believe recessive alleles are weak and will disappear. Others assume individuals displaying dominant phenotypes must possess two dominant alleles, overlooking heterozygous conditions.

Another persistent misconception involves Punnett square interpretation. Some students interpret the four compartments as representing exactly four children born in sequence, failing to understand each fertilisation is independent and ratios represent probabilities across many offspring.

Evidence from Nigeria demonstrates the problem's extent. Ojo (2024) examined 789 senior secondary students and found only 21.4% demonstrated adequate understanding of genetics concepts, while 51.0% exhibited misconceptions. Ghanaian studies similarly show students experience difficulty applying genetics principles, using genetic symbols and explaining inheritance (Attipoe, 2015; Gyamfi & Agyei, 2025; Owusu, Adongo, Agyare, & Appiah-Kubi, 2023; Quainoo et al., 2021).

3. METHODOLOGY

3.1. Research Design

The study employed a quasi-experimental research design, specifically the non-equivalent control group pretest-posttest design, to investigate the effect of digital storytelling on students' academic performance and motivation in genetics. This design was considered appropriate because intact classes were used, making random assignment of individual students impractical within the natural school setting.

Two groups participated in the study. The experimental group was taught genetics using the Digital Storytelling Instructional Approach, while the control group was taught the same genetics concepts using the Conventional Teaching Method. Both groups were administered academic-performance and motivation pretests before the intervention to determine their initial levels. After the intervention, the same instruments were administered as posttests to determine changes in students' academic performance and motivation. The study was guided by the positivist research paradigm and adopted a quantitative approach emphasising objective measurement, empirical observation and statistical analysis.

3.2. Population and Sample

The population consisted of General Science students in Senior High Schools in the Sekyere South District, with an estimated population of 485 students from three schools. Two schools were purposively selected for the main study based on criteria such as offering elective Biology, having comparable class sizes and possessing basic technological and instructional resources required for the intervention, while the third school was used for the pilot study. Within the participating schools, intact SHS 3 Biology classes were assigned to the experimental and control groups to minimise selection bias. In total, 121 students participated in the main study, comprising 70 students in the experimental group and 51 students in the control group. Although the two groups had unequal sample sizes, this did not invalidate the comparison. The larger experimental group could produce a more precise estimate of its mean and smaller standard error, while the smaller control group could have wider confidence intervals and reduced statistical power. Consequently, assumptions such as normality, homogeneity of variance and homogeneity of regression slopes were examined before conducting inferential analysis. Pretest scores were statistically controlled to minimise the influence of initial group differences. Findings were interpreted using adjusted means, significance values, effect sizes and confidence intervals rather than relying only on observed differences in group means.

3.3. Instruments for Data Collection

Data were collected using the Students' Performance in Genetics Test (SPG) and the Students' Motivation towards Learning Genetics Questionnaire (SMLGQ). The SPG assessed students' knowledge, understanding and application of genetics concepts through essay-type questions covering DNA, genes, alleles, chromosomes, meiosis, monohybrid inheritance, sex determination, blood groups, pedigree analysis, mutation and genetic disorders. Parallel SPG items (different but equivalent questions) were used for pretest and posttest. The SMLGQ measured students' interest, enjoyment, task value, self-efficacy, participation and persistence in learning genetics using 10 items on a 5-point Likert scale.

3.4. Validity of the Instruments

Validity of the SPG and SMLGQ were established through expert review. Lecturers in the Department of Science Education and experienced Senior High School Biology teachers examined the instruments to assess whether items were scientifically accurate, grammatically clear, appropriate for students' level and adequately aligned with genetics content in the biology curriculum. Their comments and recommendations were used to revise ambiguous statements, correct factual and grammatical errors, and improve alignment with study objectives.

3.5. Pilot Study and Reliability

The SPG and SMLGQ were pilot-tested with 62 SHS 3 General Science students from a school with characteristics similar to those selected for the main study but not included in the final sample. The pilot study assessed clarity of instructions and items, appropriateness for students' level, time adequacy and instrument reliability. Cronbach's alpha was used to determine internal consistency of the SMLGQ, yielding a coefficient of 0.78, considered adequate for use in the main study.

The SPG consisted entirely of essay-type questions and was evaluated using inter-rater reliability. Two independent raters trained in the marking scheme scored the 62 completed scripts, and Cohen's kappa was calculated to determine agreement between them. A kappa coefficient of 0.812 was obtained, indicating almost perfect agreement (McHugh, 2012). Following the pilot study, ambiguous questions were reworded, grammatical and typographical errors were corrected, test instructions were clarified, and the marking scheme was revised.

The inter-rater reliability of the students' performance in genetics test was assessed using Cohen's kappa, and the results are presented in Table 1.

Table 1. Inter-rater reliability results for the students' performance in genetics test.

Reliability statistic	Value
Cohen's kappa coefficient	0.812
Number of valid cases	62

4. DATA COLLECTION PROCEDURE

4.1. Ethical Considerations

Before data collection, an introductory letter was obtained from the researcher's institution and submitted to the heads of selected Senior High Schools. Permission was obtained from school authorities and Biology teachers. Students were informed about the purpose of the study, voluntary participation and their right to withdraw without penalty. They were assured that responses would remain confidential and used strictly for academic purposes.

4.2. Pretest Administration

Selected intact SHS 3 Biology classes were assigned to the experimental group (70 students) and control group (51 students). Before the intervention, both groups were administered the SPG and SMLGQ as pretests under comparable classroom conditions, receiving the same instructions and time allocation.

Biology teachers responsible for the two groups received separate training on instructional procedures over two days (six hours total), facilitated by the researcher. The experimental-group teacher was trained in digital storytelling principles. The control-group teacher was trained in standardized conventional lesson procedures.

4.3. Instructional Implementation

The intervention was conducted over six weeks comprising 12 lessons of 80 minutes each. The experimental group was taught using the Digital Storytelling Instructional Approach. The control group was taught the same genetics content using the Conventional Teaching Method. Teaching was monitored through weekly observations using a structured Instructional Fidelity Observation Checklist. An independent experienced Biology teacher observed 25% of lessons to verify fidelity ratings. The checklist assessed adherence to lesson plans, content coverage, use of prescribed activities, lesson duration, teacher implementation quality, student participation and possible contamination between groups. Any deviations were discussed with teachers immediately, with corrective guidance provided before subsequent sessions. The genetics lesson sequence is presented in Table 2.

Table 2. Genetics Lesson sequence.

Lesson	Genetics content	Digital-storytelling activities
1	DNA, genes, alleles and chromosomes	Students viewed a digital story explaining the relationships among DNA, genes, alleles and chromosomes. They identified misconceptions, discussed the visual representations and prepared a short concept storyboard.
2	Meiosis and gamete formation	An animated narrative was used to demonstrate chromosome pairing, crossing over, separation and gamete formation. Students arranged illustrated scenes in the correct sequence and explained the events.
3	Monohybrid inheritance and Mendel's law of segregation	Students viewed *Mendel's Garden Mystery*, interpreted the inheritance of tall and dwarf characteristics, constructed Punnett squares and developed a six-scene storyboard.
4	Sex determination and blood-group inheritance	Digital stories based on family situations were used to explain sex determination and ABO blood-group inheritance. Students interpreted genetic crosses and explained possible offspring outcomes.
5	Pedigree analysis and genetic disorders	Students followed a family-based digital narrative involving an inherited condition, interpreted pedigree symbols and identified possible inheritance patterns.
6	Mutation, variation and student presentations	Students developed and presented short digital stories explaining mutation, variation or a selected genetic disorder. Peer and teacher feedback focused on scientific accuracy, clarity and logical organisation.

4.4. Posttest Administration

At the end of the intervention, parallel forms of the SPG were administered as posttests, and the SMLGQ was readministered to assess motivation changes. Posttest instruments were administered under comparable conditions with the same instructions and time allocation. Completed scripts and questionnaires were collected, checked for completeness and coded to protect participant identities. Essay responses were scored using the standardised marking scheme, while questionnaire responses were coded according to Likert-scale options. Data were entered into SPSS for screening and statistical analysis.

4.5. Data Analysis

Academic-performance data were analysed using descriptive statistics (means, standard deviations and mean gains) and Analysis of Covariance (ANCOVA) to compare posttest scores while controlling for pretest performance. Motivation data were analysed using descriptive statistics and a 2 (instructional group) × 2 (time) mixed-design Analysis of Variance (ANOVA). Preliminary assumption testing was conducted to ensure appropriateness of inferential analyses. Effect sizes were reported using partial eta-squared (η^2) values and interpreted using conventional thresholds (0.01 small, 0.06 medium, 0.14 large). All data analyses were conducted using SPSS.

5. RESULTS AND DISCUSSION

5.1. Preliminary Data Screening and Assumption Testing

Before the inferential analyses were conducted, the datasets were screened for missing values, implausible scores and serious univariate outliers. The assumptions associated with ANCOVA and mixed-design ANOVA were subsequently examined. For ANCOVA, the assumptions assessed included normality of residuals, linearity between the covariate and the dependent variable, equality of variances, homogeneity of regression slopes, reliable measurement of the covariate and independence of the covariate from the instructional treatment. Summary of preliminary data screening and assumption tests are presented in Table 3.

Table 3. Summary of preliminary data screening and assumption tests.

Assumption	Statistic or assessment	Probability	Decision
ANCOVA residual normality	Shapiro–Wilk, $W = 0.992$	$p = 0.762$	Supported
Linearity	Inspection of scatterplots and partial regression plots	Not applicable	Supported
Equality of posttest variances	Levene's test, $F = 0.12$	$p = 0.730$	Supported
Homogeneity of regression slopes	Pretest × instructional-group interaction, $F(1, 117) = 1.91$	$p = 0.169$	Supported
Reliability of the covariate	Cohen's κ = 0.812 for the SPG scoring	Not applicable	Supported
Independence of covariate and treatment	SPG pretest administered before the intervention; baseline group comparison	$p = 0.480$	Supported where $p > 0.05$
Experimental-group motivation-change normality	Shapiro-Wilk, $W = 0.981$	$p = 0.380$	Supported
Control-group motivation-change normality	Shapiro-Wilk, $W = 0.991$	$p = 0.961$	Supported
Equality of motivation-change variances	Levene's test, $F = 2.60$	$p = 0.110$	Supported

The assumption tests indicated that the data were suitable for ANCOVA. The ANCOVA residuals were approximately normal, $W = 0.992$, $p = 0.762$, and the posttest variances were homogeneous, $F = 0.12$, $p = 0.730$. The non-significant interaction between pretest performance and instructional group, $F(1, 117) = 1.91$, $p = 0.169$, confirmed homogeneity of regression slopes. Linearity was supported by the scatterplots, while the reliability of the covariate was supported by the Cohen's kappa value of 0.812. The covariate was independent of the treatment because the pretest was administered before the intervention.

For motivation, the change scores were approximately normal for both the experimental group, $W = 0.981$, $p = 0.380$, and the control group, $W = 0.991$, $p = 0.961$. The variances were also homogeneous, $F = 2.60$, $p = 0.110$. Independence was supported because the groups consisted of separate intact classes, while sphericity was not assessed because motivation was measured at only two time points.

5.2. Results for Research Question One

Difference in academic performance in genetics between students taught using digital storytelling and those taught using the conventional teaching method.

Table 4. Descriptive statistics for students' academic performance by instructional group.

Group	N	Pretest M	Pretest SD	Posttest M	Posttest SD	Mean gain
Digital storytelling	70	17.49	4.17	35.03	5.49	17.54
Conventional method	51	18.43	4.54	26.43	4.75	8.00

5.3. Descriptive Results

Table 4 shows that the digital-storytelling group increased from a pretest mean of 17.49 (SD = 4.17) to a posttest mean of 35.03 (SD = 5.49), representing a mean gain of 17.54 points. The conventional group increased from 18.43 (SD = 4.54) to 26.43 (SD = 4.75), with a mean gain of 8.00 points. The experimental group therefore recorded a substantially larger descriptive improvement. A chart illustrating the mean academic performance scores by instructional group is presented in Figure 2.

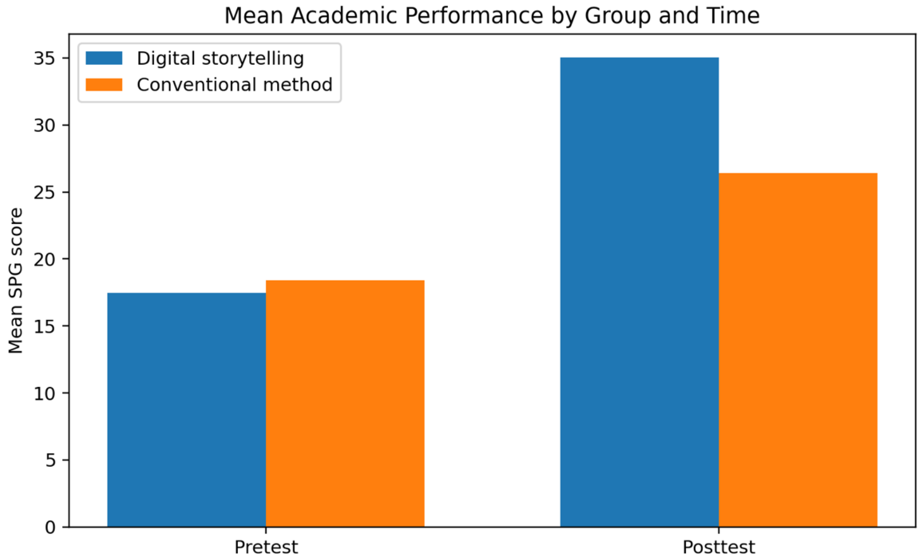

Figure 2. Mean academic performance scores by instructional group.

ANCOVA results of posttest academic performance controlling for pretest performance is presented in Table 5.

Table 5. ANCOVA results of posttest academic performance controlling for pretest performance.

Source	Sum of squares	df	Mean square	F	p	Partial η²
Pretest performance	1386.42	1	1386.42	89.79	< 0.001	0.432
Instructional group	2545.42	1	2545.42	164.85	< 0.001	0.583
Error	1822.03	118	15.44			

5.4. ANCOVA Results

After controlling for students' pretest performance, instructional group had a statistically significant effect on posttest academic performance, $F(1, 118) = 164.85$, $p < 0.001$, partial $\eta^2 = 0.583$. Using the conventional thresholds of 0.01 for small, 0.06 for medium and 0.14 for large effects, the partial eta-squared value of 0.583 represents a very large effect. This indicates that approximately 58.3% of the variance associated with posttest performance, after accounting for pretest performance, was attributable to the instructional method. The pretest covariate also had a significant and large effect, $F(1, 118) = 89.79$, $p < 0.001$, partial $\eta^2 = 0.432$, showing that students' initial performance substantially predicted their posttest scores.

The adjusted posttest mean for students taught through digital storytelling was 35.34, compared with 26.00 for those taught through the conventional method. Thus, after controlling for their initial performance, students in the digital-storytelling group scored approximately 9.34 points higher on the posttest than students in the control group. This difference is not only statistically significant but also educationally meaningful, suggesting that digital storytelling produced a substantial improvement in students' understanding and performance in genetics. Therefore, students taught genetics through digital storytelling performed significantly better than those taught using the conventional teaching method.

5.5. Results for Research Question Two

Research question two sought to find out the effect of digital storytelling on students' motivation towards learning genetics. Pretest and posttest item-level means and standard deviations are presented in Table 6.

Table 6: Pretest and posttest item-level means and standard deviations.

No.	Motivation statement	Dimension	Experimental Pretest M	SD	Experimental Posttest M	SD	Control Pretest M	SD	Control Posttest M	SD
1	I am interested in learning genetics.	Interest	3.04	0.39	3.71	0.50	2.82	0.32	3.33	0.41
2	I enjoy participating in genetics lessons.	Enjoyment	3.04	0.39	3.80	0.55	3.14	0.33	3.24	0.49
3	Learning genetics is valuable for understanding everyday life.	Task value	3.27	0.37	3.86	0.45	3.10	0.37	3.33	0.42
4	Genetics helps me understand inheritance, variation and genetic disorders.	Task value	3.13	0.28	3.89	0.49	3.06	0.37	3.37	0.33
5	I am confident that I can understand difficult genetics concepts.	Self-efficacy	3.13	0.23	3.76	0.42	2.94	0.35	3.22	0.47
6	I can successfully answer genetics questions when I make an effort.	Self-efficacy	3.09	0.21	3.70	0.57	2.88	0.39	3.06	0.38
7	I participate actively during genetics lessons and activities.	Participation	3.21	0.30	3.71	0.58	3.08	0.39	3.24	0.44
8	I am willing to ask questions and share my ideas during genetics lessons.	Participation	3.26	0.35	3.76	0.53	3.12	0.39	3.20	0.48
9	I continue working on genetics tasks even when they are difficult.	Persistence	3.00	0.34	3.87	0.52	3.06	0.38	3.29	0.44
10	I am willing to spend additional time learning genetics.	Persistence	3.13	0.37	3.74	0.51	3.10	0.30	3.33	0.35
	Overall motivation score		**3.13**	**0.39**	**3.78**	**0.53**	**3.03**	**0.39**	**3.26**	**0.40**

Note: Instructions to Respondents, indicate the extent to which you agree with each statement about learning genetics. Use the following scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Undecided, 4 = Agree and 5 = Strongly Agree.

6. STUDENTS' MOTIVATION TOWARDS LEARNING GENETICS QUESTIONNAIRE

6.1. Effect of Digital Storytelling on Students' Motivation Towards Learning Genetics

6.1.1. Descriptive Results

The descriptive statistics for students' motivation by group and time is presented in Table 7.

Table 7: Descriptive statistics for students' motivation by group and time.

Group	N	Pretest M	Pretest SD	Posttest M	Posttest SD
Digital storytelling	70	3.13	0.39	3.78	0.53
Conventional method	51	3.03	0.39	3.26	0.40

The digital-storytelling group's motivation increased from M = 3.13 (SD = 0.39) at pretest to M = 3.78 (SD = 0.53) at posttest, producing a mean gain of 0.65. The conventional group's motivation increased from M = 3.03 (SD = 0.39) to M = 3.26 (SD = 0.40), with a smaller mean gain of 0.23. The descriptive pattern therefore indicated a greater motivational improvement among students exposed to digital storytelling.

6.1.2. Mixed-Design ANOVA Results

A mixed-design ANOVA was conducted to examine changes in students' motivation from pretest to posttest and determine whether the changes differed between the digital-storytelling and conventional groups. Time was the within-subject factor, instructional group was the between-subject factor, and partial eta squared was reported as the effect size. The results is presented in Table 8.

Table 8: Mixed-design ANOVA for students' motivation towards learning genetics.

Effect	Sum of squares	df	Mean square	F	p	Partial η^2
Time	13.609	1	13.609	210.44	< 0.001	0.639
Instructional group	5.729	1	5.729	17.97	< 0.001	0.131
Time × instructional group	2.535	1	2.535	39.20	< 0.001	0.248
Within-subject error	7.696	119	0.065			

The mixed-design ANOVA showed a significant main effect of time, $F(1, 119) = 210.44$, $p < 0.001$, partial $\eta^2 = 0.639$, indicating that motivation changed across the two measurement occasions. There was also a significant main effect of instructional group, $F(1, 119) = 17.97$, $p < 0.001$, partial $\eta^2 = 0.131$. Most importantly, the interaction between time and instructional group was statistically significant, $F(1, 119) = 39.20$, $p < .001$, partial $\eta^2 = 0.248$. The significant interaction indicates that the change in motivation depended on the instructional method used.

7. DISCUSSION OF FINDINGS

Students taught genetics through digital storytelling performed significantly better than those taught conventionally, with the experimental group achieving a mean gain of 17.54 points compared to 8.00 points for the control group. The adjusted posttest mean difference of 9.34 points was statistically significant ($F(1,118) = 164.85$, $p < .001$, partial $\eta^2 = .583$), representing a very large effect. This superior performance suggests that combining narrative structure with diagrams, photographs, animations, videos and recorded explanations helped students understand the abstract and interconnected nature of genetics. When concepts are presented mainly through verbal explanations and static diagrams, students memorise definitions without understanding biological relationships. Digital stories organised concepts into coherent sequences and presented processes such as chromosome segregation, gamete formation and trait transmission in visual and contextually meaningful forms.

This finding aligns with Ojo (2024). Nigerian study where only 21.4% of students demonstrated adequate genetics understanding. It also agrees with Quainoo et al. (2021) who found the REACT strategy improved Ghanaian students' molecular genetics achievement through relating concepts to prior experiences and sharing information. The result is consistent with Gyamfi and Agyei (2025). Thinking Frames Approach, which significantly improved genetics performance among 200 Ghanaian SHS students with a large effect size. African evidence from Mosia and Egara (2025) further supports this, finding digital storytelling produced significantly higher achievement and retention in circle geometry (partial $\eta^2 = .843$). The improvement is explained by active knowledge-construction activities where students interpreted story events, answered guided questions, researched concepts, developed scripts and storyboards, and presented explanations—requiring retrieval, organisation, elaboration and communication of knowledge. This is consistent with Vygotsky's Social Constructivist Learning Theory, as digital storytelling provided opportunities for social interaction, cultural mediation and scaffolding, enabling students to move from assisted to independent performance within the Zone of Proximal Development.

Students' motivation towards learning genetics increased in both groups, but the increase was substantially greater among students exposed to digital storytelling. The experimental group's motivation increased from M = 3.13 to M = 3.78 (gain of 0.65), while the conventional group increased from M = 3.03 to M = 3.26 (gain of 0.23). The time-by-instructional-group interaction was statistically significant ($F(1,119) = 39.20$, $p < .001$, partial $\eta^2 = .248$), indicating the pattern of motivational change depended on the instructional approach. This motivational improvement is explained by digital storytelling's ability to make genetics more relevant and personally meaningful. Stories involving family resemblance, inherited characteristics, blood groups, sex determination and genetic disorders connect scientific concepts to everyday situations, reducing anxiety and helping students understand genetics' usefulness in health, agriculture and society. The finding is consistent with Ojo (2024) observation of negative perceptions of genetics and supports the perceptions reported by Ghanaian students in Quainoo et al. (2021). REACT study, where searching for information, sharing ideas and relating concepts to prior learning facilitated understanding. Evidence from South Africa (Mnisi, 2015) also demonstrates digital storytelling's affective and participatory value. Collaboration further enhanced motivation as students worked with peers, divided responsibilities, discussed explanations, received feedback and presented completed products—strengthening belonging and competence. The result is compatible with Social Constructivist Learning Theory, as motivation was supported through participation in meaningful social activity, with scaffolding enabling students to complete tasks they might not have completed independently, improving self-efficacy, participation and persistence.

8. CONCLUSION

The study concluded that digital storytelling was more effective than the conventional teaching method in improving students' academic performance and motivation in genetics. Students exposed to digital storytelling achieved higher posttest scores after their pretest performance was controlled, indicating that the approach supported better understanding of abstract genetics concepts. Their motivation also increased significantly, showing that digital storytelling made genetics lessons more interesting, meaningful and participatory. The combination of narratives, images, diagrams, animations, videos, recorded explanations and collaborative activities enabled students to organise ideas, visualise invisible processes and relate genetics concepts to familiar experiences. The findings therefore suggest that digital storytelling can improve both cognitive and affective learning outcomes when it is aligned with curriculum objectives. However, its effectiveness depends on accurate scientific content, technological resources, sufficient instructional time, students' digital competence and effective teacher guidance. Overall, digital storytelling represents a learner-centred strategy for teaching genetics in Senior High Schools.

8.1. Practical Implications

1. Biology teachers should integrate digital storytelling into genetics lessons to simplify abstract concepts and improve students' understanding, participation and motivation.
2. School administrators should provide computers, projectors, editing applications and teacher training to support the effective implementation of digital storytelling.
3. Curriculum developers should include digital storytelling among the recommended learner-centred strategies and provide suitable lesson plans, assessment rubrics and implementation guidelines.

8.2. Future Directions

Future studies should involve larger samples from different schools, districts and regions to improve the generalisability of the findings. Researchers should also conduct longitudinal studies with delayed posttests to determine whether digital storytelling improves the long-term retention of genetics concepts. Further studies should examine its effects on misconception reduction, critical thinking, creativity, collaboration, digital literacy and self-efficacy. Researchers may also compare teacher-created and student-created digital stories or investigate how gender, prior achievement, digital competence and access to technology influence the effectiveness of the approach.

8.3. Limitations of the Study

First, the study employed a quasi-experimental non-equivalent control-group design using intact classes; therefore, students were not randomly assigned individually to the experimental and control groups. Although pretest scores were statistically controlled, other differences between the groups, such as prior digital experience, learning ability, and teacher-related factors, might have influenced the results. Secondly, motivation was measured using a self-report questionnaire, making the responses susceptible to social desirability and students' desire to provide favourable answers. In addition, the novelty of using multimedia, animations and digital stories might have temporarily increased students' interest and motivation. Finally, differences in access to digital devices, internet connectivity and students' technological competence might have affected their level of participation and the effectiveness of the intervention.

REFERENCES

Al-Jabri, N. (2024). The impact of digital storytelling on motivation and achievement in teaching scientific concepts for kindergarten children. *Journal of Curriculum and Teaching Methodology, 3*(4), 29-52. https://doi.org/10.26389/AJSRP.N200124

Attipoe, J. Q. (2015). *Using cooperative instructional approach to improve the concept of genetics.* Master's Thesis, University of Education, Winneba.

Başar, T. (2022). The effect of digital stories on 3rd graders' achievement, attitudes and motivation in science lesson. *Participatory Educational Research, 9*(5), 127-142. https://doi.org/10.17275/per.22.107.9.5

Bilici, S., & Yilmaz, R. M. (2024). The effects of using collaborative digital storytelling on academic achievement and skill development in biology education. *Education and Information Technologies, 29*(15), 20243-20266. https://doi.org/10.1007/s10639-024-12638-7

Büyükkarci, A., & Müldür, M. (2022). Digital storytelling for primary school Mathematics Teaching: Product and process evaluation: Digital storytelling for primary school mathematics. *Education and Information Technologies, 27*(4), 5365-5396. https://doi.org/10.1007/s10639-021-10813-8

Gyamfi, M., & Agyei, C. A. (2025). Addressing conceptual difficulties in genetics through student-centered pedagogy: The case of thinking frames approach. *American Journal of Education and Learning, 10*(2), 249-266.

Kabaran, G. G. (2022). The effect of digital story applications on academic achievement in science education: A meta-analysis study. *E-International Journal of Educational Research, 13*(6), 86-102. https://doi.org/10.19160/e-ijer.1189309

Karakoyun, F., & Yapici, I. Ü. (2016). Use of digital storytelling in biology teaching. *Universal Journal of Educational Research, 4*(4), 895-903.

Kılıç Mocan, D. (2021). What do students really understand? Secondary education students' conceptions of genetics. *Science Insights Education Frontiers, 10*(2), 1405–1422.

Machová, M., & Ehler, E. (2023). Secondary school students' misconceptions in genetics: Origins and solutions. *Journal of Biological Education, 57*(3), 633-646. https://doi.org/10.1080/00219266.2021.1933136

McHugh, M. L. (2012). Interrater reliability: The kappa statistic. *Biochemia Medica, 22*(3), 276–282.

Mnisi, T. (2015). Digital storytelling: Creating participatory space, addressing stigma, and enabling agency. *Perspectives in Education, 33*(4), 92-106.

Mosia, M., & Egara, F. O. (2025). Enhancing achievement and retention in circle geometry through digital storytelling for senior secondary learners. *Education and Information Technologies, 30*(17), 25081-25111. https://doi.org/10.1007/s10639-025-13702-6

Mussard, J., & Reiss, M. (2022). Why is genetics so hard to learn? Insights from examiner reports for 16-18 year-olds in England. *School Science Review, 103*(384), 32-40.

Ojo, A. T. (2024). Examination of secondary school students' conceptual understanding, perceptions, and misconceptions about genetics concepts. *Pedagogical Research, 9*(1), em0185. https://doi.org/10.29333/pr/14095

Owusu, E. Y., Adongo, J. A., Agyare, E. B., & Appiah-Kubi, K. (2023). Assessing the impact of integrating information and communication technology on senior high school students' achievement in genetics. *International Technology and Education Journal, 7*(1), 18-27.

Quainoo, B. A., Otami, C. D., & Owusu, K. A. (2021). Effect of the REACT strategy on senior high school students' achievement in molecular genetics. *LUMAT: International Journal on Math, Science and Technology Education, 9*(1), 696–716. https://doi.org/10.31129/LUMAT.9.1.1418

Smeda, N., Dakich, E., & Sharda, N. (2014). The effectiveness of digital storytelling in the classrooms: a comprehensive study. *Smart Learning Environments, 1*(1), 6. https://doi.org/10.1186/s40561-014-0006-3

Tamimi, M. A. M. A. (2024). Effects of digital story-telling on motivation, critical thinking, and academic achievement in secondary school English learners. *Research in Social Sciences and Technology, 9*(1), 305-328.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, Eds.).* Cambridge, MA: Harvard University Press.

Wu, J., & Chen, D.-T. V. (2020). A systematic review of educational digital storytelling. *Computers & Education, 147*, 103786. https://doi.org/10.1016/j.compedu.2019.103786

Appendix A. Sample items from the students' performance in genetics test.

Appendix A present sample items from students' performance in genetics test.

Instructions

Answer all the questions. Show all genetic crosses clearly and explain your answers where required. The letters used for genetic symbols must be written correctly.

Sample Pretest Items

1. DNA, genes and chromosomes

a. Explain the relationship among DNA, genes and chromosomes.

b. State one function of genes in an organism.

c. Explain why body cells of the same individual generally contain the same genetic information.

Marking guide

- Chromosomes are structures composed mainly of DNA: 2 marks
- Genes are specific segments of DNA located on chromosomes: 2 marks
- Genes contain information for biological products or characteristics: 2 marks
- Appropriate function of genes: 1 mark
- Appropriate explanation concerning genetic information in body cells: 2 marks
- **Total: 9 marks**

2. Monohybrid inheritance

In pea plants, tallness ((T)) is dominant over dwarfness ((t)). A heterozygous tall pea plant was crossed with a dwarf pea plant.

a. State the genotypes of the parent plants.

b. State the possible gametes produced by each parent.

c. Use a Punnett square to determine the possible genotypes of the offspring.

d. State the expected genotypic and phenotypic ratios.

Marking guide

- Correct parental cross, (Tt \times tt): 2 marks
- Correct gametes, (T, t) and (t): 2 marks
- Correct Punnett square: 4 marks
- Genotypic ratio, (1Tt:1tt): 1 mark
- Phenotypic ratio, one tall to one dwarf: 1 mark
- **Total: 10 marks**

3. Sex determination

a. State the sex chromosomes of a human male and a human female.

b. Explain how the sex of a human child is determined during fertilisation.

c. Explain why it is scientifically incorrect to blame a mother for the sex of a child.

Marking guide

- Male: XY: 1 mark
- Female: XX: 1 mark
- All ova carry an X chromosome: 2 marks
- Sperm may carry an X or Y chromosome: 2 marks
- X-bearing sperm produces XX/female offspring: 1 mark
- Y-bearing sperm produces XY/male offspring: 1 mark
- Father's sperm determines whether X or Y is contributed: 2 marks
- **Total: 10 marks**

4. Pedigree analysis

A genetic condition is controlled by a recessive allele (a). Two phenotypically unaffected parents produced an affected child.

a. Suggest the genotype of each parent.

b. Use a genetic cross to show how they could produce an affected child.

c. State the probability that their next child will be affected.

d. Explain why the birth of one unaffected child does not change the probability for the next child.

Marking guide

- Both parents correctly identified as (Aa): 2 marks
- Correct cross, (Aa \times Aa): 2 marks
- Correct Punnett square: 4 marks
- Probability of affected child, (1/4) or 25%: 1 mark
- Each fertilisation is an independent event: 2 marks
- **Total: 11 marks**

Sample Parallel Posttest Items

1. Genetic organisation

A student stated that genes, DNA and chromosomes are three unrelated materials found in the nucleus.

a. State whether the student's explanation is correct.

b. Correctly explain the relationship among genes, DNA and chromosomes.

c. Explain how this relationship contributes to the transmission of inherited information.

2. Monohybrid inheritance

In maize, purple seed colour ((P)) is dominant over yellow seed colour ((p)). A heterozygous purple-seeded plant was crossed with a yellow-seeded plant.

a. State the parental genotypes.

b. Identify the possible gametes.

c. Construct a Punnett square.

d. Determine the expected genotypic and phenotypic ratios.

3. Human sex determination

A couple produced three daughters and expected that their fourth child must necessarily be a boy.

a. Use genetic symbols to illustrate human sex determination.

b. Explain whether the couple's expectation is scientifically justified.

c. State the probability that their fourth child will be male.

4. Human blood groups

A woman with genotype (I^(A)i) and a man with genotype (I^(B)i) planned to have children.

a. State the possible gametes produced by each parent.

b. Construct a genetic cross.

c. State the possible genotypes of their children.

d. Identify the possible blood groups of their child.