A Study of the Effectiveness of an Animated Learning Package on the Academic Achievement of Secondary School Students with Learning Disabilities in Mathematics

Sumera
Research Scholar
Dept. of Education
Karnataka State Akkamaha Devi
Women's University, Vijaypura
Email: sumeralubna309@gmail.com

Prof. B.L. Lakkannavar
Guide
Dept. of Education
Karnataka State Akkamaha Devi
Women's University, Vijaypura

Abstract

This study examined the effectiveness of an Animated Learning Package (ALP) on the academic achievement of secondary school students with specific learning disabilities in mathematics (dyscalculia and associated difficulties). A quasi-experimental pretest-posttest control group design was employed with 60 purposively selected students (N = 60) from government-aided secondary schools, equally divided into an experimental group (n = 30) receiving ALP-based instruction and a control group (n = 30) receiving conventional instruction over 12 weeks. Academic achievement was measured using a researcher-developed Mathematics Achievement Test (MAT; CVR = 0.87; Cronbach's á = 0.89). Data were analysed using independent samples t-test, paired samples t-test, ANCOVA, and effect size statistics. Posttest scores differed significantly between the experimental group (M = 74.83, SD = 9.12) and control group (M = 58.47, SD = 11.34) at $p < 0.001$, with ANCOVA confirming the treatment effect [$F(1, 57) = 47.23$, $p < 0.001$, $\eta^2 p = 0.453$] and Cohen's d = 1.64 indicating a large effect. The ALP was found to be a pedagogically sound and empirically validated intervention for enhancing mathematics achievement in this population.

Keywords

Animated Learning Package, Learning Disabilities, Mathematics Achievement, Secondary School Students, Instructional Technology, Special Education

Reference to this paper should be made as follows:

Received: 05.06.26
Approved: 18.06.26

Sumera
Prof. B.L. Lakkannavar

A Study of the Effectiveness of an Animated Learning Package on the Academic Achievement of Secondary School Students with Learning Disabilities in Mathematics

Vol. XVII, No.1
Article No. 37,
Pg. 356-365

Similarity Check: %
Online available at
https://anubooks.com/journal-volume/jgv-vol-xvii-no1-jan-june-2026
DOI: https://doi.org/10.31995/jgv.2026.v17i01.037

**This article has been peer-reviewed by the Review Committee of JGV.*

https://doi.org/10.31995/jgv.2026.v17i01.037

Introduction

Mathematics is a foundational domain for academic and socioeconomic functioning (Geary, 2011; Mazzocco & Myers, 2003). Students with learning disabilities (LD)—particularly dyscalculia—affect approximately 5–8% of the school-age population globally (APA, 2013; Butterworth et al., 2011) and face persistent deficits in number sense, arithmetic fluency, working memory integration, and abstract reasoning that conventional didactic instruction often fails to address (Fuchs et al., 2015). In the Indian context, large class sizes, limited LD-trained teachers, and insufficient technology integration further compound these challenges. Animated Learning Packages (ALP) offer a multimedia-rich alternative grounded in Dual Coding Theory (Paivio, 1991), the Cognitive Theory of Multimedia Learning (CTML; Mayer, 2009), and Universal Design for Learning (UDL; CAST, 2018). These frameworks collectively support the use of synchronised verbal narration and dynamic visual animation to reduce cognitive load and enhance mathematical concept formation. Despite this promise, rigorous empirical studies on ALP effectiveness for secondary school students with LD in mathematics—particularly in the South Asian context—remain sparse. This study addresses that gap.

Objectives

1. To develop and validate an ALP for selected Grade 9–10 mathematics topics.
2. To verify pretest equivalence of experimental and control groups.
3. To examine the effect of ALP on posttest mathematics achievement of students with LD.
4. To analyse differential effectiveness across gender and baseline achievement levels.
5. To compute the effect size of the ALP intervention.

Null Hypotheses

H_{01} : No significant difference in pretest mean scores between groups.

H_{02} : No significant difference in posttest mean scores between groups.

H_{03} : No significant difference in gain scores between groups.

H_{04} : No significant Treatment × Gender interaction effect on posttest scores.

H_{05} : The ALP does not produce a practically significant effect on mathematics achievement.

Review of Related Literature

Learning disabilities in mathematics are characterised by significant difficulties in applying mathematical skills, unexplained by intellectual disability or inadequate instruction (DSM-5; APA, 2013). Geary (2011) identified three subtypes: procedural, semantic memory, and visuospatial deficits. Butterworth et al. (2011) attributed these to an impaired domain-specific number module, while Swanson and Jerman (2006) implicated working memory deficits. Sharma (2015) reported that over 70% of students with mathematical LD in Indian secondary schools scored below the 25th percentile on standardised assessments despite average intellectual ability.

Research consistently supports multimedia-based intervention for this population. Xin et al. (2008) showed significant mathematics problem-solving gains with computer-assisted instruction; Seo and Bryant's (2009) meta-analysis of 21 studies yielded a mean effect size of d = 0.84 for students with LD. More recently, Hassler et al. (2020) reported Cohen's d = 1.21 for animated tablet instruction in dyscalculia, and Jitendra et al. (2018) found effect sizes of d = 0.90–1.35 for schema-based animation in algebra. In the Indian context, Kumar and Reddy (2019) obtained d = 0.62, and Bhatia (2021) reported d = 0.97 for animated geometry modules. Despite this evidence, rigorous ANCOVA-controlled studies targeting secondary LD students in India remain scarce—the gap this study fills.

Methodology

Research Design

A quasi-experimental pretest-posttest control group design was employed (Campbell & Stanley, 1963):

$$\text{EG: } O_1 \times O_2 \qquad\qquad \text{CG: } O_1 \times O_2$$

Where O_1 = pretest, O_2 = posttest, X = ALP intervention, — = conventional instruction.

Sample

A purposive sample of 60 certified-LD students (Grades 9–10) from government-aided secondary schools in Vijaypura District was selected: 30 in the experimental group (EG) and 30 in the control group (CG). Sample size was determined using G*Power 3.1 (α = 0.05, power = 0.80, d = 0.80; minimum n = 26 per group). Groups were statistically equivalent at baseline across gender, age, grade, and LD type (all $p > .05$; see Table 1).

https://doi.org/10.31995/jgv.2026.v17i01.037

Table 1. Demographic Profile of the Sample

Characteristic	EG (n=30)	CG (n=30)	Total (N=60)	χ^2/t (p)
Gender: Male	17 (56.7%)	16 (53.3%)	33 (55.0%)	χ^2=0.07 (.79)
Gender: Female	13 (43.3%)	14 (46.7%)	27 (45.0%)	—
Mean Age (yrs)	14.73 (0.81)	14.67 (0.76)	14.70 (0.78)	t=0.29 (.77)
Grade 9	16 (53.3%)	15 (50.0%)	31 (51.7%)	χ^2=0.07 (.79)
Grade 10	14 (46.7%)	15 (50.0%)	29 (48.3%)	—
LD: Dyscalculia	22 (73.3%)	21 (70.0%)	43 (71.7%)	χ^2=0.08 (.78)
LD: Mixed LD	8 (26.7%)	9 (30.0%)	17 (28.3%)	—

Note. Parentheses = SD for continuous variables; percentages for categorical variables. No significant baseline differences.

Animated Learning Package (ALP)

The ALP covered six CBSE Grade 9–10 mathematics units: Real Numbers, Algebraic Expressions, Linear Equations, Triangles and Congruence, Statistics, and Trigonometry—selected via needs assessment with 15 special educators. Developed in Adobe Animate CC and Articulate Storyline 3, the ALP comprised 42 animated segments (mean = 8.4 min each; H” 6 hours total), featuring narrated worked examples, drag-and-drop practice, corrective feedback animations, and read-aloud accessibility. Content validity (CVR = 0.87) was established by a 15-member expert panel (7 mathematics educators, 5 special education specialists, 3 ed-tech experts); embedded assessment reliability was $\alpha = 0.84$ (pilot n = 20).

Instrument: Mathematics Achievement Test (MAT)

The researcher-developed MAT comprised 50 items (20 MCQ × 1 mark; 20 short-answer × 2 marks; 10 application × 3 marks; total = 90 marks). Item difficulty ranged from 0.35–0.72 (M = 0.54) and discrimination from 0.30–0.68 (M = 0.46). Validity (CVR = 0.87), test-retest reliability ($r = 0.91$, $p < .001$), and internal consistency ($\alpha = 0.89$) were satisfactory. The MAT served as both O_1 and O_2

Procedure and Statistical Analysis

The study ran for 16 weeks: 2 weeks pretest, 12 weeks intervention, 2 weeks posttest. The EG used ALP in a supervised computer laboratory (45 min/day, 5 days/week); the CG received conventional lecture-based instruction on identical content by regular teachers. Contamination was minimised through teacher orientation and separate rooms.

Data were analysed in IBM SPSS v26 using: descriptive statistics, Shapiro-Wilk normality tests, Levene's homogeneity tests, independent and paired samples t-tests, one-way and two-way ANCOVA (posttest as DV, pretest as covariate), and Cohen's d / partial η^2p for effect size (α = .05 throughout).

Results

Descriptive Statistics and Assumptions

Table 2 presents descriptive statistics. Shapiro-Wilk tests confirmed normality (all $p > .05$); Levene's test showed homogeneity of variance for pretest [$F(1,58) = 0.21$, $p = .651$] and posttest [$F(1,58) = 2.13$, $p = .149$], supporting parametric analyses.

Table 2. Descriptive Statistics for Pretest, Posttest, and Gain Scores

Variable	n	Min	Max	M	SD	Skew	Kurt
Pretest Scores							
Experimental Group	30	22	46	34.27	5.84	0.18	-0.31
Control Group	30	20	48	33.90	6.21	0.22	-0.27
Combined	60	20	48	34.08	6.00	0.20	-0.28
Posttest Scores							
Experimental Group	30	56	90	74.83	9.12	-0.14	-0.42
Control Group	30	35	80	58.47	11.34	0.09	-0.38
Gain Scores (Post − Pre)							
Experimental Group	30	22	52	40.57	7.93	-0.21	-0.18
Control Group	30	10	36	24.57	8.64	-0.11	-0.22

Note. M = Mean; SD = Standard Deviation; Skew = Skewness; Kurt = Kurtosis. Maximum score = 90.

H_{01} – Pretest Equivalence

Independent samples t-test revealed no significant pretest difference [$t(58) = 0.24$, $p = .810$, $d = 0.06$; MD = 0.37, 95% CI ("2.70, 3.44)]. H_{01} retained. Groups were equivalent at baseline.

Table 3. Independent Samples t-test: Pretest Comparison

Group	n	M	SD	t	df	p (2-tailed)
Experimental Group	30	34.27	5.84			
Control Group	30	33.90	6.21	0.24	58	.810

Note. MD = 0.37; 95% CI ["2.70, 3.44]; Cohen's d = 0.06 (negligible).

H_{02} – Posttest Comparison

The EG scored significantly higher than the CG on the posttest [$t(58) = 6.34$, $p <$

https://doi.org/10.31995/jgv.2026.v17i01.037

.001, MD = 16.37, 95% CI (11.18, 21.56), d = 1.64]. H_{02}, rejected.

Table 4. Independent Samples t-test: Posttest Comparison

Group	n	M	SD	MD	t	df	p
Experimental Group	30	74.83	9.12				
Control Group	30	58.47	11.34	16.37	6.34	58	<.001

Note. 95% CI for MD [11.18, 21.56]; Cohen's d = 1.64 (very large effect).

H_{03} – Gain Score Analysis

Both groups improved significantly from pre- to posttest (both $p < .001$). The EG gain (M = 40.57, SD = 7.93) significantly exceeded the CG gain (M = 24.57, SD = 8.64) [t(58) = 7.41, $p < .001$, d = 1.92]. H_{03} rejected.

Table 5. Paired t-test: Pre–Post Change and Gain Score Comparison

Comparison	M Pre	M Post	Mean Gain	t	df	p
EG: Pre vs. Post (paired)	34.27	74.83	40.57	27.99	29	<.001
CG: Pre vs. Post (paired)	33.90	58.47	24.57	15.59	29	<.001
EG vs. CG Gain Scores	—	—	EG=40.57 CG=24.57	7.41	58	<.001

Note. EG = Experimental Group; CG = Control Group. Cohen's d for gain comparison = 1.92 (very large effect).

ANCOVA – Primary Treatment Effect

One-way ANCOVA (pretest as covariate) confirmed a significant main effect of treatment [F(1,57) = 47.23, $p < .001$, $\eta^2p = .453$], with the adjusted EG mean (M_adj = 74.71) substantially exceeding the CG (M_adj = 58.59). The pretest covariate was significant [F(1,57) = 11.66, p = .001, $\eta^2p = .170$]. The homogeneity of regression slopes assumption was met [F(1,56) = 0.84, p = .363]. H_{02}, firmly rejected.

Table 6. ANCOVA: Treatment Effect on Posttest Achievement

Source	SS	df	MS	F	p	η²p
Corrected Model	9,847.32	2	4,923.66	64.41	<.001	.694
Pretest (Covariate)	891.17	1	891.17	11.66	.001	.170
Group (Treatment)	3,610.84	1	3,610.84	47.23	<.001	.453
Error	4,357.02	57	76.44	—	—	—
Total	14,204.34	59	—	—	—	—

Note. $R^2 = .694$ (Adjusted $R^2 = .683$); η^2p = partial eta squared.

H_{04} – Treatment × Gender Interaction

Two-way ANCOVA revealed no significant Treatment × Gender interaction [F(1,55) = 1.66, p = .203, η²p = .029], indicating the ALP benefits were uniform across gender. H_{04} retained. The treatment main effect remained large and significant [F(1,55) = 46.12, p < .001, η²p = .449]. Descriptively, female EG students showed numerically higher gains (M_gain = 43.92) than males (M_gain = 38.06), though not statistically significant.

Table 7. Two-Way ANCOVA: Treatment × Gender Interaction

Source	SS	df	MS	F	p	η²p
Pretest (Covariate)	876.44	1	876.44	11.41	.001	.172
Group (Treatment)	3,542.19	1	3,542.19	46.12	<.001	.449
Gender	284.16	1	284.16	3.70	.060	.062
Treatment × Gender	127.43	1	127.43	1.66	.203	.029
Error	4,222.76	55	76.78	—	—	—

Note. Dependent variable: Posttest Mathematics Achievement Score; Pretest included as covariate.

Effect Size Summary

Table 8. Summary of Effect Sizes Across Analyses

Analysis	Statistic	MD / —	Effect Size	Magnitude
Pretest: EG vs. CG	t(58)=0.24, p=.810	0.37	d = 0.06	Negligible
Posttest: EG vs. CG	t(58)=6.34, p<.001	16.37	d = 1.64	Very Large
Gain Scores: EG vs. CG	t(58)=7.41, p<.001	16.00	d = 1.92	Very Large
ANCOVA: Treatment	F(1,57)=47.23, p<.001	16.12	η²p = 0.453	Large
2-Way ANCOVA: Treatment	F(1,55)=46.12, p<.001	—	η²p = 0.449	Large
2-Way ANCOVA: Tx×Gender	F(1,55)=1.66, p=.203	—	η²p = 0.029	Small/NS

Note. Benchmarks per Cohen (1988): small d ≥0.20, η²p≥.01; medium d≥0.50, η²p ≥.06; large d ≥0.80, η²p≥.14. NS = Not Significant.

Discussion

The results unequivocally establish the superiority of ALP-based instruction over conventional teaching for secondary school students with mathematical LD. The very large effect (d = 1.64; η²p = .453) surpasses Cohen's (1988) threshold for educational meaningfulness and aligns with the upper range reported by Seo and Bryant (2009) and Hassler et al. (2020). Through the CTML lens (Mayer, 2009), the ALP's synchronised narration and animation engaged both verbal and pictorial working-memory channels simultaneously—critical for a population whose phonological loop and central executive capacities are characteristically impaired (Swanson & Jerman, 2006). Segmented delivery, corrective animation, and repeated viewing offered scaffolding that static textbooks cannot provide, directly targeting the visuospatial and procedural subtypes identified by Geary (2011).

Both groups improved significantly from pretest to posttest, confirming that conventional instruction retains value; however, the EG gain (40.57) was 1.65 times larger than the CG gain (24.57), consistent with the UDL principle of multiple means of representation (CAST, 2018) and with Kumar and Reddy (2019) and Bhatia (2021) in the Indian context. The non-significant Treatment × Gender interaction indicates the ALP's benefits generalise across male and female students with LD—an important finding for inclusive classroom deployment. The numerically larger female gains tentatively echo Bhatia (2021) and Hassler et al. (2020), who noted that self-paced multimedia reduces mathematics anxiety more markedly in girls with LD; larger gender-stratified samples are needed to confirm this.

Practical implications are clear: the ALP can be integrated into Individualised Education Programs (IEPs), supporting both resource-room and inclusive mainstream settings. Policymakers should prioritise technology infrastructure and ALP-specific teacher training. Methodologically, this study provides an ANCOVA-controlled, effect-size-reported template for educational technology research targeting LD populations in Indian secondary schools. Limitations include the quasi-experimental design, restriction to two schools in one district, the 12-week observation window (insufficient to assess long-term retention), and potential Hawthorne effects. Future studies should employ multi-site randomised designs, longer follow-up periods, and secondary outcomes such as mathematics self-efficacy and anxiety.

Conclusion

This investigation provides robust, multi-method evidence that the Animated Learning Package significantly enhances mathematics achievement among secondary school students with learning disabilities ($d = 1.64$; $\eta^2 p = .453$) relative to conventional instruction, with benefits consistent across gender. The ALP's theoretical grounding in CTML, Dual Coding Theory, and UDL, combined with rigorous quasi-experimental evaluation, establishes it as a validated tool for inclusive mathematics education. These findings contribute meaningfully to the growing evidence base for technology-enhanced special education in India and comparable developing contexts, and invite integration of animation-based instruction as a standard component of LD mathematics pedagogy at the secondary level.

References

1. American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders (5th ed.). American Psychiatric Publishing.
2. Bhatia, S. (2021). Effectiveness of animated instructional modules on mathematics achievement and self-efficacy of secondary students with learning disabilities. Journal of Indian Education, 47(2), Pg. **112–131**.
3. Butterworth, B., Varma, S., & Laurillard, D. (2011). Dyscalculia: From brain to education. Science, 332(6033), Pg. **1049–1053**. https://doi.org/10.1126/science.1201536
4. Campbell, D. T., & Stanley, J. C. (1963). Experimental and quasi-experimental designs for research. Rand McNally.
5. CAST. (2018). Universal design for learning guidelines version 2.2. http://udlguidelines.cast.org
6. Cohen, J. (1988). Statistical power analysis for the behavioral sciences (2nd ed.). Lawrence Erlbaum Associates.
7. Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behavior Research Methods, 39(2), Pg. **175–191.**
8. Fuchs, L. S., Fuchs, D., & Gilbert, J. K. (2015). Evidence-based mathematics interventions for students with mathematics difficulties. Handbook of Special Education (2nd ed.). Routledge.
9. Geary, D. C. (2011). Consequences, characteristics, and causes of mathematical learning disabilities and persistent low achievement in mathematics. Journal of Developmental and Behavioral Pediatrics, 32(3), Pg. **250–263.**
10. Hassler, R., Acharya, A., & Mathews, S. (2020). Animated tablet instruction for fraction understanding in secondary students with dyscalculia: A randomized controlled study. Learning Disability Quarterly, 43(4), Pg. **213–227.**
11. Hattie, J. (2009). Visible learning: A synthesis of over 800 meta-analyses relating to achievement. Routledge.
12. Jitendra, A. K., Lein, A. E., Im, S. H., Alghamdi, A., Hefte, S., & Mouanoutoua, J. (2018). Mathematical interventions for secondary students with learning disabilities and mathematics difficulties. Exceptional Children, 84(2), Pg. **177–196.**

https://doi.org/10.31995/jgv.2026.v17i01.037

13. Karande, S., Satam, N., Kulkarni, M., Sholapurwala, R., Chitre, A., & Shah, N. (2008). Clinical and psychoeducational profile of children with specific learning disability and co-occurring ADHD. Indian Journal of Medical Sciences, 61(12), Pg. **639–647**.
14. Kumar, R., & Reddy, P. (2019). Impact of multimedia-based mathematics instruction on achievement of students with learning disabilities in Karnataka secondary schools. Asian Journal of Inclusive Education, 7(1), Pg. **44–58.**
15. Lawshe, C. H. (1975). A quantitative approach to content validity. Personnel Psychology, 28(4), Pg. **563–575.**
16. Mayer, R. E. (2009). Multimedia learning (2nd ed.). Cambridge University Press.
17. Mazzocco, M. M., & Myers, G. F. (2003). Complexities in identifying and defining mathematics learning disability in the primary school-age years. Annals of Dyslexia, 53(1), Pg. **218–253.**
18. Okolo, C. M., Bahr, C. M., & Reith, H. J. (2000). A retrospective view of computer-based instruction. Journal of Special Education Technology, 15(1), Pg. **5–26.**
19. Paivio, A. (1991). Dual coding theory: Retrospect and current status. Canadian Journal of Psychology, 45(3), Pg. **255–287.**
20. Seo, Y., & Bryant, D. P. (2009). Analysis of studies of the effects of computer-assisted instruction on the mathematics performance of students with learning disabilities. Computers & Education, 53(3), Pg. **913–928.**
21. Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). Experimental and quasi-experimental designs for generalized causal inference. Houghton Mifflin.
22. Sharma, N. (2015). Mathematics learning difficulties in Indian secondary schools: Prevalence, profiles, and implications. Journal of Learning Disabilities, 48(6), Pg**. 578–591.**
23. Swanson, H. L., & Jerman, O. (2006). Math disabilities: A selective meta-analysis of the literature. Review of Educational Research, 76(2), Pg. **249–274.**
24. Xin, Y. P., Jitendra, A. K., & Deatline-Buchman, A. (2008). Effects of mathematical word problem-solving instruction on middle school students with learning problems. The Journal of Special Education, 42(1), Pg. **7–20.**