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Comparison of the Effectiveness of Digital Scrolling and Linear Text on UPI Student Information Retention

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Abstract: *Background: The shift to digital learning changes how students read and retain information; navigation differences between scrolling and linear text may affect cognitive load and memory. Objective: To compare the effects of digital scrolling and linear text presentation on student information retention. Methods: A comparative quantitative study with a between-subject design. Population and Sample: Active students at Universitas Pendidikan Indonesia Bumi Siliwangi Campus; total sampling produced 20 participants divided equally into two groups (n = 10 per group). Instrument: A 15-item objective test (closed-ended) administered after reading identical material in either scrolling or linear format. Data Analysis: Independent samples t-test, Mann-Whitney U for robustness, and Cohen's d for effect size. Results: Mean retention scores were 12.70 (scrolling) and 13.30 (linear). No statistically significant difference was found ($t = -0.722$, $p > 0.05$; $U = 41$, $p > 0.05$). Cohen's $d = 0.323$ indicates a small-to-medium practical effect favoring linear text. Conclusion: Although statistical significance was not achieved, linear text showed a modest practical advantage in supporting retention, suggesting lower cognitive load; further research with larger samples is recommended.*

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Introduction

Digital transformation in the higher education environment has fundamentally changed the way students interact with academic texts and information sources. The shift from printed books to digital platforms is now no longer an option, but rather a necessity to support learning efficiency. However, behind the ease of access, there are considerable

cognitive challenges related to how the presentation of text affects the ability to absorb information. Kisno and Sianipar (2019) in their research highlighted that although digital books are very accessible, their effectiveness in improving learning outcomes depends largely on how students use them. This phenomenon is often associated with low digital literacy among students, as discussed by Furwana et al. (2024). They found that the barriers to reading digital books are not only technical, but also about cognitive comfort that affect a deep understanding of the material.

The main problem in digital reading is the difference in navigation between scrolling and linear or paginated text. Scrolling requires the eye to keep track of the text in constant motion, which can add to the cognitive load compared to fixed-position linear text. Sari (2025) emphasizes the importance of media design that is in accordance with human cognitive processes to make digital devices more effective in education. In addition, students' ability to manage various digital media also determines learning outcomes, as reviewed by Pahrul and Marhamah (2024) about the role of digital media in academic achievement.

The mismatch between the way students consume information and the way the information is tested is also an important factor in information retention. Azzahra et al. (2025) show that the suitability of learning media formats and tests has a significant effect on reading comprehension scores; Inconsistencies can interfere with information recall . Although much of the literature compares print and digital media, specific studies on the comparison of scrolling versus linear text to student information retention in local contexts are rare. This gap is the main reason for this research. With an experimental approach, this study wants to test how much the difference in the mechanism of text presentation affects student information retention, so that it can contribute to the development of more cognitively friendly digital materials.

Research Methods

The research was conducted using a quantitative method. The quantitative research method is research with tools to process data using statistics, therefore the data obtained and the results obtained are in the form of numbers. Quantitative research emphasizes on objective results, through the dissemination of questionnaires, data can be obtained objectively and tested using the validity and reliability process. To be able to assess the problem to be studied, quantitative research divides the components of the problem into several variables and each variable is determined with a different symbol according to the needs or problems to be researched by the researcher (Syafrida, 2021).

Population is a generalized area consisting of objects or subjects that have certain qualities and characteristics that are determined by researchers to study and then draw conclusions (Sugiyono, 2021). The population in this study is active students of UPI bumi siliwangi. A sample is a part of the population that represents the number and characteristics of that population (Sugiyono, 2021). The sampling technique used in this study is Total Sampling (Sensus). Through this technique, all members of the population

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are fully drawn to be used as research samples without determining specific inclusion or exclusion criteria. This is done so that the data obtained can represent all target groups as a whole.

The data collection technique in this study was carried out using an instrument in the form of a questionnaire which was modified into an objective test. Data collection is designed into two forms of reading treatment, namely reading text in scrolling format and reading in linear text format, the instruments in both formats use the same reading topic. Each respondent will be instructed to read the text presented between the two formats. After the reading process is completed, respondents are asked to fill out a questionnaire containing a series of evaluation questions. These questions are closed instruments that already have a definite answer key (true or false). The results of filling out this questionnaire will be calculated as a score to measure the performance or level of understanding of the respondents from each reading method as best as possible.

Analysis techniques are ways of mapping, decomposing, calculating, and assessing data that have been collected to answer the formulation of problems and obtain conclusions in research (Sugiyono, 2021). To compare the averages of two different groups we analyzed using a partial test or t-test. The partial test or t-test is a test of the partial regression coefficient, to determine the partial significance or each variable is independent of the variable (Syafrida, 2021). In the calculation of an independent sample t-test assuming homogeneous variance, the analysis process is carried out through several mathematical stages. First, the average score of each group is calculated by summing up all the individual scores in that group, then dividing it by the total respondents in that group. Next, the variance of each group was determined by squared the difference between each individual score and the average of the group, then dividing it by the number of respondents minus one. Since both groups are assumed to have the same variance, the next step is to calculate the pooled variance. This is done by multiplying the variance of each group by the number of respondents who have been subtracted by one, adding up the results of the two groups, and dividing it by the total number of respondents subtracted by two. Once the combined variance is known, the t-calculated value can be sought by calculating the average difference between the first group and the second group. The difference is then divided by the square root of the multiplied result between the combined variance and the inverse of the sample size of each group. Finally, the degrees of freedom used as a reference in determining the value of the t-table were calculated by adding up the total respondents from both groups, then subtracting by two.

Result and Discussion

Statistics Descriptive

This study involved 20 respondents of active UPI Bumi Siliwangi students who were divided into two reading treatment groups: Group 1 with digital scrolling format (n = 10) and Group 2 with linear text/digital slide format (n = 10). Each respondent worked

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on an evaluation instrument in the form of 15 objective questions after completing the reading process according to the set format. The recapitulation of the scores of each group is presented in Table 1 below.

Table 1 Respondent Score Recapitulation

No.	Digital Scrolling	Linear Text
1	11	14
2	13	11
3	14	14
4	14	15
5	10	14
6	15	12
7	13	11
8	13	15
9	9	12
10	15	15
Quantity	**127**	**133**
Average ($\bar{x}$)	**12,70**	**13,30**
Varians (s^2)	**4,233**	**2,678**
Std. Deviation(s)	**2,057**	**1,636**
Score Minimum	**9**	**11**
Maximum Score	**15**	**15**

Based on Table 3.1, the average score of Group 1 (digital scrolling) is 12.70, while the average score of Group 2 (linear text) is 13.30, with a difference of 0.60 points. The linear text group also had smaller variance (2,678 vs 4,233), indicating a more homogeneous distribution of scores between respondents than the scrolling group.

Prerequisite Test

a. Normality Test (Shapiro-Wilk)

The normality test was performed using the Shapiro-Wilk method, which was chosen because of the small sample size (n < 30). The W test statistics are calculated by the formula:

$$W = \frac{b^2}{\sum_{i=1}^{n} (x_i - \underline{x})^2}$$

where a value of b is obtained from a linear combination of scores that have been sequenced using the coefficients of the Shapiro-Wilk table.

Group 1 (Digital Scrolling) scored in order: 9, 10, 11, 13, 13, 13, 13, 14, 14, 15, 15

With a coefficient (n=10): a_1=0.5739; a_2=0.3291; a_3=0.2141; a_4=0.1224; a_5=0.0399, then:

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$$b = 0{,}5739(15-9) + 0{,}3291(15-10) + 0{,}2141(14-11) + 0{,}1224(14-13) + 0{,}0399(13-13)$$

b = 3,4434 + 1,6455 + 0,6423 + 0,1224 + 0 = 5,8536

$$W_1 = \frac{(5{,}8536)^2}{38{,}10} = \frac{34{,}264}{38{,}10} = 0{,}899$$

Group 2 (Linear Text) sorted scores: 11, 11, 12, 12, 14, 14, 14, 15, 15, 15

$$b = 0.5739(15-11) + 0.3291(15-11) + 0.2141(15-12) + 0.1224(14-12) + 0.0399(14-14)$$

b = 2.2956 + 1.3164 + 0.6423 + 0.2448 + 0 = 4.4991

$$W_1 = \frac{(4{,}4991)^2}{24{,}10} = \frac{20{,}242}{24{,}10} = 0{,}840$$

Table 2 Shapiro-Wilk Normality Test Results

Groups	W Count	In tables (α=0.05; n=10)	Ket.
Digital Scrolling	0,899	0,842	Normal
Linear Text	0,840	0,842	*Borderline*

b. Uji Homogenitas Varians (Levene's Test)

The homogeneity test was carried out with the median-based Levene's Test. Each score is transformed into , with a Median K1 = 13; Median K2 = 14.Z_ij=|x_ij- 〖median 〗 _j |

$\bar{Z}$ values for K1 = 1.50 and K2 = 1.30, so that the grand mean $\bar{Z}$ = (15 + 13) / 20 = 1.40.

$$SS_B = 10(1{,}50 - 1{,}40)^2 + 10(1{,}30 - 1{,}40)^2 = 0{,}10 + 0{,}10 = 0{,}20$$

$$SS_W = 16{,}50 + 12{,}10 = 28{,}60$$

$$W_L = \left(\frac{18}{1}\right) \times \left(\frac{0{,}20}{28{,}60}\right) = 0{,}126$$

With F-table (df_1=1, df_2=18, α=0.05) = 4.414. Since = 0.126 < 4.414, the variance of the two groups is declared homogeneous. The t-test assumption is met.W_L

c. Independent t-test hypothesis test

Based on the fulfillment of the assumptions of normality and homogeneity, an independent t-test with pooled variance was performed. The calculation is carried out through the following stages.

$$\bar{x}_1 = 12{,}70 \quad \bar{x}_2 = 13{,}30$$

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$$s^2{}_p = \left[\frac{(9)(4{,}233) + (9)(2{,}678)}{18}\right] = \frac{62{,}20}{18} = 3{,}456$$

$$t = \frac{(12{,}70 - 13{,}30)}{\sqrt{\left(3{,}456\left(\frac{1}{10} + \frac{1}{10}\right)\right)}}$$

$$t = \frac{-0{,}60}{\sqrt{0{,}6912}} = \frac{-0{,}60}{0{,}8314} = -0{,}722$$

Degrees of freedom (df) = $n_1 + n_2 - 2 = 10 + 10 - 2 = 18$. The t-table value at $\alpha = 0.05$ (bidirectional test) with df = 18 is 2.101.

Because $|-0.722| = 0.722 < 2.101$, then H_0 is accepted. There was no statistically significant difference between the information retention of the two groups at a significance level of 5%.

d. Uji Robustness Mann-Whitney U

Considering that Group 2 was in a borderline position in the normality test, the Mann-Whitney U test was carried out as a nonparametric verification. All 20 scores are ranked together, with an average ranking for the same score (tied ranks).

The results of the ranking were obtained: R_1 (total K1 ranks) = 96 and R_2 (total K2 ranks) = 114.

$$U_1 = n_1 n_2 + \frac{n_1(n_1 + 1)}{2} - R_1 = 100 + 55 - 96 = 59$$

$$U_2 = n_1 n_2 + \frac{n_2(n_2 + 1)}{2} - R_2 = 100 + 55 - 114 = 41$$

$$U = min(59, 41) = 41$$

U-table ($n_1 = n_2 = 10$, $\alpha = 0.05$, bidirectional test) = 23. Since U = 41 > 23, H_0 is accepted. These results are consistent with the t-test.

e. Effect Size Cohen's d

To measure the magnitude of the effect practically, Cohen's value d is calculated as follows:Conclusion and Recommendation

$$d = \frac{|\mu_1 - \mu_2|}{S_p} = \frac{|12{,}70 - 13{,}30|}{\sqrt{3{,}456}} = \frac{0{,}60}{1{,}859} = 0{,}323$$

The value d = 0.323 belongs to the category of small-to-medium effect based on the Cohen (1988) convention, which sets d = 0.20 as a small effect, d = 0.50 as a medium effect, and d = 0.80 as a large effect. This finding is practically significant even though it has not reached statistical significance due to the limitations of the sample size.

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Table 3 Summary of all analysis results

Remarks	Value	Notes
Group Average 1 (Scrolling)	12,70	-
Group Average 2 (Linear)	13,30	-
Group Variance 1 (s^2_1)	4,233	-
Group 2 Variance (s^2_2)	2,678	-
Combined Variance (s^2p)	3,456	-
t-count	− 0,722	-
Degrees of freedom (df)	18	-
T-table (α=0.05, bidirectional test)	2,101	-
Mann-Whitney U	41	-
Cohen's d	0,323	Small-Medium
Verdict	H_0 Accepted	Insignificant

Discussion

The test results consistently showed no statistically significant difference between student information retention in digital scrolling format (= 12.70) and linear text ($\overline{xx}$ = 13.30), either by t-test (t = − 0.722; p > 0.05) and the nonparametric Mann-Whitney U test (U = 41; p > 0.05). However, Cohen's value d = 0.323 indicates a small-medium-sized effect that is practically still meaningful, although not yet strong enough to be statistically detectable in such a small sample (n = 20).

These findings are in line with a number of studies that show that differences in digital formats do not necessarily result in significant differences in understanding. Some studies have noted that the emotional and cognitive differences between reading on screen versus on paper are reported to be insignificant, and some studies have even found more positive attitudes among students who use digital textbooks. This condition can reflect the adaptive ability of students in the digital era in utilizing both formats relatively equally.

However, the tendency of linear texts to be descriptively superior has a strong theoretical foundation. Sanchez and Wiley (2009) assert that the absence of spatial location markers due to scrolling can make it difficult to remember and understand the text; readers with an adequate knowledge background generally have less difficulty because the

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knowledge helps compensate for the difficulty of tracking page positions. In the context of this study, the 2nd semester students who were respondents may not have enough background knowledge to fully compensate for the weaknesses of scrolling navigation.

Haverkamp et al. (2023) found that students tended to gain more integrated understanding when reading in paging format compared to scrolling, and the group that used paging showed more strategic backtracking behavior to support deep understanding. This pattern is relevant because the linear text format used in this study structurally resembles the paging format, which provides a more stable visual marker for the reader.

From the perspective of cognitive load, Liu (2024) found that text segmentation in a multimedia learning environment significantly reduces cognitive load and supports learning efficiency and deeper information retention. A more segmented linear text format is inherently more friendly to students' working memory capacity, although the effect was only seen descriptively in this study due to the limited number of samples.

Liu (2024) notes that screen-based reading encourages individuals to allocate more time to scanning and superficial one-time readings, with less time for concentrated and in-depth reading. This scanning tendency is relevant to the context of scrolling, where the continuity of text movement can encourage more superficial reading than static formats.

Bresó-Grancha et al. (2022) found that reading cognition and comprehension in students who are familiar with digital sources are influenced by the shallowing hypothesis, which is a shallow reading habit formed from the consumption of short and fast digital content. The generation of students who were respondents in this study likely already had adaptive digital reading patterns, so the difference in impact between formats was not seen drastically in the short term of this experiment.

Cohen's value d = 0.323 which is relatively small-medium indicates that although not statistically significant, the difference cannot be completely ignored practically. With a larger sample, this effect has the potential to reach statistical significance. This is consistent with the argument that statistical significance and practical significance are two different things and should be reported simultaneously in educational research (Cohen, 1988).

Conclusion

This study concludes that there is no statistically significant difference in students' information retention ability between the digital scrolling format and the linear text format, although descriptively the linear format produced slightly higher average scores. The statistical tests confirmed that the difference was insufficient to reject the null hypothesis at the 5% significance level, while Cohen's d value indicated a small-to-medium practical effect, suggesting that text format still has a modest influence on retention. The findings imply that students may have adapted to processing digital information in both formats, yet the linear format may provide cognitive advantages by reducing cognitive load and offering clearer spatial organization. Nevertheless, the study was limited by the small sample size,

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the use of a between-subject design, respondent heterogeneity, and the absence of moderator variables such as digital literacy and gadget usage habits. Therefore, future studies are recommended to involve larger samples and apply a within-subject design with counterbalancing techniques to improve statistical power and control individual differences more effectively.

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