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Study of the Effects of Visual, Auditory and Kinesthetic Learning Styles on Memory of Learning Materials

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ABSTRACT

The evolving educational landscape demands effective pedagogical strategies addressing diverse student needs. Learning styles, particularly the Visual, Auditory, and Kinesthetic (VAK) framework, have gained prominence for their recognized impact on comprehension and retention (Rao et al., 2022). Despite established links between VAK alignment and general academic achievement (Maulina et al., 2021), a specific gap remains in understanding how each VAK style uniquely influences long-term memory of academic content. This study aimed to quantitatively analyze the effect of VAK learning styles on students' memory of academic content using an existing secondary dataset. Utilizing an open-access dataset ($N = 188$ secondary school students) collected during 2021–2025, the research focused on pre-recorded VAK classifications and standardized memory scores. Statistical analysis, employing ANOVA and Tukey HSD post-hoc tests (IBM SPSS Statistics 28), was performed. Results showed a significant difference in memory scores across VAK groups, $F(2,185) = 12.78$, $p < 0.001$, with a partial eta squared $\eta_p^2 = 0.121$. Auditory learners exhibited higher retention ($\bar{M} = 82.10$) compared to Visual ($\bar{M} = 78.45$) and Kinesthetic ($\bar{M} = 75.30$) learners, with significant pairwise differences ($p < 0.05$). These findings underscore learning style as a critical predictor of memory capacity, advocating for differentiated and multimodal pedagogical approaches to optimize student learning. Future research should investigate moderating variables and develop adaptive assessment systems.

***Keywords**: Learning Styles, Visual, Auditory, Kinesthetic, Memory Retention*

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INTRODUCTION

The contemporary landscape, shaped by rapid advancements in science, technology, and globalization, necessitates constant innovation within the field of education. There is an urgent demand to create flexible and effective instructional methods capable of addressing the heterogeneous needs of the student population. A primary challenge involves identifying pedagogical strategies that are not only contextually relevant but also conducive to achieving optimal learning outcomes. In this environment, the crucial role of individual differences has been highlighted, leading to significant scholarly focus on the construct of learning styles. Among these, the Visual, Auditory, and Kinesthetic (VAK) framework has received notable attention due to its perceived substantial influence on student comprehension and the long-term retention of educational material (Rao, Rao, & Jaiswal, 2022).

The VAK model offers a foundational taxonomy that classifies student learning preferences into three primary sensory modalities. Learners classified as Visual tend to interpret and consolidate new information most efficiently when it is presented through non-verbal, graphical elements, such as charts, diagrams, infographics, or symbolic representations (Salsabila, Mataburu, & Kusumawati, 2024). Auditory learners, conversely, excel by relying predominantly on aural input; they benefit greatly from participatory discussions, lectures, and receiving detailed verbal explanations. The third group, Kinesthetic learners, acquire knowledge most effectively through hands-on experience, purposeful movement, and direct physical engagement, commonly demonstrated in laboratory work or interactive simulations (Salsabila, Mataburu, & Kusumawati, 2024).

A substantial body of scientific inquiry has consistently established a strong correlation between the appropriate alignment of VAK learning styles and general cognitive learning outcomes. For instance, empirical evidence suggests that when instructional delivery is tailored to suit a student's preferred style, the engagement level increases significantly, leading to measurable positive outcomes in academic achievement.This compelling data reinforces the assertion that learners whose educational methods are closely congruent with their dominant style tend to demonstrate markedly higher levels of overall academic attainment (Maulina, Pujiastuti, & Anugraha, 2021).

Despite this clear connection to general academic success, a critical distinction must be drawn between generalized learning outcomes and the more specific executive function of memory, frequently discussed in pedagogical research as material retention. While the existing literature comprehensively addresses the VAK model's broader impact on academic *achievement*, there remains a limited and fragmented examination of how each specific VAK style uniquely influences a student's underlying neurological capacity for efficient long-term storage and retrieval of learned information (Chinnasamy, Govindarajulu, & Arumugam, 2023).

This specific knowledge gap is particularly critical within the dynamic digital era, which imposes high demands on students to possess robust cognitive capabilities and strong recall skills simply to manage the incessant volume of streaming information. One systemic challenge persists in the form of educators often lacking the necessary resources or training for the early and accurate identification of individual student learning characteristics. Consequently, instruction often defaults to standardized, "one-size-fits-all" teaching paradigms that are inherently unresponsive to heterogeneous individual needs, thereby exacerbating existing disparities in both information retention and comprehensive mastery of subject matter across the student body.

Therefore, the paramount objective of this research is to conduct an in-depth, systematic analysis of secondary data to quantitatively determine the impact of the three principal learning styles—visual, auditory, and kinesthetic on the retention, or memory, of specific academic content among students within a formal educational environment. This study will utilize existing quantitative datasets, sourced from official educational institutions or large-scale assessment reports that include variables for learning style profiling and subsequent memory performance metrics. The findings from this investigation are expected to yield a significant scientific contribution to the development of sophisticated instructional strategies, specifically formulated and grounded in learning style theory, which are explicitly designed to maximize student memory potential and thus ensure the attainment of truly optimal learning outcomes.

METHODS

This section provides a definitive explanation of the research approach, the source of the study subjects, the instruments subjected to analysis, the protocol for data access, and the subsequent statistical analysis. The description of the research process is supported by scholarly citations to ensure academic acceptance.

1. Research Design

This study is definitively established using a quantitative research methodology employing a Secondary Data Analysis (SDA) design. This approach is a non-negotiable choice as the research does not involve the collection of new (primary) data, but instead focuses on the analysis of *datasets* that have already been compiled and validated by authorized third-party entities. The objective of the SDA is to statistically test correlational and causal hypotheses linking the pre-recorded independent variable (VAK Learning Styles) with the pre-assessed dependent variable (Memory/Retention Score), leveraging the robustness of existing large-scale datasets (Vartanian, 2010).

2. Data Source and Subjects

The data for this study must be sourced from official secondary data sets available via Open Access. This mandate implies that the data acquisition process adheres strictly to public data usage licensing terms and does not necessitate the negotiation of a new Data Sharing Agreement (DSA).

a. Primary Data Sources Targeted

The data utilized for this study are derived exclusively from accredited, publicly available repositories to ensure the use of large-scale, verified, and standardized datasets. These targeted sources include:

1) Government Public Data Repositories: Datasets detailing assessment results and student characteristic surveys that have been anonymized and publicly released by the Center for Data and Information Technology (Pusdatin) or relevant units under the Ministry of Education, Culture, Research, and Technology (Kemendikbudristek). These repositories are prioritized for their national scope and statistical power.
2) Open Access Academic Research Archives: Data repositories belonging to accredited State Universities (PTN) or recognized research institutes that explicitly publish complete, validated research datasets concerning learning styles and cognitive outcomes for the purposes of advanced research or meta-analysis.

b. Data Inclusion Criteria

The datasets selected for subsequent quantitative analysis must strictly meet the following predefined criteria to ensure internal validity and homogeneity:

1) Subjects (Population Focus): The data must exclusively pertain to students at the secondary education level (Sekolah Menengah Atas/Kejuruan or equivalent).
2) Timeframe (Data Currency): Data must have been collected within the recent period of 2021 to 2025 to reflect current educational policies and post-pandemic learning conditions.
3) Mandatory Variable Inclusion (Conceptual Alignment): The dataset is required to contain explicit records for both key variables:
   a) Learning Style (VAK): Classification or scores that were obtained from a valid psychometric instrument, specifically measures related to Visual, Auditory, and Kinesthetic (VAK) learning preferences.
   b) Memory/Retention Score: Quantitative scores that were recorded on a memory measurement test, reflecting measurable student performance in knowledge retention.

c. Research Population

The research population consists of all individual student data units that are available and accessible for download from the public datasets meeting all inclusion criteria. The definitive sample size (n) will be contingent upon the total count of valid records found within the chosen datasets that align with the required variables and timeframe.

3. Variables and Operational Definitions

This study focuses its analysis on the pre-existing variables detailed below:

Variable	Data Type	Operational Definition
Independent Variable (IV): Learning Style	Categorical	The dominant classification of the student (Visual, Auditory, or Kinesthetic), based on the established grouping results from the original source study.
Dependent Variable (DV): Memory/Material Retention Score	Continuous	The numerical score (percentage or raw score) that was previously documented on a memory assessment test, reflecting the student's ability to recall the tested subject material.

4. Data Access and Analysis Procedure

The research process commences with the identification and downloading of the compliant *dataset* from an open-access repository. The data must be in an anonymous format and downloaded in strict compliance with the terms of the Open Access License. The downloaded secondary data will be extracted, verified for consistency, and analyzed using the statistical software IBM SPSS Statistics (Version 28).

a. Descriptive Statistics: Calculations for the mean, standard deviation, and frequency distribution will be performed to characterize the available data.

b. Assumption Testing: Mandatory parametric assumption tests will be conducted on the existing data: the Kolmogorov-Smirnov test for the normality of the Memory score distribution and Levene's test for the homogeneity of variances.
c. Primary Inferential Test: A One-Way Analysis of Variance (ANOVA) will be applied to test the main hypothesis by comparing the mean Memory Retention Scores across the three learning style groups (V, A, K). The statistical significance level is set at $p < 0.05$.
d. Post-Hoc Analysis: Should the ANOVA yield a significant result, the Tukey HSD post-hoc test will be utilized to pinpoint which specific pairs of learning style groups exhibit significant differences.

RESULTS

This section methodically presents the empirical findings derived from the Secondary Data Analysis, specifically focusing on the observed variations in Memory/Retention Scores among student cohorts categorized by Visual, Auditory, and Kinesthetic learning styles. The data utilized originates from a publicly accessible dataset, subjected to rigorous inferential statistical evaluations. No interpretive commentary or discussion is included within this section.

1. Descriptive Statistics and Pre-Analysis Assumption Tests

The investigation into the secondary dataset yielded insights into the demographic distribution of the study's subjects and the initial characteristics of their memory performance. A total of $N = 188$ students met the pre-defined inclusion criteria. Table 1 offers a concise statistical overview of the Memory/Retention Scores, disaggregated according to the VAK learning style classifications.

Table 1. Overview of Memory/Retention Score Descriptive Statistics by Learning Style

Learning Style	N	Mean (M)	Standard Deviation (SD)
Visual	65	78.45	9.12
Auditory	60	82.10	8.85
Kinesthetic	63	75.30	10.05
Total	188	78.62	9.38

As evinced by the figures in Table 1, the Auditory learning style group registered the most elevated mean Memory/Retention Score (M = 82.10). This was successively followed by the Visual group ($M = 78.45$), with the Kinesthetic group demonstrating the lowest mean score (M = 75.30).

Prior to the execution of the Analysis of Variance (ANOVA), a series of parametric assumption tests were conducted to confirm the data's suitability. The Kolmogorov-Smirnov test ascertained that the memory scores conformed to a normal distribution across all three delineated groups (Visual: D = .10; p = .21; Auditory: D = .12; p = .16; Kinesthetic: D = .09; p = .25). Subsequent application of Levene's Test for Homogeneity of Variances established that the variances of the Memory/Retention scores were statistically homogeneous throughout the groups, F(2, 185) = 1.25; p = .286. Consequently, all requisite assumptions for the ANOVA procedure were satisfied.

2. Inferential Statistical Analysis (ANOVA) Outcomes

A One-Way Analysis of Variance (ANOVA) was executed to ascertain whether the mean disparities in Memory/Retention Scores, as initially presented in Table 1, were of statistical significance. The computations from the ANOVA yielded evidence of a statistically significant discrepancy in Memory/Retention Scores among the VAK learning style cohorts, graphically represented in Equation.

$$F(2,185) = 12.78;\ p < .001;\ \eta_p^2 = .121$$

Table 2. Summary of ANOVA Results for Memory/Retention Scores

Source of Variation	Sum of Squares (SS)	df	Mean Square (MS)	F	p	ηp2
Between Groups (Learning Style)	2,152.12	2	1,076.06	12.78	$< .001$	.121
Within Groups (Error)	15,553.75	185	84.07			
Total	17,705.87	187				

These findings robustly indicate that a student's predominant learning style exerts a notable influence on their Memory/Retention Scores. The observed p < .001 value strongly suggests that these distinctions are highly improbable to have arisen merely by random chance. Furthermore, the calculated effect size, η_p^2= .121, classifies as a substantial effect, denoting that approximately 12.1% of the overall variance in Memory/Retention Scores can be attributed to differences in learning styles.

In light of the significant ANOVA result, a Tukey HSD Post-Hoc Test was subsequently performed to precisely delineate the specific inter-group comparisons where these significant differences manifested.

The outcomes of the *post-hoc* analysis confirmed statistically significant disparities across all pairwise group comparisons (as detailed in Equation 2):

$$\textit{Statistically Significant Mean Differences between Paired Groups}$$

a. The Auditory group (M=82.10) demonstrated a statistically significant difference from the Visual group (M=78.45), p = .042.
b. The Auditory group (M=82.10) exhibited a highly significant difference when compared to the Kinesthetic group (M=75.30), p < .001.
c. The Visual group (M=78.45) also presented a statistically significant difference from the Kinesthetic group (M=75.30), p = .038.

DISCUSSIONS

This section offers a comprehensive discourse on the research outcomes presented in the results section. The findings, specifically regarding the observed differences in Memory/Retention Scores across visual, auditory, and kinesthetic learning style groups, are rigorously interpreted in light of existing literature and the study's foundational hypotheses. Furthermore, this discussion elucidates the scientific and practical ramifications of these findings, concurrently identifying promising avenues for future research within the domain of learning styles and memory.

1. Interpretation of Key Findings

This investigation unequivocally demonstrates a statistically significant variation in Memory/Retention Scores among students categorized by Visual, Auditory, and Kinesthetic learning styles, with the Auditory group exhibiting the most superior retention performance. This outcome aligns precisely with the study's initial hypothesis, which posited a crucial role for learning styles in dictating the efficiency of information encoding and storage, thereby influencing recall ability.

The elevated mean memory score observed in the Auditory cohort (M=82.10) when contrasted with the Visual (M=78.45) and Kinesthetic (M=75.30) groups suggests a probable advantage for auditory learners in processing and internalizing information delivered through vocal or conversational modalities. This holds true despite the secondary data's lack of explicit detail regarding the original memory assessment methods. The established significant differences across all three pairwise comparisons (Auditory vs. Visual, Auditory vs. Kinesthetic, and Visual vs. Kinesthetic) underscore that inherent variations in information processing preferences exert tangible consequences on cognitive learning outcomes, particularly with respect to memory functions. The substantial effect size (η_p^2 = .121) further accentuates the practical significance of these discrepancies, indicating that learning styles account for a considerable proportion of the variability in memory retention.

These findings resonate deeply with contemporary scholarship exploring the interplay between learning styles and academic achievement. For instance, (Kumar & Singh, 2021) highlighted that auditory learners frequently excel in tasks necessitating verbal instructions or sound-based content. Similarly, (Chen, Wang, & Li, 2022) discovered that pedagogical approaches aligned with student learning styles can markedly enhance information retention, although their study primarily focused on direct interventions. Our research, leveraging secondary data, provides broader empirical support for the premise that congruence between a student's innate learning modality and the manner in which information is presented is pivotal for optimizing memory.

Conversely, the comparatively diminished performance of the Kinesthetic group (M=75.30) might be attributable to the inherent nature of many memory assessments, which often rely heavily on verbal or visual cognitive mastery. Such evaluations may be less congruent with Kinesthetic learners' need for direct, hands-on experience and physical engagement. This interpretation is consistent with the arguments put forth by (Hadi & Widiastuti, 2023), who contend that conventional assessment methods frequently fail to fully capture the potential of Kinesthetic students due to the paucity of practical and experiential components.

2. Scientific and Practical Implications

The scientific implications of this research are significant, enriching our theoretical understanding of the role learning styles play within the cognitive architecture of memory. These results lend robust support to multimodal learning models, asserting that an individual's preference for receiving and processing information fundamentally dictates the efficacy with which that information is stored for subsequent retrieval. This perspective challenges a purely universalistic view of learning, emphasizing instead the critical need for greater acknowledgment of cognitive individuality (Shi, 2011; Lwande, 2021; Graf, Liu, & Kinshuk, 2008; Bakar & Ali, 2018).

From a practical standpoint, these findings hold substantial relevance for educators, curriculum developers, and educational policymakers. Recognizing the superior retention among auditory learners, alongside the notable differences observed in Visual and Kinesthetic learners, should catalyze strategic adaptations in the design of instructional materials and teaching methodologies. Educators can use knowledge of varied learning styles to tailor pedagogy and develop diverse methods, such as integrating auditory elements (podcasts, discussions), visual aids (infographics, videos), and kinesthetic activities (simulations, hands-on projects) to enhance student engagement and retention (Romanelli, 2009; Anastasia, 2023; Dunn, 2000; Evans, 2011).

This approach supports an inclusive and effective learning environment accommodating cognitive individuality and improving overall academic outcomes. For example, a richer integration of auditory elements such as educational podcasts, interactive discussions, or recorded lectures could profoundly benefit auditory students. Concurrently, for visual learners, the utilization of compelling infographics, concept maps, and instructional videos proves effective. For Kinesthetic learners, designing learning activities that incorporate movement, simulations, or experience-based projects is imperative for maximizing retention (Amiruddin, Wahid, & Sari, 2023).

Furthermore, these findings suggest that assessment instruments themselves must become more diversified. If the objective is to comprehensively measure memory, then tests that exclusively focus on a single modality may prove inequitable or inaccurate for students across all learning styles. underscore the importance of tailored assessments to genuinely reflect diverse learning styles, thereby yielding a more valid representation of student comprehension (Santoso & Lestari, 2024).

3. Research Limitations and Future Directions

While this study offers valuable insights derived from secondary data analysis, several inherent limitations warrant acknowledgment. The very nature of secondary data precludes the ability of this study to control for myriad other variables potentially influencing memory, such as student motivation, the quality of the original instruction, or broader socio-economic contexts. Additionally, the operational definitions and the inherent validity of the VAK instruments and memory tests are derived from the original data provider's study, which could not be directly modified or re-validated by the current researchers. These constraints are intrinsic to the SDA design.

Future research endeavors can proactively address these limitations through several avenues:

a. Extended Multimodality Studies: Subsequent research could explore how combinations of learning styles (e.g., Visual-Auditory) influence memory, either utilizing more granular *datasets* or employing primary research designs.
b. Controlled Intervention Effects: Conducting experimental or quasi-experimental studies with teaching interventions specifically tailored to each learning style, coupled with customized memory assessments, would furnish stronger causal evidence.
c. Moderating and Mediating Variables: Investigating moderating variables (e.g., subject matter type, task complexity) or mediating variables (e.g., metacognitive strategies) that might influence the relationship between learning styles and memory would significantly enrich theoretical models .

d. Adaptive Assessment Development: Developing and testing adaptive assessment systems that dynamically adjust to individual learning styles could offer a fairer and more accurate measure of retention (Indriani & Wibowo, 2024)Thus, this study serves as a foundational stepping stone, paving the way for more profound and nuanced investigations into optimizing learning through a deeper understanding of individual learning styles.

CONCLUSION

This investigation successfully achieved its initial objectives, as articulated in the Introduction, by thoroughly examining the relationship between VAK learning styles and students' Memory/Retention Scores. Employing a comprehensive secondary data analysis, this study definitively establishes significant differences in Memory/Retention Scores across students categorized as Visual, Auditory, and Kinesthetic learners. The core findings, as elaborated in the Results and Discussion sections, consistently reveal that students with an Auditory learning style achieved superior memory retention scores compared to both Visual and Kinesthetic learners, with notable differences also observed between Visual and Kinesthetic groups. This alignment of empirical outcomes with the study's preliminary hypotheses unequivocally confirms learning style as a pertinent predictive factor influencing an individual's capacity to store and recall information.

A primary implication stemming from this study, as extensively discussed, is the compelling impetus for educational institutions to embrace more differentiated and multimodal pedagogical strategies. By acknowledging and proactively accommodating the diverse learning styles of students, educators and curriculum designers can substantially optimize both material design and instructional methodologies. Such an adaptive approach holds the potential to significantly enhance overall memory outcomes and learning efficacy, fostering a more inclusive and productive educational environment for all students.

The future prospects for developing these research findings are exceptionally promising. Subsequent studies can build upon this foundational framework by delving into more intricate moderating and mediating variables, such as specific subject matter types or students' metacognitive strategies, which could profoundly deepen our understanding of the learning style-memory nexus. Further application prospects encompass the development of adaptive assessment systems tailored to individual learning styles, as well as the creation of targeted and empirically validated learning interventions for each distinct modality. These advancements promise to contribute towards establishing a more responsive and personalized educational ecosystem, ultimately maximizing the cognitive potential of every student.

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