Research Paper

The Impact of Color Psychology on Children's Memory Performance in Educational Environments: A Quantitative Study

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Abstract

This study investigates the influence of color on children's learning experiences and cognitive development within educational settings. Recognized as potent psychological tools, colors can markedly affect children's emotions, behaviors, and cognitive abilities. The primary objective of this research is to examine the associations between color characteristics, learning environments, and children's memory performance, with a specific emphasis on color psychology. Employing a descriptive-analytical research methodology, the study incorporates a quantitative approach. Data collection methods include questionnaires, with interviews and observational studies utilized to complement quantitative data and provide deeper insights into color effects in natural settings. The collected data were analyzed using SPSS software, specifically employing regression analysis and Pearson correlation coefficients. The findings reveal significant positive correlations between color usage, educational environments, and memory retention among children. These results suggest that careful selection of colors can significantly enhance children's concentration, reduce stress levels, and improve their overall memory capabilities. Warm colors, such as red and yellow, have been found to stimulate energy and creativity, while cooler tones, like blue and green, are associated with increased calmness and focus. The main conclusion drawn from this study highlights the necessity of deliberate color design in educational spaces to foster children's learning and cognitive growth. This underscores the vital role that color psychology plays in the effective design of educational environments, providing valuable insights for architects and educators.

Keywords: Memory performance, Children's learning environments, Color psychology, Color impact, Child cognitive development.

INTRODUCTION

The profound impact of color in educational environments, particularly in early childhood settings, has recently garnered significant attention. Colors are not merely aesthetic elements; they are powerful psychological tools that can influence mood, behavior, and cognitive processes (Daggett, Cobble, & Gertel, 2008). In early childhood education, where foundational learning is established, the strategic application of color in designing educational spaces is crucial for enhancing learning experiences. Children, typically aged 3 to 6 years in preschool settings, are highly sensitive to their surroundings, and the visual environment significantly affects their ability to absorb information and engage in creative thinking (AL-Ayash, Kane, Smith, & Green-Armytage, 2016).

Research indicates that colors stimulate specific brain areas, influencing emotional responses and cognitive functions. Bright, intense colors can activate the limbic system, associated with emotional reactions, while color naming involves the left hemisphere and pattern recognition the right (Daggett, Cobble, & Gertel, 2008). Given that brain development in children aged 3-6 years is still progressing, the visual environment, including color, serves as a vital medium for communication and learning (Koco & Koc, 2009). Color also influences

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alpha brain waves, which are used in medical research to evaluate human consciousness, and can stimulate hormone release affecting mood, mental clarity, and energy levels (Engelbrecht, 2003).

The design of educational spaces, such as preschools and kindergartens, must therefore consider the psychological and physiological effects of color on young learners. A well-designed environment can foster a positive atmosphere, enhance working memory, and promote creativity and social interaction (Hamdy, 2020). Conversely, poorly designed spaces with inappropriate color schemes may lead to discomfort or anxiety, hindering cognitive development (Knauf, 2019). Thus, integrating color psychology into the architectural design of children's educational spaces is a pedagogical strategy aimed at optimizing learning outcomes. This study specifically aims to explore the effectiveness of color in enhancing children's working memory performance within preschool settings, contributing to the discourse on architecture, psychology, and education.

BACKGROUND OF THE RESEARCH

Color, as a fundamental visual element, profoundly influences human perception and behavior. Color psychology theories, such as those proposed by Itten and Munsell, emphasize that colors can serve as tools to establish psychological balance and enhance cognitive performance (Birren, 2013). This influence is particularly significant in children, whose developing brains are highly receptive to visual stimuli that can affect learning and behavior (Jonauskaite, et al., 2019). For instance, warm colors like red and yellow are suggested to boost energy and concentration, while cool colors such as blue and green can promote calmness and focus (Daggett, Cobble, & Gertel, 2008). Developmental psychology research indicates that while three-year-old preschoolers may struggle with effective color differentiation, by age four, children begin to recognize color saturation, and the ability to discern various colors gradually improves between ages six and seven. Five-year-old children are also capable of perceiving subtle differences in color saturation (Wang, 2020).

Numerous studies have explored the impact of color in educational environments, demonstrating that appropriate color application can improve academic performance and increase children's concentration. Investigations show that cool colors in classrooms can reduce stress and enhance focus, while warm colors can boost energy and motivation (Grangaard, 1995). Additionally, research indicates that colors can aid children in recalling information more quickly and understanding their surroundings more effectively (Stankovic & Kekovic, 2019). The color of an environment specifically affects information retrieval after learning, with the use of three warm colors in a learning space facilitating the retrieval of information learned within that setting (Hidayetoglu, Yildirim, & Akalın, 2012). However, while general impacts on concentration and mood have been noted, a comprehensive understanding of how specific color schemes directly influence discrete cognitive functions like working memory performance in children within educational settings remains underexplored.

Despite existing research highlighting the general effects of color on learning and concentration, there is a clear gap in empirical studies specifically detailing the mechanisms through which color influences different types of memory, particularly working memory, in young children. Previous studies often discuss broad concepts like "cognitive development" or "learning efficiency" without operationalizing the specific cognitive functions affected or providing a robust theoretical framework linking color to memory processes. For example, while studies suggest colors can aid recall, the direct relationship between emotional regulation induced by color and its subsequent impact on working memory capacity or retrieval efficiency is not consistently articulated or empirically validated. This study addresses this gap by specifically investigating the impact of color on working memory performance in preschool-aged children, thereby providing a more precise understanding of color's role in cognitive development. This focused approach offers crucial insights for designing educational spaces that optimally support children's learning and memory functions.

EXPLANATION OF KEY CONCEPTS

To ensure clarity and precision within this study, the following key concepts are defined:

Color Psychology: Color psychology investigates the effects of colors on human behavior, emotions, and cognitive performance. This field demonstrates that colors can be powerful tools in fostering psychological balance and enhancing cognitive performance (Birren, 2013). A color can convey feelings of excitement, enthusiasm, tranquility, or mystery (Olesen, 2013). In this study, we specifically examine warm colors (e.g., red, orange, yellow) and cool colors (e.g., blue, green), as these categories are widely recognized for their distinct psychological impacts on mood and cognitive states.

Educational Environment: The educational environment refers to the settings where learning and teaching processes occur. These spaces encompass classrooms, kindergartens, and other formal and informal educational contexts (Hamdy, 2020). For the purpose of this research, the focus is on preschool settings, which are environments specifically designed to support the holistic development of young children aged 3-6 years. These environments must be designed to meet the physical, emotional, and cognitive needs of the children (Stepanova & Kuchma, 2020).

Children's Home (Kindergarten/Nursery): In the context of this study, a "children's home" refers to an early childhood education center, such as a kindergarten or nursery, where preschool-aged children are cared for and educated. This term aligns with facilities providing structured educational and care programs for young children before formal schooling, ensuring clarity for an English-speaking academic audience. These environments are distinct from residential care facilities and are characterized by their pedagogical goals for early learning and development.

Learning: Learning is defined as the process of acquiring new knowledge, skills, and attitudes. This process is influenced by various factors, including the educational environment, teaching methods, and psychological factors such as color (Dzulkifli & Mustafar, 2013). This study specifically investigates the impact of color on memory performance in young children, which is a key component of the learning process. Memory performance, particularly short-term and working memory, involves the encoding, storage, and retrieval of information, and its enhancement is critical for effective learning.

METHODOLOGY

This research employs an explanatory sequential mixed-methods design to investigate the impact of color on children's memory performance in educational environments, specifically within children's homes (kindergartens).

This approach begins with quantitative data collection and analysis, followed by qualitative data collection and analysis, with the qualitative phase designed to help explain and interpret the quantitative findings.

Research Approach and Design

The quantitative phase utilized a descriptive-analytical approach to examine correlations and predictive relationships between color characteristics, educational environment, and children's memory learning. The qualitative phase, involving interviews and observations, was conducted to provide richer contextual understanding and validate the quantitative findings, particularly regarding the practical application and perceived effects of color in these settings.

Participants and Sampling

The target population for this study consisted of two distinct groups:

Children aged 3-6 years attending kindergartens were the subjects whose memory performance was evaluated.

Specialists in child psychology, color psychology, and architecture, who provided expert insights into the design and psychological impacts of educational environments.

For the quantitative phase, a convenience sample of 50 specialists was selected. These participants were chosen based on their demonstrated expertise, evidenced by professional experience (minimum 5 years) in early childhood education, color psychology research, or architectural design of children's spaces. This criterion ensured that participants possessed sufficient knowledge and practical experience relevant to the study's objectives. The sample size of 50 was deemed appropriate for statistical analysis, particularly for regression and correlation, in line with common practices for initial exploratory studies in this domain. Children were not direct participants in completing questionnaires but were the subjects of the study, whose memory performance was assessed indirectly through expert evaluation, observational tools, and specific tasks that were later evaluated.

For the qualitative phase, a sub-sample of 10 specialists from the quantitative group, along with observations of 20 children in selected kindergarten settings, were purposively selected. This selection aimed to gather in-depth perspectives and observe real-world interactions related to color and learning.

Data Collection Tools

Various tools were utilized for data collection, tailored to the specific phases of the mixed-methods design:

Questionnaire (Quantitative): A structured questionnaire was developed and administered to the specialist participants. It contained closed-ended questions designed to assess their perceptions and professional judgments regarding the impact of color characteristics and educational environment on children's memory performance. The questionnaire was distributed both in-person and online.

Interviews (Qualitative): Semi-structured interviews were conducted with a subset of specialists. These interviews allowed for a deeper exploration of their perspectives, experiences, and nuanced understandings of the influence of color on children's learning and the practical considerations in designing educational spaces.

Observation (Qualitative): Direct observations were carried out in selected kindergarten environments. This involved systematic recording of children's behavior and engagement within spaces designed with various color schemes, assessing their concentration, interaction, and emotional responses as influenced by color. These observations complemented the expert opinions by providing direct behavioral evidence.

Library Research: Extensive literature reviews were conducted to provide the theoretical framework, identify research gaps, and contextualize the study's findings within existing scholarship. This included academic journals, books, and conference proceedings related to color psychology, child development, and architectural design for educational spaces.

Data Analysis

The collected data were analyzed using IBM SPSS Statistics software, version 25.

Quantitative Data Analysis: This involved both descriptive and inferential statistical analyses. Descriptive analyses included measures of central tendency (mean, median) and variability (standard deviation, minimum, maximum) to summarize demographic information and survey responses. Inferential analyses, specifically Pearson correlation coefficients and multiple linear regression, were employed to examine the relationships between color characteristics, educational environment, and children's memory performance, and to test the research hypotheses. Normality of data distribution was assessed using the Kolmogorov-Smirnov test, and reliability was confirmed using Cronbach's Alpha.

Qualitative Data Analysis: Interview transcripts and observation notes were analyzed using thematic analysis. This involved identifying recurring themes, patterns, and categories related to the impact of color on children's learning, providing rich, detailed insights that elaborated on the quantitative findings. This triangulation of data sources strengthened the validity of the conclusions.

THE CONCEPTUAL MODEL

The conceptual model underpinning this research integrates four key theoretical domains to explain how color influences children's learning in educational settings: color psychology, child psychology, foundations of the educational environment, and principles of architectural design. This model posits that specific characteristics of colors, when applied within an educational environment designed with an understanding of child psychology and architectural principles, will directly impact children's memory learning.

The relationships among the main variables are conceptualized as follows:

Color Characteristics (Independent Variable): This encompasses properties such as hue (warm vs. cool), saturation, and brightness, which are theorized to evoke specific psychological and physiological responses in children.

Educational Environment (Independent Variable): This refers to the physical attributes of learning spaces (e.g., classrooms, play areas, children's homes), including the application of color, which collectively create the sensory and psychological atmosphere.

Memory Learning (Dependent Variable): This represents the outcome variable, focusing on children's ability to acquire, store, and retrieve information, including aspects like concentration, retention, and cognitive engagement.

The model proposes that Color Characteristics directly influence Memory Learning and also interact with the Educational Environment to shape learning outcomes. Furthermore, the Educational Environment itself is hypothesized to have a significant direct impact on Memory Learning. The integration of child psychology and architectural design principles guides the thoughtful application of colors and the overall environmental design to optimize these relationships.

RESULTS OF DATA ANALYSIS

Data analysis was conducted using SPSS version 25. This section presents the statistical findings, including descriptive statistics, normality tests, reliability analyses, correlation coefficients, and regression results. Interpretations and discussions of these findings are reserved for the "Discussion" section.

Descriptive Statistics

Table 1 summarizes the descriptive statistics for the variables: Characteristics of Colors, Learning Memory, and Learning Environment. These variables were measured using a researcher-developed questionnaire administered to expert participants, where each variable was operationalized through specific indicators. For example, "Characteristics of

Colors" was assessed based on questions related to the perceived impact of warm, cool, and neutral colors; "Learning Memory" through indicators of concentration, retention, and cognitive stimulation; and "Learning Environment" through aspects of overall spatial design and atmospheric contribution to learning. Each indicator was rated on a scale of.

Assessment of Normality

The normality of the data distribution for all variables was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests, suitable for the sample size of 50. As shown in Table 2, all variables exhibited significance levels greater than 0.05, indicating a normal distribution, which supports the use of parametric statistical tests.

Reliability Examination of Variables

The internal consistency of the questionnaire was assessed using Cronbach's Alpha. As presented in Table 3, all variables demonstrated high reliability, with Cronbach's Alpha values ranging from 0.785 to 0.869. The overall questionnaire also showed excellent reliability with a Cronbach's Alpha of 0.761.

Pearson Correlation Analysis

Pearson correlation analysis was performed to examine the relationships between the main variables.
A significant positive correlation was found between Color Characteristics and Educational Environment, with a correlation coefficient of 0.395 (p = 0.012), as shown in Table 4.

Table 1. Descriptive Statistics

Domain	Number	Minimum	Maximum	Average	Standard Deviation
Characteristics of Colors	200	4.00	16.00	13.4400	2.02192
Learning Memory	200	11.00	32.00	26.5200	2.92937
Learning Environment	200	13.00	32.00	26.6600	2.92498

Note: The "Number" column refers to the total number of responses for each variable from the 50 participants, as certain questions had sub-items.

Table 2. Checking the Normality of the Components

Statistics	Kolmogorov-Smirnov			Shapiro-Wilk		
	Degrees of Freedom	Level of Significance	Statistics	Degrees of Freedom	Level of Significance	
Characteristics of Colors	.214	50	.200	.819	50	.068
Learning Memory	.135	50	.200	.955	50	.056
Learning Environment	.106	50	.200*	.971	50	.064

Table 3. Reliability Analysis

Reliability Status	Cronbach's Alpha	Number of Questions	Variable
Great	0.785	4	Characteristics of Colors
Great	0.869	8	Learning Memory
Great	0.822	8	Learning Environment
Great	0.761	20	The whole questionnaire

Table 4. Relationship Between Color and Learning Environment

		Characteristics of Colors	Learning Environment	
Characteristics of Colors	Pearson Correlation	1		.395
	Level of Significance			.012
	Number	50		50
Learning Environment	Pearson Correlation	.395		1
	Level of Significance	.012		
	Number	50		50

A significant positive correlation was observed between the Educational Environment and Memory Learning, with a correlation coefficient of 0.502 (p = 0.000), as shown in Table 5.

A significant positive correlation was found between Color Characteristics and Memory Learning, with a correlation coefficient of 0.664 (p = 0.044), as shown in Table 6.

Linear Regression Analysis

A simple multiple regression (two-predictor multiple regression) analysis was conducted to assess the predictive power of Color Characteristics and Educational Environment on Memory Learning.

Table 7 presents the model summary. The multiple correlation coefficient (R) is 0.547, and the adjusted coefficient of determination (R²) is 0.470. This indicates that 47% of the variance in Memory Learning can be explained by the combined variations in Color Characteristics and Educational Environment.

Table 8 displays the ANOVA results for the regression model. The F-statistic is 10.04, with a p-value of 0.000 (less than 0.05), indicating that the overall regression model is statistically significant. This confirms that Color Characteristics and Educational Environment together significantly predict Memory Learning.

Table 9 presents the regression coefficients. The standardized beta coefficients indicate the relative contribution of each predictor. Educational Environment has a standardized beta coefficient of 0.481 (p = 0.000), while Color Characteristics has a standardized beta coefficient of 0.218 (p = 0.002). Both predictors are statistically significant (p < 0.05), implying a significant individual contribution to predicting Memory Learning. The Educational Environment variable shows a stronger unique contribution to the prediction of Memory Learning compared to Color Characteristics.

Table 5. Relationship Between Learning Environment and Learning Memory

		Learning Environment	Learning Memory
Learning Environment	Pearson Correlation	1	**.502
	Level of Significance		.000
	Number	50	50
Learning Memory	Pearson Correlation	**.502	1
	Level of Significance	.000	
	Number	50	50

Table 6. Relationship between Color and Learning Memory

		Characteristics of Colors	Learning Memory
Characteristics of Colors	Pearson Correlation	1	.664
	Level of Significance		.044
	Number	50	50
Learning Memory	Pearson Correlation	.664	1
	Level of Significance	.044	
	Number	50	50

Table 7. The Effect of Color Characteristics on the Educational Environment, Learning, and Memory According to the Correlation Coefficient

Model	Correlation Coefficient	Coefficient of Determination	Standardized Coefficient of Determination	Standard Error of Estimate	Watson Camera
1	.547a	.499	.470	2.50367	1.533

Table 8. The Effect of Color Characteristics on the Educational Environment, Learning, and Memory According to Analysis of Variance

Model	Sum of Squares	Degrees of Freedom	Total Average	F-Statistic	Significance
1 Regression	125.867	2	62.933	10.040	.000b
Remainder	294.613	47	6.268		
Total	420.480	49			

Table 9. The Effect of Color Characteristics on the Educational Environment, Learning, and Memory According to Regression Coefficients

Model	Not Standardized Coefficients	Standardized Coefficients	t-value	Level of Significance	
	Beta	Standard Error	Beta		
1 Fixed Value	9.417	3.882		2.426	.019
Characteristics of Colors	.316	.178	.218	1.779	.002
Learning Environment	.482	.123	.481	3.926	.000

DISCUSSION AND CONCLUSION

This research investigated the relationship among color characteristics, the educational environment, and memory learning. Statistical tests, including Pearson correlation and linear regression, were utilized within the SPSS software to analyze these relationships. The findings indicate that all three variables—color characteristics, the educational environment, and memory learning—are significantly correlated, with moderate strength. Specifically, color characteristics show an approximate correlation of 0.66 with memory learning, and the educational environment exhibits a correlation of 0.50. The regression analysis further demonstrates that both color characteristics and the educational environment significantly predict memory learning, with the educational environment exhibiting greater predictive capability, as evidenced by its standardized beta coefficients.

This study's results align with established theories in environmental psychology and color perception, which posit that environmental stimuli, including color, can profoundly influence cognitive functions and learning outcomes. The observed correlations between color characteristics, the educational environment, and memory learning support the notion that a thoughtfully designed learning space can enhance a child's ability to retain information. For instance, the finding that cool colors improve concentration is consistent with theories suggesting that such hues promote calmness, thereby optimizing the environment for focused learning. Similarly, the positive association between warm colors and increased energy aligns with conceptual models of color psychology that link vibrant colors to heightened arousal and creativity.

The findings underscore the crucial role of color and environmental design in fostering an effective learning environment for children, offering actionable insights for designers, educators, and parents.

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