

Experiment on the Application of Polychromatic, Monochromatic, and Achromatic Educational Materials and Their Effect on Memory Recall

ABSTRACT

This study investigates the impact of polychromatic, monochromatic, and achromatic-based educational materials on memory recall. Specifically, it aims to evaluate which method has a notable influence on retention. The research, conducted with 45 college students, utilized a between-subject design where participants were equally and randomly distributed to three groups: polychromatic group, monochromatic group, and achromatic group. To test the normality of the data, the Shapiro-Wilk test was utilized showing a normal distribution by assumption ($p=0.185$). Descriptive Statistics revealed that the use of polychromatic educational materials yields the highest average score in memory recall ($M = 10.3$, $SD= 2.09$). Using the Analysis of Variance (ANOVA), results revealed a statistically significant difference between the conditions ($F=4.08$, $p=0.024$). However, Post-Hoc Comparison Test revealed that only the use of polychromatic educational materials in contrast with the use of achromatic yielded a statistically significant difference ($p= 0.020$, $d= 1.030$), compared to the use of monochromatic against achromatic-based educational materials ($p= 0.179$, $d= 0.660$), and the use of polychromatic opposed to the use of monochromatic educational materials ($p = 0.573$, $d= 0.370$). Findings emphasized the significant role of color in facilitating memory recall, which is supported by existing literature. Moreover, the study contributes to the limited literature in the context of color psychology and provides insights for developing effective learning strategies.

Keywords: polychromatic, monochromatic, achromatic, memory recall

INTRODUCTION

The ability to retain information are the goals that are directed when one engages in active reading. The use of educational materials, such as highlighters or markers, are relevant in attaining this goal. These materials put emphasis on sections of information in the given passages or texts. According to the study of Ponce et al. (2022), highlighting can be accomplished by using colored markers to add color to the important information or simply utilizing single-colored materials, such as pencils to emphasize significant ideas in a paper medium. Memory recall plays a paramount role in a student's scholarly endeavor, especially in this fast-paced era where attention and retention are necessities in the fields of academics. This is affirmed by the recent research of Roy et al. (2021), which states that active reading strategies involving content annotations by highlighting and taking notes have demonstrated to enhance improvement on learner's knowledge and understanding. Facilitating learning is associated with the interdependence of memory and learning involves encoding, storing, and retrieving of information. The retrieval is essential in recalling and updating new structured ideas in memory (Savarimuthu & Ponniah, 2024). Memory recall is essential component in academic performance, especially in activities like test situations (Swargiary & Roy, 2024).

Numerous existing literatures emphasize the significance of multi-colored or unicolored highlighters. As explained by Nanglu and Sharma (2024), colors have more than simply aesthetic value; they also have the ability to improve memory recall, impact mood, and have a notable impact on academic achievement. Moreover, Hosseini and Ghabanchi (2022), stated that colors significantly contribute to retrieving information, such as vocabularies. The use of colored markers and highlighters also increase one's motivation in doing scholarly tasks. Highlighting or marking enables one to visualize the progress that one is under, making him or her feel more self-efficacious, and have heightened self-esteem throughout the course of the action, hence yielding greater academic performance (Martin et al., 2022).

In addition, in international studies relating to highlighting method have shown significant impact in activating the cognitive process of filtering essential ideas and content to be processed in the working memory, and is a fundamental step in attaining new knowledge and storing them in the long-term memory (Mason et al. 2024). This result is similar to the study of Gole and Pyland (2022), which affirmed that learning can be optimized with the aid of colors. By using colors while learning, students recall more information efficiently and the existing retained information becomes part of their procedural memory. Highlighting technique is the most common method used by college students in terms of studying. Although highlighting enhances reading comprehension when students incorporate note-taking and conceptualizing of the text, comprehension may be poorer as students focus on irrelevant and insignificant information (Leonard et al., 2021). According to the finding of Biber et al. (2020), highlighting and rereading are ineffective and passive learning strategies which creates the idea of learning process as simple, but the method tends to neglect the goal for retention which is essential for the academic performance.

Attention is described as a process of selecting and prioritizing information,

given the limitation of an individual's capacity. Attention is a key predictor of memory recall, since it highlights the ideas that will be remembered later on (Shi & Qu, 2022). According to Chang et al. (2021), deep learning's attention process is fundamentally similar to the selective human attention mechanism. The image or text may be swiftly scanned by human vision to determine the target areas that require attention. Then, these areas can receive more focus in order to obtain comprehensive data regarding the objectives.

However, this contradicts the result gained from the study of Choudhury and Bhansali (2022), which stated that highlighting in general is not consistently reliable as relevant information might not be emphasized compared to those that are highlighted. As reported by Ronconi et al. (2025), selecting of relevant information effectively to be highlighted becomes a struggle. They may focus greatly on the selection process with the insufficient room for putting the highlighted texts in application or incorporating them with their existing knowledge. Also, highlighters can be a distractor even if it facilitates attention. The use of highlighter can deviate or shift individuals focus on the color and not to the content of the information presented (Alftisya et al., 2023). Moreover, according to the study of Meusel et al. (2024), using color or highlighting alone as a retrieval cue is insufficient. The background color is still context information that is kept apart from the item information, rather than aiding in memory retrieval.

In the Philippine setting, as stated by Eliot et al. (2024), colors influence the memorization skills as of consistently using variety of color-coding strategies indicating the relevance and reliance on colors to retain information. According to Ardizzone (2024), incorporating light color theory into educational practices can result in a more conducive learning, ultimately leading to increased academic engagement and motivation. Moreover, the use of highlighters in marking and organizing information have a significant impact on academics by visual effects and marking works, especially physical readings. It is confirmed that highlighting keywords or important concepts contributes to essential memorization ability, cognitive capacity, and attentional capacity of learners (Lopez et al. 2022).

Given the numerous literatures emphasizing the efficiency of using polychromatic and monochromatic educational materials, such as highlighters and colored markers in academic readings, limited literatures are available in the Philippine setting relating to this subject which highlights education. Moreover, little attention has been drawn to the specificity of what particular method or technique shows the most favorable outcome under controlled condition of using colorless educational materials. Hence, this research aims to bridge the gap by methodologically comparing and assessing the three conditions: polychromatic, monochromatic, and achromatic, and their impact on the memory recall of diverse participants. Also, this study aims to contribute to the existing documented findings and provide concrete results for further research relevant to this study. Moreover, this study holds implication for educational pursuits for learners as the study emphasizes a key technique that better impact memory recall; hence, enhancing academic performance. Also, to educational practices or curriculum development as the results of this research may serve as basis for crafting effective learning technique.

Objectives of the Study

This study aimed to investigate whether the use of polychromatic or monochromatic educational materials significantly influence the memory recall of students. By statistically discovering the answers of the following research questions, the researchers will be able to determine the significance of the study, as well as determine which condition is more effective when it comes to recalling memory.

1. Does the use of color influence the memory recall of the students?
2. Is there a significant difference between the three conditions?
3. Which among the conditions produces the most favorable outcome in memory recall?

Comment [k1]: You have three question but two hypothesis?

Hypothesis

Null Hypothesis (Ho): There is no significant difference between the use of polychromatic, monochromatic, and achromatic educational materials to memory recall.

Alternative Hypothesis (Ha): There is a significant difference between the use of polychromatic, monochromatic, and achromatic educational materials to memory recall.

METHOD

Research Design

This experimental research aims to determine whether the use of colors in educational materials significantly affect to the memory recalling capabilities of college students. True experimental research design has been used in this study as the researchers employed a random assignment of participants for the three conditions that has been set: the polychromatic, monochromatic, and achromatic use of educational materials. This random assignment of participants measures the effects of the interventions (Hassan, 2024). Random assignment of participants assures that all groups are already comparable at the beginning of a study, and having the differences between the conditions to be anticipated to random factors and by no means in sampling or selection bias (Bhandari, 2023). To determine which among these three conditions significantly contribute to memory recall, the between-subjects design has been utilized. In this design, each participant is assigned to only one treatment, giving the researchers the opportunity to compare the differences between the conditions, and ascertaining the effects of the independent variable (Simkus, 2024).

Comment [k2]: How you implement this study?

Research Participants

The participants of the study were college students ($N = 45$) ranging from 18 to 25 years of age, representing the whole population of a university in Davao del Sur. There were 45 participants in total: 7 of them aged 18 years old (4 females, 1 male, 2 LGBTQ+); 15 of them were 19 years old (6 females, 7 males, 2 LGBTQ+); 8 of them were 20 years old (4 females, 2 males, 2 LGBTQ+); 6 of them were 21 years old (5 females, 1 LGBTQ+); 4 of them 22 years old (3 females, 1 male); 2 of them were 23 years old (1 female, 1 male); 2 of them were 24 years old (1 female, 1 male); and there was 1 participant who aged 25 years old (1 male). The majority of the participants were females ($N = 24$), followed by males ($N = 14$), then LGBTQ+ ($N = 7$). These participants were selected after they passed the screening for English Proficiency Test (EPT) which was conducted prior the actual experimentation.

Comment [k3]: You should use table style to refer it

Research Procedure

The researchers employed an English Proficiency Test (EPT) to select the participants for the actual experiment to ensure that they have the average level of English proficiency, and to prevent the study from having confounding variables. The students who took the EPT, however, failed to attain the average scores were excused to participate on the actual experiment. Conversely, to the students who has obtained the average scores, their information has been collected, as well as their free time for the day of the actual experimentation. The researchers set a total of 45 participants. The actual experiment was to be conducted at the same time of the day for all the participants which was afternoon. On the day of the experiment, the

researchers first prepared a quiet space with comfortable seating, mimicking a real-life set-up. Then, they contacted and gathered the participants who have passed the EPT. The 45 participants had been randomly assigned to the three treatments: the polychromatic, monochromatic, and achromatic use of educational materials, with 15 of them in each condition. This distribution is to ensure that everyone have equal chance of being assigned to any of the three treatments. To randomly assign, the researchers used a fishbowl draw method wherein the participants pick a piece of paper in a bowl consisting of numbers: 1, 2, and 3, wherein 1 refers to the use of polychromatic, 2 for the monochromatic, and 3 for the achromatic use of educational materials. In addition to this approach, the researchers utilized the between-subjects design, wherein each participant is assigned to only one treatment, to ensure that the outcomes between the three conditions are comparable with each other, and so that the researchers can examine the effectiveness of different treatments involving the use of colors in memory recall. After these arrangements, the participants were given an explanation of the purpose of the experiment, as well as the instruction on what to expect during the activity.

In the Polychromatic Group, the participants were given three different colors of highlighters to be utilized, while in Monochromatic Group, the participants were given only one colored highlighter, and the Achromatic Group were tasked to use no highlighters nor markers while reading the given study material. The participants under the three conditions were given 15 minutes to read a story while utilizing the highlighters given to them. At the end of the 15 minutes review, the participants set aside the materials then prepared for the memory test, which were given subsequently. This memory recall test was to be answered within 10 minutes. After the experiment, the researchers once again expound to the participants about the nature of the study, the purpose of using polychromatic, monochromatic, and achromatic educational materials, as well as the significance of the findings which is to determine which among these conditions contributes to the memory recalling capabilities of college students.

Comment [k4]: Conceptual model?

Research Instrument

The researchers utilized an English Proficiency Test (EPT) to assess the language competency of the participants. The significance of English proficiency in this study is to ensure that the participants have similar level of understanding in the materials they will be given during the actual experiment. This test has been implemented prior the actual experiment to avoid the presence of confounding variables such as language expertise and academic history. The students who scored below average has been excused to participate in the study, whereas the students who attained the average scores were selected to participate in the experiment to ensure the level of consistency and proficiency among the participants. The story entitled "The Celestial Academy: A Magical Quest of Inner Discovery" has been developed to be utilized as basis for the Memory Recall Test (MCT). The MCT is a 15-item multiple choice questions which aims to challenge and assess the memory recall capability of the participants after the intervention: the application of polychromatic, monochromatic, and achromatic educational materials.

For data analysis, to determine the validation of the normality of the dataset, the Shapiro-Wilk test has been employed by the researchers. This test has been utilized as the sample size of the data involves a total of 45 participants, with 15 of them in each condition. Moreover, this test guarantees the proper and relevant use of statistical methods and the reliability of the results of the experiment. In addition to this test, the raw scores of the participants were compared for the between-group effect analysis through the Analysis of Variance (ANOVA), this test allows the researchers to compare the mean outcomes of the conditions. The between group design has been utilized as this experiment aims to compare the three conditions and determine which among them significantly contribute to the memory recalling capability of the students. Lastly, the researchers employed the Post-Hoc Comparisons which statistically shows the significant difference between the conditions while considering the effect size of the study. This test exhibits the substantial difference between the polychromatic and achromatic group, and the monochromatic and achromatic group. Therefore, assessing which specific group or groups are statistically different.

Ethical Considerations

Before the experimentation, various ethical considerations had been taken into account. Researchers provided printed informed consent for the participants to be signed on, as an indication of their voluntary participation. These forms contain information about the purpose, procedures, and any potential risks involved in the experiment. Through the informed consent, participants voluntarily signed and participated in the study. In addition, the researchers provided further verbal explanations to ensure that the participants fully understand their rights in partaking the experiment. The researchers also ensured the participants that all data collected during the experiment will remain confidential and anonymous, with no identifiable information disclosed. After the experiment, all participants had been debriefed about the nature of the experiment, and has been given the opportunity to ask questions regarding the significance of the study with the researchers who provided factual response.

RESULTS

The result of Analysis of Variance (ANOVA) shows that there is a significant difference in memory recall across the three conditions: polychromatic, monochromatic, and achromatic. This result indicates that the use of colors in educational materials has a significant impact on memory recall. See table 1 for Normality Test to assess the normality of the data specifying a normal distribution. See table 2 for the test of difference results and the rejection of the null hypothesis. See table 3 for the Post-Hoc Comparison Test which summarizes the evaluation of the differences between the conditions.

Table 1: Normality Test (Shapiro-Wilk)

Assumption Checks	
Statistic	p
0.965	0.185

Note. A low p-value suggests a violation of the assumption of normality

Table 1 summarized the results of normality test of the dataset; the researchers utilized the Shapiro-Wilk test. The results showed no significant deviation from the normality, with $W = 0.965$ and $p = 0.185$. therefore, these findings suggest that the normality assumption for this variable is not violated.

Table 2: Descriptive Statistics for Memory Recall

		Descriptives						
	Condition	N	Missing	Mean	Median	SD	Min	Max
Recall Scores	Polychromatic	15	0	10.3	11	2.09	7	13
	Monochromatic	15	0	9.33	9	2.23	6	13
	Achromatic	15	0	7.67	8	3.13	3	12

Table 2 displays the descriptive statistics for the three conditions. Among the three, the Polychromatic yields the highest average score in memory recall ($M = 10.3$, $SD = 2.09$), followed by Monochromatic ($M = 9.33$, $SD = 2.23$), then Achromatic

($M = 7.67$, $SD = 3.13$). Likewise, the median scores resemble a comparable arrangement, with the Polychromatic ranking the highest ($Mdn = 11$), followed by the Monochromatic ($Mdn = 9$), then the Achromatic use of Educational Materials ($Mdn = 8$). In addition to this, the range also exhibits diversity, with Polychromatic ranging from 7 to 13, Monochromatic from 6 to 13, and Achromatic from 3 to 12. These findings illustrate that the use of colors, specifically the polychromatic, significantly contribute to the memory recalling capacities of the participants.

Table 3: ANOVA – Conditions

	Sum of Squares	df	Mean Square	F	p	η^2
Conditions	52.0	2	26.02	4.08	0.024	0.163
Residuals	267.6	42	6.37			

Table 3 summarizes the results of the Analysis of Variance (ANOVA) to determine whether the level of memory recall differed significantly based on three conditions: the use of Polychromatic Educational Materials, the use of Monochromatic Educational Materials, and the use of Achromatic Educational Materials. The results showed a significant difference in scores, with $F(2, 24) = 4.08$ and $p < 0.02$. The degrees of freedom ($df = 2$) are consistent with the number of classifications of the independent variable minus one. The between-groups sum of squares was 52.0, while the residual variance was 267.6, which indicates that the use of colors in educational materials significantly contributes to the variation in scores. The effect size, measure using eta-squared (η^2), was $\eta^2 = 0.163$, indicating that approximately 16.3% of the variance in memory recall scores can be explained by the condition of the educational materials used. As the p-value was less than the significance threshold of 0.05, the null hypothesis, which stated that there is no significant difference in memory recall across the three conditions, was rejected. These findings indicate that the use of colors in educational materials has a significant impact on memory recall.

Table 4: Post Hoc Comparisons – Conditions

Comparison		Mean Difference	SE	df	t	P _{tukey}	Cohen's d
Condition	Condition						
Polychromatic	- Monochromatic	0.933	0.922	42.0	1.01	0.573	0.370
	- Achromatic	2.600	0.922	42.0	2.82	0.020	1.030
Monochromatic	- Achromatic	1.667	0.922	42.0	1.81	0.179	0.660

Note. Comparisons are based on estimated marginal means

Shown in Table 4 is evaluation of the differences between the conditions – polychromatic, monochromatic, and achromatic using Post-Hoc Analysis. The results revealed a statistically significant difference between the polychromatic and achromatic conditions ($p = 0.020$, $t = 2.82$), with an effect size ($d = 1.030$) interpreted as a large effect. In contrast, the comparison between monochromatic and achromatic ($p = 0.179$, $t = 1.81$) indicated a medium effect size ($d = 0.660$), but did not yield statistically significant results. Similarly, the comparison between polychromatic and monochromatic conditions ($p = 0.573$, $t = 1.01$) yielded a small effect size ($d = 0.370$), which was also not statistically significant. The t-value represents the test statistic used to assess which specific group or pairs of groups are statistically different. These findings that the polychromatic condition leads to a notable difference compared to the absence of color. The results also indicate varying magnitudes of effect in the non-significant comparisons.

DISCUSSION

With the presented data, the first test employed was descriptive statistics which summarizes the major feature of the dataset. Results revealed that the use of polychromatic educational materials is the most favorable method in facilitating memory recall with the highest garnered mean suggesting that participants retained more information in this condition. This is affirmed by the study of Khan and Liu (2020), which highlighted that colors influence human memory which captivate the words and information on retention process. Analysis of Variance (ANOVA) was used to evaluate if there is a significant difference in memory recall under three conditions: polychromatic, monochromatic, and achromatic educational materials. Results revealed a statistically significant difference in treatment conditions. This indicates that the presence and absence of colors notably influence the recall of details and information among the participants. This finding is similar to the study of Winchell et al. (2020), which stated that highlighting predicts academic performance, reflects interest, and focus. However, this contradicts the results of Sajnani and Chaturvedi (2021), which stated that the information remembered do not yield a statistically significant result according to color.

Post-Hoc Test was utilized to evaluate which condition differ in terms of memory recall. On per item evaluation, the use of polychromatic educational materials and achromatic materials yielded a statistically significant difference indicating that the use of multiple colors has a notable influence compared to the absence of color in terms of memory recall. This is similar to the findings of Dianchenko et al. (2022), which emphasized that the use of color in highlighting important text portions in activating memory process and information recall; therefore, improving learning quality and better memorization of materials. However, this is opposed by the study of Wippich and Mickols (2021), which revealed that using variety of colors may have an adverse influence on focus, hence impairing focus and decrease retention. Meanwhile, comparison between the use of monochromatic and achromatic did not yield a statistically significant result. This indicates that the use of a single color and the absence of color do not have a noteworthy influence on memory recall. This result is similar to the study of Zou (2023), which stated that there is no statistically significant difference between the group that used single color and non-colored educational materials upon studying. Moreover, comparison between the use of polychromatic and monochromatic materials exhibit no statistically significant difference, indicating that the use of multiple colors or a single color do not have a notable impact on memory recall. This result is similar to the study of Genon and Saldua (2024), which claimed that colors, especially primary colors, do not significantly predict memory retention. This emphasizes that better performance involving the memory is unattributable to the use colors. However, this contradicts the results from the study of Kurt and Osueke (2014) as stated by Istiono (2022), which highlighted that some hues can be beneficial in attaining focus, attention span, hence, support learning and memory retention. It was also shown thar red and blue were the most effective; however, red was significantly superior to blue in terms of depth regarding brain function and cognitive ability, oriented tasks, and memory retention of college students.

Comment [k5]: Scientific justification for assumptions?

Comment [k6]: What is practical implications of this paper?

Findings indicate a notable difference in the application and the variety of colors used, as compared to the absence of it. Based on the results, the use of polychromatic materials proves the most effective method in facilitating memory retention compared to both monochromatic and achromatic materials. This suggests that incorporating multiple colors in educational materials significantly influence memory recall; therefore, boosting academic performance. Considering the valuable findings in this research, it is crucial to address the limitations encountered during the experimentation of this study. First, the colors used to highlight important information on the passage given. The researchers provided the participants with a great range of options and let them choose the color of their preference to both polychromatic and monochromatic conditions, without considering the possible impact of their color choice by nature. Second, the environment where the experiment was conducted. The experiment was implemented in a natural setting, simulating a real-life context where students are exposed to in preparation for an exam or an activity. Lastly, the number of participants involved. The experiment included an exact number of 45 participants, who were equally distributed into three conditions, with 15 participants in each. The sample size may have a significant influence in the experiment as varying sample sizes can yield different outcomes.

Moreover, since the notable difference of each condition is revealed and evidences from related literatures are presented, the implication of this research may aid the academic pursuits of learners as it has been shown that incorporating colors in educational materials influenced memory recall. Nevertheless, it is crucial for future researchers to study the advantages and disadvantages in incorporating colors in educational materials and further delve into the nature of this type of study technique to bridge gaps and contribute to the limited literatures under this study of interest. Also, future researchers may expand the sample size to increase the external validity of the research. Educational practices or curriculum development may also be aided by the implication of this research as findings may provide a foundation for developing effective learning technique for learners. Additionally, further researchers may further explore the impact of different color combinations or the specificity of colors to be used to deepen our understanding of how colors effect memory.

CONCLUSION

The study revealed that using polychromatic (multi-colored) educational materials significantly enhanced memory recall compared to monochromatic (single-colored) and achromatic (black-and-white) materials. This suggests that incorporating multiple colors in learning materials can make them more engaging and improve learner's ability to remember information. In contrast, monochromatic materials had moderate effects, while achromatic materials were the least effective, indicating that the absence of color can limit the learning experience. Additionally, these findings are important for the reason that they emphasize the value of color in educational design. Using polychromatic educational materials can make learning more interactive and appealing, especially for students who benefit from visual stimulation. By using color strategically, educators can enhance student's memory retention and overall learning experience. However, further studies on this subject are necessary to fill any possible gaps within this research.

Comment [k7]: The limitation of this paper?

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Comment [k8]: Apa style is not considered very well.

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