International Journal of Multimedia and Ubiquitous Engineering
Vol.10, No.9 (2015), pp.9-16
http://dx.doi.org/10.14257/ijmue.2015.10.9.02

Study of Learning Performance Improvement Based on Color Changes of Test Sheets

KwangCheol Rim[1] and YeongBea Yoon[2*]

[k,m]*rtment of Mathematics, Chosun University, KwangJu, Korea*
[2]*Department of English Language, Chosun University, KwangJu, Korea*
rim1201@hanmail.net, toeic21@hanmail.net

Abstract

Of the five senses, color vision is the most responsive. Color is an energy that can control the psychological and physiological responses of human beings. This study investigates improvements in learning performance by conducting an experiment wherein the colors of papers were changed. We examined whether the primary learning techniques utilized by students in English and math (i.e., memorization, logical thinking, reading comprehension, and calculation) changed according to the color of a test sheet. The experiment was performed in a regular classroom setting; lighting and temperature were the same as usual; however, the color of test sheets varied between blue, orange, yellow, and white. The experiment revealed that yellow improved math performance, blue improved memorization skills in English, and that orange improved calculation and comprehension skills. This indicates that simply changing the color of a sheet can contribute to improved learning performance. Furthermore, these finding can be applied in many different fields.wt

Keywords: *color strip, numeracy, comprehension, memorization, change paper color*

1. Introduction

Color is a type of visual perception and subjective sense that arises from a person's ability, through sensory organs, to perceive the spectrum of light projected and reflected by objects. Of the five senses, sight, specifically, color vision, is the first reactionary element of design [1].

Color is an energy that constantly surrounds us, affecting us physiologically and psychologically, and this phenomenon reveals itself in nature. Color has evolved with humanity, possessing its own unique emotion and expression. Johann Wolfgang von Goethe presented the "color theory," which discusses colors and the correlations between them. Sigmund Freud claimed that we are able to recognize the inherent qualities of each color and what they symbolize. In Carl Gustav Jung's depth psychology perspective, color is defined as a radiative energy that brings forth emotion and that is emitted based on an archetype and an original form inherent in particular colors.

Studies on color include those on preferred color [2], the relationship between color preference tendencies and theory of aggression [3-4], and color psychology and sensitivity [5].

Since colors are influenced by temperature, they are accordingly discussed in terms of color temperature. For example, in low temperatures colors tend to be in a spectrum of reddish hues. However, as temperatures rise colors become lighter, and at the highest temperatures exhibit bluish hues. Research concerning attention and memory tests revealed improved precision under cool lighting, and decreased reaction time under warm lighting. Moreover, research indicates that when compared to red lighting, green lighting enhances both work performance and

ISSN: 1975-0080 IJMUE

psychological stability. Other studies revealed differences in activity, capacity, and stability levels depending on color temperature. Studies have also examined the effect of lighting on academic performance [7,10-12].

The visual sense is known to make up over 70% of all human perception, in which color is recognized before shape or form. As one of the most important elements in understanding human psychology, color is studied throughout the world in myriad ways [6].

Color preference results are used in psychology to assess personalities and developmental stages, in psychiatry as a cure for mentally ill patients, and as fundamental data to meet consumer's segmentalized demands for products in various industries. Nevertheless, some research suggests that no correlation exists between color preference and product purchases. Moreover, when color preference experiments are performed on identical study subjects, results differ concerning general color preferences and their preferences for specific items. Furthermore, more than 90% of the time generally preferred colors and those preferred for certain products differ. This is because individuals select colors that complement a given product in relation its function, not colors that they would ordinarily prefer. Consumers may also consider personal preferences and social attributes at the time of product selection [8].

Color preference manifests itself differently based on personality, age, gender, nationality, ethnicity, and environment. For this reason, when people see a certain color, they associate it with many different images; the associative and symbolic images that colors embody evoke various psychological effects in response to human emotions. Although there are differences among individuals due to their subjective perceptions, commonalities also exist [9].

As shown in Table 1, the reasons for liking or disliking certain colors are related to association. Regarding the preferred colors, most (76.3%) selected a given color because it “gives a good impression” (*i.e.*, role of association). As for the undesirable colors, most (54.7%) disliked a given color because it “gives a bad impression” (*i.e.*, role of association). This indicates that people’s controlling actions are in response to their impression of colors.

Individuals who like orange are characteristically cheerful, positive, straightforward, outgoing, bright, socially adaptable, and adept at leading others. In contrast, those who favor dark orange could potentially exhibit agitation or irritability. Yellow symbolizes control, superiority, eloquence, responsibility, and authority. Accordingly, individuals who prefer yellow are prone to dependency, and often exhibit a desire to remain in a child-like state. Finally, individuals fond of blue are typically gentle, kind, introverted, reliable, assertive, highly adaptable, and relatively cheerful.

Table 1. What Participants Liked and Disliked about a Selected Color

Reasons for liking/disliking a color.		Ratio
Likes	Color suites me	17.7%
	Color makes a good impression	76.3%
	Other	6.0%
Dislikes	Color does not suit me	30.3%
	Other people do not like the color	0.3%
	Color does not make a good impression	54.7%
	Other	13.3%
	No answer given	1.3%

For this particular study, an experiment was carried out to determine if learning abilities can be affected by color. The experiment was conducted in a classroom setting with appropriate lighting to which the students were already accustomed. The difference in scores on tests with equal difficulty levels on colored paper versus regular white paper was analyzed. SPSS ver. 22 was utilized for the *t*-tests and descriptive statistics.

Chapter 1 discusses prior studies and justifies the necessity of this research, while Chapter 2 describes the experiment and its analysis methods. The experiment's results are analyzed in Chapter 3. Chapter 4 discusses the study's results and directions for future research.

2. Colored Sheet Experiment

The target participants of this experiment were college students who had recently graduated from high school. To ensure an equal ratio of male and female participants, students were selected from the college of engineering (where male students are the majority) and the college of humanities (where female students are the majority).

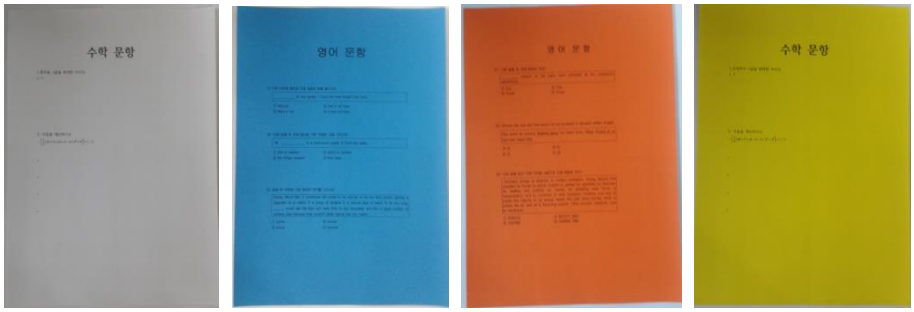

Figure 1. Colored Sheets 수학문항=Math Question, 오일러수 e 값을 최대한 쓰시오=Write Down the Full Value of the Euler Number e, 다음을 계산하시오=Calculate the Following, 영어문항=English Question, 다음 밑줄 친 곳에 알맞은 것은?= The Following Underlined Where Appropriate?, 다음 글을 읽고 뒤에 이어질 내용으로 가장 알맞은 것은?= It is Best to Continue after Reading the following Article Details?, 공해문제=Pollution, 통신수단발달=Communication Development, 산업개발=Industrial Development, 대체연료개발=Alternative Fuels

The experiment measured participants' improvement in math and English. There were two questions concerning math, and three questions related to English. In the math section, the first question involved mathematic memorization, while the second measured logical reasoning using parentheses and the order of operations. The first question in the English section was used to assess the vocabulary knowledge of entry-level government employees; the second and third questions assessed grammar knowledge and reading skills respectively.

To prevent false memories, two tests were administered one month apart. The first test was printed on regular white paper, and a month later a second test of similar difficulty was printed on three differently colored sheets and administered. To ensure consistent lighting conditions, the experiment was carried out in students' regular classrooms during hours in which their lectures were usually conducted.

This test required students to memorize vocabulary words that regular college students frequently encounter, which included words used on entry-level tests for government employees.

Table 2. Experiments

mwm	White paper number memorization	ewm	White paper word memorization
mbm	Blue paper number memorization	ebm	Blue paper word memorization
mom	Orange paper number memorization	eom	Orange paper word memorization
mym	Yellow paper number memorization	eym	Yellow paper word memorization
mwl	White paper calculation order	ewg	White paper grammar test
mbl	Blue paper calculation order	ebg	Blue paper grammar test
mol	Orange paper calculation order	eog	Orange paper grammar test
myl	Yellow paper calculation order	eyg	Yellow paper grammar test
mwc	White paper numeracy	ewr	White paper comprehension
mbc	Blue paper numeracy	ebr	Blue paper comprehension
moc	Orange paper numeracy	eor	Orange paper comprehension
myc	Yellow paper numeracy	eyr	Yellow paper comprehension

3. Result Analysis

3.1. Mathematics

3.1.1. Number Memorization

Studies concerning the range of human memory indicate that our instant memory capacity is 7±2. Short-term memory functions as temporary storage for processing information, while working memory is a process wherein information is selected through conscious effort. Some scholars assert that short-term and working memory are virtually identical as general memory systems, although others argue that working memory functions as a component of short-term memory. In this paper, we maintain that mathematical memory is a form of a short-term memory.

We began the experiment by writing the value of π on the board and *e* with 21 digits following the decimal point on the white test sheets. Students were given two minutes to memorize these numbers, after which the board was erased and participants were asked to write down what they had memorized on colored sheets, which we distributed.

Table 3. Memorization of Numbers According to Sheet Color

	N	*M*	*SD*	*t-value*	*Significance*
Mwm	47	7.79	4.644	3.478	0.001
Mbm	47	11.18	6.953		
Mwm	35	12.83	4.427	1.887	0.068
Mom	35	14.71	5.909		
Mwm	66	14.76	5.455	-0.376	0.708
mym	66	14.50	5.625		

The averages show improvement in the tests that were given on colored sheets. The *t*-value proved significant in the experiment with blue test paper. The *t*-value of mwm-mbm was 3.478, and the level of significance was less than 0.05, *i.e*., 0.001, which proves the improvement in the average score was notable. While the means increased for mom-mym, the significance level was 0.159, which is not within a significant range, thus indicating an insignificant result.

3.1.2. Calculation Order

Table 4. Calculation Order According to Sheet Color

	N	*M*	*SD*	*t-value*	*Significance*
mwl	47	0.70	0.462	0.404	0.688
mbl	47	0.73	0.451		
mwl	35	0.78	0.419	-0.119	0.906
mol	35	0.77	0.426		
mwl	66	0.75	0.438	1.425	0.159
myl	66	0.82	0.389		

For the experiment that tested students' understanding of order of operations, participants were given middle school level problems with four fundamental arithmetic operations in parentheses. Before being distributed, an equal sign (=) was printed on the test sheet, on which students could write the order of operations along a guided line on the left side of the paper. Regarding the analysis, a 1 was entered when the order of operations was written correctly; in contrast, a 0 was entered when the order of operations was not written or was written incorrectly. The scores were then entered into SPSS. The results revealed that the mean values of mwl-myl and mwl-mbl increased from 0.75 to 0.82 and from 0.70 to 0.73 respectively. However, neither of these results reached a significant level. Furthermore, for mwl-mbl the mean value actually decreased.

3.1.3. Numeracy

Regarding calculation skills, exponent problems and four fundamental operations with parentheses from the first-year middle-school level were provided on white sheets of paper. A month later, a set of equally difficult problems were provided on colored sheets of paper. To create the same types of questions, identical operation symbols were used, in addition to an identical format comprising parentheses and exponent problems. Scoring was carried out by comparing model answers without considering the order of operations. When an answer matched the model answer, a 1 was entered into SPSS Version 22 for analysis; conversely, a 0 was entered when an answer did not match.

Table 5. Numeracy According to Sheet Color

	N	*M*	*SD*	*t-value*	*significance*
mwc	47	0.66	0.479	0.400	0.691
mbc	47	0.69	0.469		
mwc	35	0.46	0.505	3.282	0.002
moc	35	0.71	0.458		
mwc	66	0.62	0.489	2.215	0.0308
myc	66	0.85	0.361		

The average test score in the mwc-moc experiment rose from 0.46 to 0.71, and further showed progress with a *t*-value of 3.282 and significance level of 0.002. The average test score in the mwc-moc experiment showed improvement from 0.62 to 0.85, with a *t*-value of 2.215 and significance level less than 0.05, *i.e.*, 0.030. For mwc-mbc, the mean value rose slightly from 0.66 to 0.69, although it is still did not fall within a significant range, and therefore could not be deemed significant.

3.2. English

3.2.1. English Word Memorization t-Verified

To increase the test's authenticity, the experiment was conducted using a white sheet of paper and three colored sheets. The test was carried out under conditions identical to a typical classroom environment.

Table 6. Word Memorization According to Sheet Color

	N	*M*	*SD*	*t-value*	*significance*
ewm	38	0.34	0.481	-1.598	0.118
ebm	38	0.23	0.427		
ewm	34	0.28	0.456	0.877	0.387
eom	34	0.35	0.485		
ewm	41	0.26	0.445	3.191	0.003
eym	41	0.51	0.506		

When comparing the mean values, only ewm-ebm decreased from 0.34 to 0.23, whereas ewm-eom and ewm-eym increased. A significant difference was observed only for ewm-eym, with a *t*-value of 3.191 and significance level of 0.003. There was a slight change in the mean values for ewm-ebm and ewm-eom, although the significance levels exceeded 0.05, and hence did not lead to significant results.

3.2.2. English Grammar t-Verified

According to dictionaries, grammar is the hidden system of a language, or a collection of rules and information needed to use a language. Non-English speakers can sense differences in grammatical sequences of English words.

High school level grammar problems were used in this experiment to determine the distinct characteristics of a logical sequence according to paper color. The test was first given to students on white paper. A month later similarly difficult problems were given to students on three differently colored sheets of paper. In all instances the results revealed a rise in mean values, although in two cases (ewg-ebg and ebg-eog) the means exceeded a significant level (0.965 and 0.149 respectively). The mean value of ewg-eyg rose from 0.21 to 0.51, with a *t*-value of 3.824 and significance level of 0.000, thus deeming it significant

Table 7. Grammar According to Sheet Color

	N	*M*	*SD*	*t-value*	*significance*
ewg	38	0.26	0.446	0.044	0.965
Ebg	38	0.33	0.478		
ewg	34	0.23	0.427	1.478	0.149
eog	34	0.35	0.485		
ewg	41	0.21	0.415	3.824	0.000
eyg	41	0.51	0.506		

3.2.3. English Comprehension t-Verified

Regarding comprehension skills, one can infer meaning wholly by identifying the flow and structure of a complete sentence. Therefore, comprehension skills are used as data to determine overall insight rather than simple knowledge. In this experiment, reading comprehension questions were taken from a low difficulty exam for government employees. As with the other experiments, the questions were initially presented to

students on a white sheet of paper, and then on three differently colored sheets of paper a month later.

Table 8. Comprehension According to Sheet Color

	N	*M*	*SD*	*t-value*	*significance*
ewr	38	0.68	0.471	1.754	0.088
ebr	38	0.79	0.409		
ewr	34	0.69	0.468	3.430	0.002
eor	34	0.88	0.327		
ewr	41	0.71	0.457	5.266	0.000
eyr	41	0.93	0.264		

The results revealed increases for all mean values. Although the mean values for ewr-ebr rose from 0.68 to 0.79, this difference cannot be deemed significant since the significance level (0.088) exceeded 0.5. The mean values for ewr-eor and ewr-eyr rose by 27.5% and 30.9% respectively, and the significance levels (0.002 and 0.000, respectively) were significantly different.

4. Conclusion

This experiment was conducted to study the influence of three test sheet colors on students' English and math outcomes using the colors blue, orange, and yellow. The focus of this experiment was to examine the learning skills necessary for both math and English: memorization, logical reasoning, and calculation/comprehension skills—all of which require comprehensive thinking. To measure mathematical memorization, circular constants πand Euler numbers ewere used. For English, vocabulary was memorized from a low difficulty exam for government employees. Order of operations, understanding of grammar, and calculation/comprehension skills were common elements evaluated by each test.

For the mathematics memorization section, the average test scores, excluding that of the white test sheet condition, were ordered as follows: mom > mym > mbm, and the blue test scores (mbm) showed the greatest improvement. Regarding the test involving the order of operations, which was designed to assess mathematical logic, simple means rose slightly for blue and yellow sheets, and decreased for orange sheets. However, in the *t*-test analysis none of the results reached significant levels, and thus failed to produce significant results. The average *t*-test value for calculation skills on the blue test showed no change, but there was a significant average improvement on the orange and yellow tests.

Regarding the tests examining vocabulary memorization and students' understanding of English grammar, the mean values for eym and eyg increased sharply, while the mean values for ebm, eom, ebg, and eog rose just slightly. For the *t*-test analysis, eym and eyg exhibited significant results. In contrast, the results for ebm, eom, ebg, and eog exceeded the significance level. Concerning the reading comprehension test, the simple means from the *t*-tests increased for each of the three colored sheets, although only eor and eyr exhibited significant results.

The above results revealed that, for the mathematical memorization test, the use of blue paper produced a significant increase in mean values. Moreover, yellow paper produced a significant increase in mean values for the vocabulary test, which required memorization in English. Additionally, there were significant rises in mean values for tests involving reading comprehension and calculation (which require calculation skills and holistic insight) when yellow and orange sheets of paper were used. As prior studies have indicated, colors not only affect human psychology, but also learning.

With such results, one can deduce that, rather than making efforts to change the classroom environment with wall decorations, desk arrangements, or classroom lighting, a higher level of student performance can be achieved by simply changing the color of test sheets and textbook pages. The study results prove that color changes can positively influence students' learning outcomes. In the future, in addition to the inclusion of colored test sheets and textbook pages, we can expect to see a variety of studies that will contribute to improvement in learning outcomes.

References

[1] H. Y. Park, K. N. Shim, M. Y. Park and Y. K. Park, "Difference of Perception and Preference of Color according to General Characteristics of Subjects", Korea Society of Color Studies, vol. 19, no. 3, **(2005)**.
[2] G. Y. Je and K. H. Lee, "Color Preference and Color Meaning of University Students", Fashion & Textile Research Journal, vol. 13, no. 3, **(2011)**.
[3] Y. H. Kim, J. I. Hong and S. E. Yoo, "A Study on the Correlation and Difference of Color Preference between Mother and Children on Pre-school Age", Korea Society of Color Studies, vol. 25, no. 1, **(2011)**.
[4] E. J. Hong, J. Y. Yun, H. E. Kim and Y. O. Song, "A study on the Relationship between University Students Color Preference and their Level of Optimism", Journal of Arts Psychotherapy, vol. 8, no. 3, **(2012)**.
[5] N. M. Park, "Color Psychology Analysis of Georgia O'Keffee's works based on Suenaga's Heart & Color Method", Korean Art Psychotherapy Association, vol. 6, no. 2, **(2010)**.
[6] N. N. Je, Y. S. Yoo and G. S. Choi, "Analysis of the Study pattern on Preferred Colors – Focusing on Papers Published 2000-2011", Korea Society of color studies, vol. 26, no. 2, **(2012)**.
[7] S. D. Jee and C. B. Kim, "Objective Evaluation of Learning Performance according to the Color Temperature of LED Illumination", Journal of Korean Institute of Educational Facilities, vol. 18, no. 2, **(2011)**.
[8] N. N. Je, Y. S. Yoo and G. S. Choi, "Analysis of the Study Pattern on Preferred Colors", Journal of Korean Society of Color Studies, vol. 26, no. 2, **(2012)**.
[9] Y. S. Park and S. A. Song, "Study of Preferred Colors and Color Images Among People in Their Twenties", Journal of Korea Society of Color Studies, vol. 28, no. 3, **(2014)**.
[10] H. S. Jae, "Analysis on the Digital Textbook's Different Effectiveness by Characteristics of Learner", International Journal of Education and Learning, vol. 1, no. 1, **(2012)**.
[11] U. Tomas and Jr. Ganiron, "Application of Accelerated Learning in Teaching Environmental Control System in Qassim University", International Journal of Education and Learning, vol. 2, no. 1, **(2013)**.
[12] D. T. Martinez, U. Tomas, Jr. Ganiron and S. H. Taylor, "Multimedia Tools for Teaching Basic Electronics", International Journal of Education and Learning, vol. 3, no. 2, **(2014)**.

Authors

KwangCheol Rim, Received the PhD Degrees in mathematics from Chosun University in 2006. He is currently a researcher in Education and information security. His current research interests are applied Education, endpoint security and big data.

YeongBea Yoon, Literature the PhD Degrees in English Language from Chosun University in 2015. He is currently a researcher in English Education and Teaching Method. His current research interests are applied Education, English Education and Teaching Method.

