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ABSTRACT

This study investigated whether students' memory retention rate improved when they were provided with blue ink printed material. A pretest, treatment, posttest with control group design was used. The participants were 93 10th and 11th grade students in algebra and geometry courses, and there were 2 classes in each course. The treatment lasted for 8 weeks. Analyses of the data from the pretests and posttests with the Dependent t Test and the ANCOVA test indicated that no significant differences were found from the within-class comparisons for each of the 4 classes, neither were differences found from the between-class comparisons. (Contains 21 references.) (Author/PVD)

The Effects of Blue Ink Print on Students' Memory Retention of Math Terms and Definitions

Feng S. Din

University of St. Francis

Kahlon Barnes

Illinois School District 209-U

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Abstract

This study investigated whether students' memory retention rate improved when they were provided with the blue ink printed study material. A pretest, treatment, posttest with control group design was used. The participants were 93 10th and 11th grade students in algebra and geometry course, and there were 2 classes in each course. The treatment lasted for 8 weeks. Analyses of the data from the pretests and posttests with the Dependent t Test and the ANCOVA test indicated that no significant differences were found from the within-class comparisons for each of the 4 classes, neither differences were found from the between-class comparisons.

The Effects of Blue Ink Print on Students' Memory

Retention of Math Terms and Definitions

As part of the learning process or for necessity, students always need to memorize a lot of things, such as spellings, word meanings, grammar rules, concepts, definitions and so forth. Memorization for students, at least for the vast majority of them, has always been a challenge in their schooling life. For a large number of students, memorization means hard work. Unfortunately, many of them are not motivated to work hard. Due to lack of effort, many high school students face some learning problems. It is common knowledge to math teachers that one such problem is their poor knowledge retention rate on definitions of math terms.

Among the many issues that have been studied by researchers to understand and improve human memory, one such issue is on whether and to what extent color plays a role in human memory. The literature seems to have provided mixed findings on the effects of color on memory in various aspects. A number of studies examined the effects of color used as cues on memory. In their investigation on the effects of color cues, Sabo and Hagen (1972) found that children's recognition for central stimuli improved when color cues differentiated them from incidental stimuli; however, they found no differential effect with age. In studying the role of color in remembering graphically presented information, Pruisner (1995) reported that the use of color as a graphic feature did not increase their participants' retention of verbal information presented as a color cue.

Several investigations focused on the role that color plays in pictures and its effect on memory. As to the effect of color change in pictures on memory, the observations of Cave, Bost and Cobb (1996) were that color change in pictures had no influence on the participants'

recognition of the pictures. However, color pictures were found by Shaari (1998) to have been recalled better than black and white pictures and drawings. With respect to the effect of color realism on memory retention of pictures, Berry's (1991) findings were that realistic color cuing was the most effective in recall memory tasks, followed by black and white and then unrealistic colors. With regard to the effect of different colors on memory, the results of one study indicated that yellow, light green, blue, and pink were the worst remembered colors, orange was best remembered color (Perez-Carpinell, Baldovi, de Fez, & Castro, 1998).

A group of studies in the literature examined the effects of color in presentation materials on human responses. Based on a study of presentation software, McConnohie (1999) concluded that the participants' responses to black text upon a white background ranked higher than those upon both blue and green backgrounds. Background color did not seem to have a positive effect on their memory. With respect to the effects of color in slide/tape presentations, Farley and Grant's (1973) findings included: The proportion of participants' reminiscing in color condition was significantly greater than that in black/white condition; and a relative lack of strength of the color effect was also noted in the study.

The literature also includes studies on functions that color plays in background. In a study that focused the impact of background color changes, Brandimonte, Schooler and Gabbino found (1997) that the changes in background color had no effect on imagery recognition. In studying whether the participants who received one of the three treatments of color cues in an instructional program differed significantly on three learning tasks, Allington (1974) reported that color treatment enhanced the learning of visual discrimination, visual memory and paired-associate tasks when compared to the no-color treatment. According to Allington, this enhancing effect seemed

to result from improved attention to the distinctive feature of a stimulus.

A body of literature focused on investigating whether color plays a role in children's cognition and perception process. Regarding the effect of color on the naming process in children for pictures of increasing vocabulary difficulty levels, Barrow, Holbert and Rastatter (2000) concluded that color affected speed of naming only when the vocabulary level of the picture was within the developmental range of the child; and colored drawings were named significantly faster than black and white line drawing. Color did not significantly influence speed of naming for pictures either for vocabulary well established in the child's lexicon or for vocabulary above the child's developmental age. In a study with a similar pursuit, Johnson (1995) reported, children (age 5 to 10) named objects in typical colors faster than they did in atypical colors. In Lin's (1997) study, background color was found to have no effect on perception and cognition; text color was found to have no effect on cognition, but on affection and perception. In testing the effects of the addition of color to assessment instruments (a subtest of the Stanford-Binet Intelligence Scale and the WISC-III), Husband and Hayden (1996) found that clear student preferences existed for colored stimuli; and their conclusion was: Changing subtests to color appeared to be advantageous.

From the education perspective, the issue on whether color plays a role in students' learning process and achievement has also been investigated. In a study on the role of color in memory for textual information, Gaddy (1996) reported that cued recall of the highlighted or underlined information (in used textbooks) by college students was significantly better than recall of unmarked information, and highlighter color (yellow, blue or pink) had no significant effect on recall. In music education, the effect of color-coded notation on music achievement of elementary

instrumental students was examined by Rogers (1991), who found no clear evidence that color-coded notation enhanced achievement on performing by memory, sight-reading or note naming. With regard to the effect of color coding and test type on students who were identified as possessing different levels of field dependence, according to Dwyer and Moore (1995), the color-coding illustrations provided an insufficient structure for the field dependent learners, and achievement herein was not significantly enhanced. The effect of verbal and visual (color or black/white) coding strategies in self-paced instruction and test materials for facilitating student retention on different cognitive tasks was investigated by Lamberski (1982). His conclusions were that color-coded materials were superior to black/white presentation materials on both immediate and delayed tests; however, color presence in evaluation materials did not affect achievement. Color-coding had a more positive effect on visual than on verbal task tests. In studying the effect of color-word interference on children' memory for words, Malliet (1986) found that the motivational benefits of color in educational materials did not automatically lead to increased learning.

The above brief literature review seems to suggest that color does play a role in various aspects of the human perception, cognition and memory. However, findings from the studies on investigating whether color can be used to improve students' achievement are not encouraging. Further research on this issue remains necessary.

For years, one of the efforts math teachers make in their instructional practice is searching for ways to help students improve their memory retention rate on definitions of math terms, which has been a problem for many high school students in math learning. The following is the background of this study: One day, a high school math teacher found that students in the 11th

grade geometry class greatly improved their memory retention rate on definitions of math terms when the terms and definitions were printed in blue ink. The teacher suspected that the blue color ink might have played a role in those students' learning results. The implication of this finding by chance was that: If this theory can be supported by research evidence, blue color ink can be used to print instructional materials that lead to better achievement of students, at least in the area of memory retention of math terms and definitions. Consequently, a study was conducted to investigate whether high school students' memory retention rate on math terms and definitions would improve when the terms and definitions were printed in blue ink on study sheets.

Method

Participants

The participants (N =93) of the study were 10th and 11th grade students from 4 classrooms: The 10th grade students (Class A & B) were in algebra course; there were 21 students (male = 11, female = 10) in Class A; 26 (male = 14, female = 12) in Class B. For the 11th grade algebra course (2 classes), there were 21 students (male =9, 12 female) in Class C; 25 (male = 9, female = 16) in Class D. These classes were in shape before the study was conducted: They were formed by the school authority at the beginning of the school year. The classes were considered equal in academic achievement by the school authority. These students were attending a rural school with an enrollment of 475 students, with a vast majority of them from Caucasian families. The school was located in a northern Illinois small town with approximately 5,000 residents, who mostly had low to middle family incomes.

The participating teacher (male, Caucasian, age in the twenties) was certified in teaching high school math, had one year of teaching math at the high school level. He taught both algebra

and geometry courses of the 4 classes.

Procedure & Design

The study utilized a pretest, treatment, posttest with control group design (a 4-group design). For the 10th grade algebra course, Class A was the experimental class, Class B was the control class; for the 11th grade geometry course, Class C was the experimental class, Class D was the control class. The experimental classes were selected by a simple random drawing process. In this case, each class had 50% chance of being selected as the experimental class.

For the prestest, on the first day of a week, each participating student was given a piece of white paper listing 10 math terms and definitions in black print. One such sheet was designed for the algebra course, and another one was designed for the geometry course. Namely, students in the algebra and geometry course used different study sheets. Then the teacher explained the definitions to the students and told them to study those definitions, and they would take a matching quiz on the last day of the week. All students in the 4 classes received the study sheets with black print. For the quiz (a matching type of test), each correct answer was awarded one point. A full score would be 10 points in this case.

During the treatment stage, the experimental groups received weekly study sheets (like the pretest sheet, with 10 terms and definitions) with blue print, the control groups received study sheets with black print (a standard practice). One study sheet was designed by the teacher for the algebra course, another was designed for the geometry course. The weekly terms and definitions were selected by the teacher from the students' textbooks. These weekly terms and definitions on the matching tests were scored by the teacher the same way as that was used for the pretest. This treatment process lasted for 8 weeks.

For the posttest, a similar matching quiz containing 10 terms and definitions for each course was given to the students of each course, with blue print sheet for the experimental groups, black print sheets for the control groups. Again, the terms and definitions on the postest were selected by the teacher from the students' textbooks, and they were scored the same way as the presttest and weekly quizzes were scored.

A Dependent t Test was conducted on the raw scores of pretest and posttest for each class for within-class comparison. An ANCOVA test was conducted to compare the raw scores of the pretest and posttest of the 2 classes in the algebra course (Group 1) and those of the 2 classes in the geometry course (Group 2).

Results

Results from the Dependent t Test indicated that no improvement was found for any of the 4 classes respectively. See Table 1. Results from the ANCOVA test showed that no significant difference was found between the 2 algebra classes, neither difference was found between the 2 geometry classes. See Table 2.

Discussion

This study constituted a concrete effort of investigating whether the blue ink can be used as a mechanism to boost students' memory retention of math terms and definitions. Again, like other studies with similar objectives, findings from this study were not encouraging, either. Although these findings are not conclusive, they relate to the question of whether students' achievement is associated with the manipulation of color in their learning materials. With respect to the impact of color on memory, it seems that the knowledge from the research literature shows such impact on short-term memory, which has a transient nature (Vogel, Woodman, & Luck,

2001): memory either a few seconds or one hour (or more) after exposure to an object or color. However, this type of impact does not seem to be significant enough, and lead to boosting students' learning: in this case, students' memory retention rate (a long term verbal memory, per se) of math terms and definitions, which seems to be educators' ultimate reason in attempting to manipulating color in the instructional materials. The effort that educators make in using colors in various ways in the instructional materials may be made for reasons, such as: to facilitate students' cognition process, for attracting students' attention, or for some motivational effect, but not for the reason of directly improving their memory retention of some school subject. At the present, there is no research-based evidence to support such claim or practice in schools.

As the literature shows, color plays a role in human's cognition and memory. Regarding the nature of color in memory, Fargo (1995) offered a theory: Color may be visually encoded separately from any verbal encoding; color memory is a visual memory (not verbal memory, which is different from visual memory). If the manipulation of color has some impact on visual memory, then the nature of the relationship between the color-impacted (color-enhanced) visual memory and student academic learning constitutes an important research issue that warrants further investigation.

The study utilized a four-group design: two experimental groups, two control groups, in two math courses. Although algebra and geometry are different subjects, they are generally considered to be branch areas of mathematics. The experiment was conducted in two math courses with control groups. Results from the data of a four-group design should be relatively more convincing than those from a two-group design data, either in a positive or negative way. To put it succinctly, chances for making a Type I mistake from a four-group design should be

smaller than that of a two-group design, although a two-group design is a good design by itself.

Conclusion

Based on the results from the Dependent t Test and the ANCOVA test, it is concluded that after 8 weeks of treatment no single class in the two courses made significant improvement in their memory retention rate on the math terms and definitions; the use of blue ink printed study sheets did not contribute to a notable improvement in the memory retention rate of the participating students in the math terms and definitions in the experimental classes in both the algebra and geometry course.

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Table 1

Results from Dependent t Test: Within-Class Effects

Class	Prestest Mean	Posttest Mean	Std. Error of Mean	t	p (2-tailed)
A	8.28	8.33	.2338	-.204	.841
B	8.0	8.03	.2111	-.182	.857
C	8.33	8.47	.2419	-.591	.561
D	8.8	9.1	.4159	-.866	.395

Table 2

Results from ANCOVA Test: Between-Class Effects

Group*	Source	SS	df	MS	F	p
	Pretest**	118.018	1	118.018	100.614	.000
1	Class***	6.07E-03	1	6.07E-03	.005	.943
	Error	51.611	44	1.173		
	Pretest	114.67	1	114.67	38.543	.000
2	Class	.663	1	.663	.223	.639
	Error	127.929	43	2.975		

* Group 1 = 2 classes in algebra, Group 2 = 2 classes in geometry.

** Prestest = Correlation between pretest and posttest.

*** Class = Comparison between the experimental and control class.

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