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<https://doi.org/10.15760/etd.2153>

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AN ABSTRACT ON THE THESIS OF Shirley Jo Brehm for the Masters of Science
in Teaching, in Art presented May 16, 1974.

Title: The Value of Color Systems in Education

APPROVED BY MEMBERS OF THE THESIS COMMITTEE:

Richard Prasch, Advisor

Jean Glazer

Fred Heidel

Color is with us everywhere, all the time. It is an integral part of our existence. Sensitivity to color and awareness of color's physical and psychological qualities is undeveloped in the normal, average human being. What can be done about this? Where can it be done? The answers to these two questions form the basis for this thesis. Color awareness as part of visual education and environmental sensitivity can be taught and should be taught in every educational institution. The key to successful instruction is informed, knowledgeable, color sensitive teachers and the exposure of students to workable color systems. Color instruction can be approached from many directions; an observation and study of nature, a research of man's uses of color, past and present, and the examination of the scientific aspects of color to name a few. All are

expressed in some kind of color systems. Whether the systems are identified to the students is of less importance than the instructors having a good understanding of these systems to help guide the students to more complete color awareness.

Research for this thesis consisted of an examination of available material on color in the Portland area. In addition a questionnaire was given to all teachers at the elementary level and to teachers of Art, Science and Home Economics at the junior high and senior high level in a test school district to determine the color curriculum, at what grade levels color was introduced and the methods of introducing color. Also a color quiz was given to first year art students in one of the three high schools in the district to determine the amount of color knowledge or information retained from previous schooling. All instructional material in the same district was examined and evaluated.

The results from the questionnaire and the quiz indicated a lack of color awareness by the elementary teachers and, consequently, the students in first year art classes. This was felt to be in part due to the minimal Oregon state requirements in Art for elementary teachers, which therefore would result in inadequately trained teachers. The lack of acknowledgement of the importance of color awareness by faculty and administration were also prevailing influences.

This thesis is being written in the hope of enlightening teachers on the importance and necessity of color awareness and sensitivity at all grade levels.

TO THE OFFICE OF GRADUATE STUDIES AND RESEARCH:

The members of the committee approve the thesis of Shirley Jo Brehm
presented May 16, 1974.

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THE VALUE OF COLOR SYSTEMS IN EDUCATION

by

SHIRLEY JO BREHM

A thesis submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN TEACHING
in
ART

Portland State University
1974

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Note: The above letter symbols denoting color charts appear throughout the text.

CHAPTER I

INTRODUCTION

Man has been struggling since time began to develop a rational, workable system of color that would satisfy all the demands of a growing, changing society. Many systems have been created and all satisfied some of the needs, but none served all the needs of the society. Although the scientific aspects of color,^A as discovered by Sir Isaac Newton in 1766, have not changed radically since that time; the uses and needs for color have seen a constant progression of changes and demands. As one of the most influential factors of anyone's life, color has become an area of concern for artist and layman alike. In business and industry great strides have been made to present color, in it's fullest potential, to the public.

The purpose of this paper is not to examine the history or judge the validity of color systems. This paper is being written on the premise that color systems do exist and play a vital role in the field of color. Thus the purpose of this paper is to evaluate the influence of color systems in our educational system and to help teachers realize the potential and importance of color sensitivity and awareness for every student.

Almost every system developed through the years had some kind of visual representation to how or demonstrate the workability of the system. In many instances this visual material was a two-dimensional color chart or wheel, sometimes a three-dimensional color solid.^J It is this color chart or wheel and what it represents that is being examined to find what value it has in the educational system.

This thesis is being written in the hope of helping art instructors and all teachers re-evaluate their approach to color.. For through the teacher and his/her thorough understanding of color and the systems developed to organize color the student may be provided with a more complete visual sensitivity and application of color affectiveness.

The following chapters attempt to point out reasons for the examination and use of color systems in the educational program.

A final note, that is not meant to be 'How-To-Do-It' paper, with exercises and answers complete in a package. Information is given in the hope that individual teachers, seeing the need, will incorporate it into their own teaching situation, whatever it may be.

CHAPTER II

RESEARCH

A large portion of the research for this paper was the reading of the many excellent books on color that are available in libraries and book stores. Authors such as Itten,¹ Albers,² Graves,³ Birren,⁴ Moholy Nagy,⁵ to mention only a few give any reader a good background on color. Among the non-art educational material it was hard to find authors of as high a caliber. In fact, the aspect of color instruction seems to have been over-looked by most educators, at least at the lower levels of education. This is probably due to the very minimum art training required of elementary teachers.

As the second part of the research for this paper, a questionnaire was given to the teachers in the Beaverton School District #48, Beaverton, Oregon. From the answers obtained on the questionnaire, the amount of color instruction being done at each grade level was established. Also the approach to color and the use of a color systems chart or wheel was determined.

The reason for using this particular school district was the availability in terms of distance and also the size of the student body. Beaverton District is a typical middle sized district, with 1,100 teachers and an enrollment of over 20,000 students. There are 26 elementary schools, five intermediate (junior high) schools, and three senior high schools.

Along with the questionnaire, which solicited the teachers' responses, a color quiz was given to first year art students at the high

school level. The purpose of the quiz was to estimate the amount of color information acquired and retained through elementary and junior high school instructional programs.

On both the questionnaire and the quiz there was an obvious lack of any organized color program. It should be said at this point that the Beaverton School District does not hire an Art Director or Supervisor. The teaching of color is the personal responsibility of each individual teacher. After a strong concentration of color in the first grade, color was dropped as a subject and doesn't appear again until the fifth or sixth grade as a science project, dealing with light. Then in junior high school, grades 7, 8 and 9, with the introduction of Art classes, color is again tackled as a subject in its own right. By the time high school is reached, color and color instruction seem to be taken for granted. Only a few, less than 20%, of the teachers questioned felt any detailed color analysis was necessary. Yet all other phases of art instruction, such as line, form, texture, etc., were dealt with in depth. More emphasis seems to be placed on the product than the process. Not until the college level are students exposed to color in any depth. Only then are they taught to perceive and respond to one of the most important and most prevalent visual elements of their lives, color.

SAMPLE QUESTIONNAIRE

PLEASE READ AND RESPOND PLEASE

This questionnaire is being given in conjunction with thesis work for a MST degree at Portland State University. Your time and effort are greatly appreciated. Thank you for your assistance. If you have any questions please contact me at 292-5857. Please return to the office when completed.

Shirley Jo Brehm

1. I teach...(circle appropriate number of numbers) grade.
 - a) elementary...1...2...3...4...5...6
 - b) junior high ...7...8...9
 - c) senior high...10...11...12
2. My subject area is...(circle one or more)
 - a) art
 - b) home economics
 - c) science
 - d) general
 - e) other
- 3.. Is there a color chart visible in your room at this time?
 - a) yes
 - b) no
4. Do you now or have you ever used a color chart in your teaching situation?
 - a) yes
 - b) no
5. If so, how was it used? (circle one or more)
 - a) as supplementary material
 - b) as an art lesson in itself
 - c) as a continuous learning plan
 - d) other.....(explain if possible on back of sheet)

6. What is the brand name or type of color chart you are using?

7. Did you use a text in conjunction with your color projects?

a) yes

b) no

If so what was the title and the author?

8. Could you approximate how much time you spend on color in a year?

a) hours _____ or days _____ or weeks _____

RESULTS FROM QUESTIONNAIRE

The questionnaire was given to all elementary teachers, approximately 400, of which 50% responded. On the second level the questionnaire was only given to Art, Science and Home Economics instructors, of which there are sixty-two. The response on the junior high level was 66% and at the high school level was 75%.

On the elementary level color charts were found in 12% of the rooms, but 75% of the teachers stated they had used a color chart at some other time. The majority of teachers used the color chart as an art lesson in itself and made their own charts for demonstration purposes. Among the printed color charts used were Milton Bradley, Grumbacher, Prang, Instructor, and the World Book Encyclopedia. Over 80% indicated they used no text and the texts named by the remainder were not major works on color, but small volumes picked by personal preference of the teacher. The district curriculum material center was only referred to by 2% of the teachers. One-third of the first grade teachers stated they taught color an average of six weeks out of the year, while the second one-third indicated they taught color all year. Of the remaining one-third only a few days were spent on color. A few teachers did indicate a concentration of color work in the first grade at the beginning of the school year with a slackening off as the year progressed.

In second grade an average of one and one-half weeks were spent on color instruction. This was true for the third and fourth grades also. At the fifth and sixth grade levels an increase in time spent on color was noted; four to five weeks being the average. The reason for this

can be attributed to the introduction of color in the science courses as well as work done in conjunction with art.

On the junior high school level color charts were visible in 50% of the rooms in both Art and Home Economics classes but were not displayed at all in Science classes, although all three classes indicated they used charts at some previous time. In Art the color chart was used either as a lesson in itself or as a continuous learning plan, while in Science when used it was as supplemental material only, and in Home Economics the color chart was used in all three of the above manners with emphasis on supplemental material.

As to the brand or type of chart used, Art teachers mentioned Grumbacher,^H Milton Bradley and clay glaze charts. Science teachers covered the spectrum using their science texts and teachers of Home Economics used color charts by Sears, McCall Pattern Co. Prang, and Brewster.

Texts were used at the junior high level by 50% of the teachers, but no two teachers mentioned the same book. The curriculum material center was indicated only once as a source of reference material.

The time spent on color at the junior high level varied from subject to subject. In Art the average was six to seven weeks, in Science the time was reduced to a few days, and in Home Economics even less time was spent on color.

Senior high responses were very similar to those at the junior high level with the exception of more color work being done in the Science area. In the Art classes color was dealt with as a continuous learning process with no strong concentration on color as a separate subject.

COLOR QUIZ

1. What are the primary colors?
2. What are the secondary colors?
3. What is the origin of color?
4. How many colors are there?
5. What are the warm colors?
6. What are the cool colors?
7. What happens to colors as they recede into the distance?
8. How does this differ with colors that are at close range?
9. What is your favorite color? Why?
10. What colors must be mixed to produce...
 - a) green
 - b) purple
 - c) orange
 - d) pink
 - e) brown
 - f) gray
 - g) black
11. What primary color or colors do you see most in nature?
12. Name two colors that are used to get your attention.
13. Color associations; what do you think of when I say...
 - a) blue
 - b) yellow
 - c) orange
 - d) violet
 - e) green
 - f) red
 - g) black
 - h) white
 - i) pink
 - j) gray
14. Name the colors in a rainbow in the order they appear?
15. What have you seen today that is completely colorless?

RESULTS OF THE COLOR QUIZ

The color quiz was given to first year art students at the high school level. Practically all the students had had previous art classes in junior high. The majority of the students knew the primary and secondary colors and how to mix the colors asked. The cool and warm colors were identified by about 50% of the students. When it came to the questions concerning general observation, such as 7, 8, 11, 12, 14 and 15, the students had a more difficult time. Less than 25% understood or remembered what happens to colors as they recede into the distance, or how that differs from colors that are at close range. The questions on color in nature and attention-getting colors were answered correctly by 75% of the students. The rainbow question seemed to be the most difficult with not more than 10% answering it correctly. Many students knew the colors, but not the sequence in which they appeared. Another question that only a few students answered correctly was #3, concerning the origin of color. Practically all the students answered paint or pigment, which indicates the type of color instruction they have received. The light theory of color seemed to have been overlooked or by-passed and only the pigment aspect defined and explored. The question on color associations was included not as a right or wrong type question, but more as an indicator to see if these students related to color as the psychologists determine current color associations. The students had no problem with this question and most of the answers were the same found in any text on color psychology.

The problems of giving a successful quiz or questionnaire are many and the wording that is required to achieve maximum understanding for

beneficial results is very important. After this quiz was given it was noted that certain parts were misleading and difficult for the students to answer. To begin with, the title should have indicated that this quiz was dealing with pigment colors. Question #11 was also misleading. It asked what primary color or colors are found most in nature. The use of the word 'primary' ruled out the answer that ~~many~~ the students felt was correct, green, which is a secondary color. The question should have read: what color is seen most in nature?

CHAPTER III

RATIONAL ORDER OF COLOR

The word 'system' denotes an orderly presentation of elements into a whole, according to some rational principle. Therefore a color system can easily be imagined as a combination of colors or hues into some kind of orderly arrangement. The easiest system to view and acknowledge is the spectrum.^A By passing a ray of (sun) light through a prism, or by viewing a rainbow, an orderly arrangement of colors can be seen. This could be called the 'original' color system. But long before this scientific fact was discovered, men were trying to develop some rational order to the color they saw around them. As early as the 1600's, it was decided by some that the three primary colors were red, yellow and blue, on the basis that these three colors could not be mixed by any combination of pigments or dyes.

In time as science advanced, it became obvious that there were two different kinds of color; color in light^C produced through a prism, and color in pigment^D produced through organic and inorganic mixtures. Each has specific qualities and properties that made it distinguishable from the other. The same color system would not work for both. So according to their interests and backgrounds, whether artist, scientist, or industrialist, men developed color systems to satisfy their own needs. As stated before, all served some purpose, but none of the color systems answered all the problems of color. Two systems became standardized for use in industry and were widely used by all professions. They are the

Ostwald System, used extensively in Germany, Switzerland and Great Britain, and the Munsell System, which was adopted for use in the United States. Both systems had popular use in the first half of the 20th century, and are still being used today. However both systems had a serious shortcoming; they tried to go beyond the analysis of what color is and does, and became involved with how color should be used, thus abandoning the major objective of a good color system, which is described by Kuppers⁶ as:

1. It must be clear, understandable by everyone both as a scheme and as a model.
2. It must be firmly and obviously related to the physical principles of color.
3. It must agree with the physiological functions of the visual organ, the eye.
4. The laws of both the additive and the subtractive mixture must be clearly defined.
5. It must be logical.
6. It must be easy to represent all relations mathematically.

Since that time other systems have been devised but few have achieved success. Among the ones that did survive is the Ross System, which is based on the behavior of pigments, as opposed to the Munsell System which dealt with the qualities of colors in light. Ross' system is very similiar in many aspects to the Munsell System, but the main difference lies in the complementary colors, which are pigment complements, not light complements. Each system is valuable, as one can mix pigment according to the Ross System and organize color schemes according to the Munsell System.⁷

It is imperative that teachers being trained in elementary and secondary education understand these two basic systems (or similar ones) of color. Although the pigment system still depends on the light system to produce its colors, the workings of the two systems are different and should be understood as such. When instructing students, it would not be valid to use one system and not the other, as both are equally important. One is how we see or visualize color, the other is how we use color.

At the present time only the use of color or pigment system is taught in elementary grades. The light system isn't introduced until the fifth or sixth grade, usually in the context of science material. Not until high school or more often college do students become aware of the two interrelated systems and their proper functions.

Since color, dependent on sight and light, is with us from birth, it would seem appropriate to learn about this important visual stimulus as soon as possible. Visual education is as valid as reading or math, and is as important in the development of the total person. We begin to learn to read and spell in the first grade, both skills that demand great concentration and organization.. Can the learning about color in all its aspects be that much more difficult? If only the perceiving or seeing of color was developed in students, and the use of color left to follow in its own accord, the student would have a greater understanding of color and its influences.

CHAPTER IV

RELATIONSHIPS OF COLOR

As soon as anyone begins to work with pigment colors it becomes apparent that there are basic relationships of color. Colors have certain properties that give a basis for these relationships. The three most important properties of color are intensity, value and hue variation. Intensity refers to the amount of pure color involved, value indicates the amount of white or black that has been added to the color, and hue variation describes the change in a color by its progression along the color spectrum. From these three basic properties, there are a wide range of relationships established. These can be described as color schemes.^M Many texts refer to them as the harmonies of color. The use of the words harmony/discord can be misleading and consequently cause discriminations in color selections. It seems that the idea of harmony/discord denotes a psychological preference and not a mathematical equable set of circumstances, which would make harmony/discord a personal and individual decision. Color schemes are classified as being:

1. Analogous, where three or more colors occur side by side in the spectrum.
2. Complementary, where the colors result in a gray or neutral when mixed, where colors that appear directly opposite each other on a color wheel, or where colors are visually balanced by the result of an after-image in visual perception.
3. Achromatic, degrees of black and white forming a scale of grays.
4. Monochromatic, showing a color scale of one color from near black to the color to near white.

Harmony is generally referred to as the product of any of the earlier mentioned color schemes and discord is said to happen when any of these color schemes are disturbed. This happens when there is a reversal of the natural order or sequence of colors. It can be seen more and more in contemporary art. This also occurs in nature, the brilliant, small accents of pure color dispersed on a neutral, low value field.

One of the more easily recognized relationships is that of contrast. These are not difficult for a first grader to distinguish. Johannes Itten,¹ in his book The Art of Color, describes seven kinds of contrasts^L as the contrasts of: hue, light and dark, cold and warm, complementary, simultaneous, saturation, and extension. These are defined in greater depth in the section on color charts to appear later in this paper.

Other properties of color that would give basis for relationships are the qualities of texture, transparency, filminess, opacity, luster and matte finish of the color surface.

The greatest relationship of color and probably the least taught at the lower grade levels is the relationship of a colored body to its immediate surroundings. Surroundings, in this case, include light factors as well as other colored objects or surfaces. The eye has to be trained to see that a local color, like that of a 'red' apple, can appear in a multitude of variations depending on its nearest neighbors and light sources. From the beginning of visual perception, children tend to generalize colors into the six colors of the spectrum. This generalization continues as they grow even though they are able to perceive and discriminate many more colors, values and intensities. By the time a child reaches the age where he/she is capable of a greater amount of detail and realism in his work, a difficulty arises for the child is still making

these broad generalizations of color. This is very important when the student gets ready to paint or re-create what he/she sees, for what is seen is not what the mind says to put on the paper. A difficult situation may arise, leaving the student feeling very inadequate and unable to relate to what he/she sees, but if his/her mind did not generalize so extremely concerning color but instead to perceive and realize what is really there, this difficult situation would not happen. Many students turn away from art for this very reason.

CHAPTER V

SENSITIVITY TO COLOR

Color systems enable a person to develop greater visual sensitivity to color. Although it is agreed that there are people with remarkable natural color acuity and there are those who are completely color blind, in between these two extremes, most people are able or capable of perceiving color, but are color naive. Color awareness must be developed, through experience and the deliberate attempt to cultivate color sensitivity. Correct seeing must be first experienced, then learned and developed as an important aspect of human awareness.

Everyone makes color decisions every day of his/hers life. Most of these decisions are involuntary and not acknowledged, but they have a strong influence on the total person. Whether selecting a suit of clothes, a new car, a set of dishes, we inevitably must make a color decision. It has been learned from science that color and our color choices have a great effect on our lives. Psychologists have determined that color can change moods and affect our physical and mental activity. Color can bring about conditioned reactions in people, in the form of prejudices. Color symbolism has had a universal effect on people. From primitive to contemporary time, all cultures have had some kind of color symbolism, either in their religion, their art, or their economic systems. Color can affect people as strongly as sound, for the eye is as sensitive or more so than the ear. We usually don't experience this as we receive colors only in small doses (the eye focuses on one thing at a time) or patches, where

sounds fill the entire ear. To be completely affected by color would be like being in a room that was illuminated only by red light.

Color can appear to recede or advance, grow or diminish in size, change in value or intensity. Color has associations in many forms. People tend to form visual associations with color, as blue brings to mind sky, white implies snow, purity, etc. Usually these associations are deep-seated and ages old, passed down from one generation to the next.

To educate students in the many aspects and influences of color in our everyday lives would help them cope and understand the many reactions and responses that have been triggered by color stimuli without their realization. In other words, color sensitivity is an important factor in becoming a sound, balanced individual, as evidenced by the influence of color balance, the effect of color after-images to bring about complementary balance and the psychological effects of color.

CHAPTER VI

COLOR VOCABULARY

Although many color variations can be seen, up into the thousands, the eye tends to simplify vast numbers of colors into the six spectrum colors. Naming so great a number of color variations would be difficult, except by a coded or numerical system. So we find there are only a few standard color names, and even these are open to dispute among artists, technicians, scientists and laymen. But as each system has a definite arrangement of colors, so it has its own terminology for those colors. Since the Munsell Color System is widely used in the United States, it is logical that we find his terminology also the most popular. Munsell's color circle^G contains ten colors; five basic colors, red, yellow, green, blue and purple, and five intermediate colors, red-yellow, yellow-green, green-blue, blue-purple and purple-red. To describe the properties of color,^N he used the words hue, value and chroma. (The word intensity has been substituted for chroma by many.) Hue, describing one color from another; value, the amount of black or white in a color; chroma, the amount of pure color contained in a given mixture. Even these definitions are limited and difficult when describing exact measurements. We say a color is of high or low value, but unless a definite scale is designated, it is difficult to determine what the exact value is. Munsell's value scale has nine steps and is described in numerical terms.³

Among the average person's color vocabulary we find words of description that are nature-related terms, such as sea green, rose red, or sky

blue. These terms are poetic in origin and are used as symbolic descriptive adjectives. They are totally unsatisfactory for anyone dealing with color in an artistic, scientific or economic way. So it would seem of sufficient importance to teach correct terminology at an early age, to destroy as much color misconception as possible.

COLOR TERMS

ACROMATIC: Free from color. Pertaining to values of black and white.

ANALOGOUS: Similar or resembling, as colors adjacent to each other on a color circle.

CHROMA: Degree of intensity, strength, saturation, or purity of a color.

COLOR: A sensation produced by excitation of the eye by a stimulus; such as light that is refracted, and reflected from an object.

COLOR PROPERTIES, PHYSICAL: Spectrophotometric analysis or physical measurement of color of light, that is specified in dimensions of wave lengths.

COLOR PROPERTIES, PSYCHOLOGICAL: Hue, value, chroma are the three psychological color attributes or qualities. They are measured in degrees of difference of color sensation.

COLOR TREE, SPHERE, OR SOLID: A three-dimensional structure that shows all the colors in an orderly arrangement that is based on hue, value, and intensity relationships.

COMPLEMENT: That which completes. Complementary colors are those that differ most from each other, those which are diametrically opposite on the color circle, and those which produce neutral or gray when mixed in the proper proportions.

CONTRAST: A combination of opposite or nearly opposite qualities. Opposition, unlikeness, variety, conflict.

HARMONY/DISCORD: Used to imply a pleasant or unpleasant arrangement of colors. Depends on personal attitudes and preferences.

HUE: The quality or characteristic by which one color is distinguished from another color, classification to which one color belongs, name of a color.

INTERMEDIATE COLORS: The color resulting from the mixture of a primary and a secondary color that are adjacent to each other on the color wheel.

MONOCHROMATIC: Color combinations consisting of colors of the same hue, but differing in value and intensity.

PRIMARY COLORS: Colors that cannot be produced by a mixture of any other colors. There are three kinds of primary colors:

1) Light primaries- red, green and blue-violet

2) Pigment primaries- red, yellow and blue

(Further explanation of light and pigment primaries included in chapter on color charts.)

SATURATION: The degree of vividness or purity of a color.

SECONDARY COLORS: Colors produced by mixing two primary colors.

SPECTRUM: A colored image produced when white light is dispersed by a prism.

VALUE: The degree of lightness or darkness of a color.

CHAPTER VII

COLOR SYSTEMS TODAY

Although systems for color organization began in the 1800's and continued through the nineteenth century, little has been done to update these systems.

With scientific discoveries and industrial advances, the field of color has broadened tremendously. New kinds of color have been developed; in photography, the use of infra-red light, in pigments, day-glo and metallic paints, new colored lights, neon and other gases, to name only a few. Yet there have been no new theories that include these new aspects of color.

The role of color systems is most apparent in the man-made area of color. Color reproduction depends on a rigid discipline and a dependable system of color that will meet its demands. From the conception by the artist, to the drawing board, to the reproducing staff, a constant, reliable, standardized color system must be followed. Textile designers, interior and exterior designers, graphic designers are only a few of the fields using a standard color system. Although the artist has the freedom of expression and creative inspiration to make color choices, he/she depends on pigment suppliers to be constant and reliable in the production of colored pigments.

Everything comes 'color co-ordinated,' from clothes, to wall paint, to bathroom fixtures. Even the adjustable television set is a thing of the past; just 'push the button for instant tuning' the commercials say.

Do the eyes become lazy? Are we conditioned from birth by an over-exposure to color, so that the senses become dulled to color stimuli? If that is true, then only by a very strong attempt to re-activate the color sensors can the value of color reach its greatest potential. And where else but in the educational system could such a task be accomplished?

CHAPTER VIII

COLOR INSTRUCTION

How to instruct students in color is a problem that all art teachers are involved with. Each instructor with his or her varied background, interests, surroundings and personality, will obviously go about this task differently. Only the end product, the knowledge of color, is important. Most learning situations start with the simple and work toward the complex. This appears to be for color also. If the colors are presented as they appear in the 'original' color system, the spectrum, a systematic, rational beginning and basis to build on has begun. The spectrum, with the addition of magenta, leads to the color circle, which can be used to demonstrate primary and secondary colors, complementary and intermediate color combinations. From the development of a value scale, patterned after the Munsell scale with nine steps, the perception and control of light and dark are experienced. Color contrasts follow in logical order and are easily seen and adapted to many other art projects. To develop color acuity, exercises in color perception or recognition can become games with 'decks' of color cards. Color terminology should be taught at an early age to enable students to communicate easily with each other and the instructor and to enable them to express in words what they see with their eyes.

In the elementary grades color instruction is begun in the first grade, but because of lack of teacher education or interest, it seems to disappear in later grades. Most color exercises are developed by a back-handed process. With the assignment of maps, charts or other visual

material, color is used as a means to an end. In these cases, personal color expression becomes more apparent than a sensitive, educated use of color. For full creativity, both education and personal expression of color are necessary. As Richard Ellinger states, "Everyone who works creatively with color needs a sound understanding not only of the resources of his color and their expressive potentials, but the means and techniques of ordering his color so that he can convey his personal expression in its most effective form."⁷

For the student, color awareness can be developed through the deliberate attempt to cultivate color sensitivity. This can be accomplished in many ways, most of which are an incorporation of different subjects. In science, a study of leaves, plants and flowers and their color variations is an excellent example. Through simple observation, the student can train his eye to see and analyze minute differences in those colors which at first glance appear the same.

The study of color should proceed through the eye, not the intellect, through the observation processes, not just through memorizing of systems. This reasoning is used in almost all subject areas in today's education.

CHAPTER IX

COLOR CHARTS

The following charts were made to visually present color systems and other basic color functions. They were done on 22x28 railroad board. Colored paper was used for the color areas; using construction paper, fadeless paper, tissue paper, colored acetates and color dots from Hickethier's book, Color Mixing By Number.⁸

These charts were made for use as classroom visual material to be used by the teacher in explaining color or for the student to experience by himself. They were designed to be self-explanatory, but there is a short paragraph of explanation for each one to follow.

CHART A

THE SPECTRUM

The major source of color is light. Most of the color we see in everyday living comes from sun light or artificial lighting. By passing a ray of light through a prism, the ray is diffracted and splits into a visible arrangement of colors. These colors always appear in the same sequence and the same magnitude. Sir Isaac Newton called this the spectrum. Newton's spectrum had seven colors, as shown on this chart. Later the number of colors was reduced to six; leaving out the color between blue and green, aqua.

The colors of the spectrum vary in frequency and wave length. Violet at one end having the highest frequency and the shortest wave length

and red at the other end, having the lowest frequency and the longest wave length.

On each side of the visible light waves are the waves that can be measured but not seen, at least with the naked eye. These are the short cosmic waves at one extreme and the long radio and electrical waves at the other end. It is important to notice how small the area of visible light waves is in comparison to all the other kinds of waves.

CHART A: THE SPECTRUM

CHART B

THREE COMPONENTS NEEDED FOR COLOR

To see color three things must be present; light, an object, and the eyes. The light serves to radiate waves that are either reflected or absorbed by objects, depending on their physical and chemical make-up, which in turn transmit the reflected color to the eye. On reaching the eye, color receptors are activated that inform the brain a certain color has been perceived.

There are many kinds of light; sun light, flourescent light, gas lights, as neon, argon, etc. Each kind has a different effect on color perception. Objects also can affect color by surface texture, density, type of material as metal, glass, etc. Even the eye is unreliable in color perception. Fatigue, after-images, psychological elements all have a bearing on color perception. Consequently, the same 'red' apple will not appear the same to any two people at the same time. Color perception is at best a relative thing, depending on a multitude of factors.

CHART B: THREE COMPONENTS NEEDED FOR COLOR

and red at the other end, having the lowest frequency and the longest wave length.

On each side of the visible light waves are the waves that can be measured but not seen, at least with the naked eye. These are the short cosmic waves at one extreme and the long radio and electrical waves at the other end. It is important to notice how small the area of visible light waves is in comparison to all the other kinds of waves.

CHART A: THE SPECTRUM

CHART C

COLOR MIXTURE - ADDITIVE

Light waves when mixed or super-imposed on each other become lighter and brighter. This is called the additive mixture of color. Green and red produce a yellow light, green and blue-violet produce a blue-green (turquoise) light, and red and blue-violet make magenta light. The primary colors of light are red, green and blue-violet, shown on the left. When all three primaries are mixed the result is white light. The secondary colors of light, shown on the right, are red-violet (magenta), blue-green (turquoise) and yellow. To produce this effect in the classroom, colored acetates or gels (stage craft) can be used. The opaque projector is an ideal source of light, and by covering the front lens with a colored acetate and projecting on a screen in a darkened room, the above effect can be obtained. On a small scale this same thing can be done with flashlights at a much closer range. This is an excellent experiment for primary grades as the phenomenon is hard to explain but easily observed. If baby spot lights are available from the stage, they provide an excellent light source using gelatins over the light and projecting on to a movie film screen, white wall or cardboard.

CHART C: COLOR MIXTURE - ADDITIVE

CHART D

COLOR MIXTURE - SUBTRACTIVE

Pigment colors react very differently than light colors. As they are mixed they become darker and less bright, with the possible result of losing any recognizable hue direction. This is called the subtractive mixture. The colors as they are added one to the other absorb or subtract the amount of light being reflected from the surface. The primary colors are most commonly called red, yellow and blue, as shown on the left, and the secondary colors, on the right, are usually referred to as orange, green and purple (violet). These are standard terms used in educational institutions for pigment-mixture colors.

When both light and pigment colors are being discussed, the relationship of the primary and secondary colors should be acknowledged. The light-mixture primaries are pigment-mixture secondary colors and the light-mixture secondary colors in turn are pigment-mixture primaries. This is evident in Charts C and D. To keep from confusing the light-mixture primary red from the red used as a pigment-mixture primary, a color discrimination must be made. In printing, the primary colors are referred to as magenta for red, cyan for blue, and yellow. This red has a quality of violet and the cyan blue is a blue-green mixture. This terminology would solve the duplication of the word red in both the light and the pigment primaries and better describe the resulting mixtures.

Thus instead of the often used red, blue and yellow pigment primaries more and more in recent color references the terms magenta, cyan and yellow are used, with red, green and blue-violet as secondary colors. Using these terms in this manner enables the interchanging of primary and

secondary colors in light and pigment mixtures, without a repetition of any color terms. These terms, magenta, cyan, yellow, refer to printer's ink colors and are not used by the general public. They are mentioned here only to explain the relationship between light and pigment colors and to show their relationship to the pigment primaries.

When all the primaries of pigment are mixed a color approaching black is the result. These mixtures are easily demonstrated with any number of media, paint, chalk, dye, inks, crayons, etc.

CHART D: COLOR MIXTURE - SUBTRACTIVE

CHART E

COLOR MIXING

Color mixing with the primary colors represented by the use of construction paper is very obvious but also very different from the previous charts. The circles on the left are the complementary colors and on the right are the mixtures that result in the secondary colors. The bottom row demonstrates tints or light values (white and a color) and how they are made.

This is very basic and should be used at the lower grade levels. Similar color exercises, using paint, paper or any medium, can be beneficial.

The primary colors used here are the standard red, blue and yellow found in construction paper. They are not the magenta, cyan and yellow used by printers. The mixture of this red, blue and yellow is very limited and does not result in very satisfactory secondary colors.

CHART F

COLOR MIXING - ACETATES

Here are two variations of the primary colors represented in acetates. By the overlapping of the round color shapes, many different color combinations can be produced. This shows the great variety of colors in a particular hue grouping and the variations in their mixtures. Other transparent materials could be tried to produce even more variations.

The darkness of a color is related to the number of overlays, as in the subtractive mixture of pigments.

CHART G

COLOR WHEELS

Three color wheel variations are shown here. A is the Munsell Color Wheel based on visual colors or light colors. There are five basic colors; magenta, yellow, green, blue and purple, and five intermediate colors. B represents the Ross Color Wheel based on colored pigments. There are three primaries; yellow, magenta and cyan, and three secondary colors. The larger circle in the center C, is a double primary wheel by Grumbacher. It has a warm and a cool color for each of the primaries, with three intermediate colors between the primaries. The triangular shapes in the center represent color mixtures of the primary colors. This gives the artist or anyone working with color a much broader selection of mixtures.

CHART H

POPULAR COLOR WHEELS

These are color wheels being used in schools today. All are produced by pigment manufacturers and represent their line of color pigments. Other than these, it was found on the questionnaire that the largest percentage of teachers in the lower grades made their own color wheels. But they were based on systems the same as the manufactured ones. Even these printed charts show variations in the primary and secondary colors.

CHART I

FABRI COLOR DESIGN

This color design was made of tissue paper and is on a clear transparent surface for viewing against strong light. Only the three colored areas in the center of the design are actual color mixtures. They are colors produced by mixing the secondary colors, green, orange and purple. The black outline is butcher paper and helps to make the colors sharp and stand out.

CHART J

COLOR SOLIDS

Most all color systems developed had a three dimensional representative. This chart shows a few of the prominent color systems down through the ages.

It is interesting to notice the way the shapes seemed to change in a mannerly way, from pyramid to cone to sphere to cube to rhombhedron, from the simple to the complex.

CHART K

VALUE SCALE

This value scale was developed from magazine color chips. Each row should progress from white to black vertically and maintain the same value on a horizontal level.

This is an excellent exercise for high school students to develop color sensitivity. The chart can be simplified or expanded to meet the needs of the individual. This example has weak areas that are more apparent in the photograph than on the original.

CHART M

COLOR SCHEMES

Color schemes are some times referred to as color harmonies. For reasons discussed earlier, the word schemes is being used. This chart shows only a few, as the number is countless. The most often discussed are the following.

- A . Analogous colors, those that neighbor one another on the color circle
- B Complementary colors, those directly across from each other on the color circle
- C Achromatic colors, values of gray from white to black
- D Monochromatic colors, values of one color from white to the color to black
- E Analogous variations
- F Analogous variations

These are only a few examples, the combinations of colors are limitless.

CHART M: COLOR SCHEMES

CHART N

COLOR TERMS

Color terminology is very important for understanding and comprehending color language. Although definitions vary, the words shown on this chart are the same. A list of definitions is listed elsewhere in this paper. This chart is only a visual aid in helping to understand the meaning behind the word. Proper terminology helps to eliminate words that are vague and inaccurate. A word can stand for a single color or an entire color composition.

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