

THE EFFECT OF COLOUR BLINDNESS ON ACHIEVEMENT IN READING
COLOURED AND BLACK AND WHITE MAPS

by

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ABSTRACT

This study investigated the effect of defective colour vision on coloured and black and white map reading achievement. Subjects were twenty-seven colour blind intermediate grade pupils (the experimental group) and a matching group having normal colour vision (the control group). First a coloured and then a black and white map reading test was administered to both groups. Achievement in each test was compared. Data was treated with the Wilcoxon Matched-Pairs Signed-Ranks Test. Results revealed that colour blind pupils achieve significantly lower than their peers with normal colour vision in coloured map reading exercises. There was no difference between the two groups in black and white map reading achievement. The variable of colour blindness would appear to have a detrimental effect on the ability to read coloured maps.

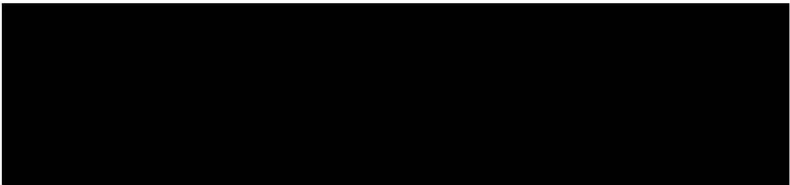




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CHAPTER I

STATEMENT OF PROBLEM AND NEED FOR THE STUDY

Statement of Purpose

The purpose of this investigation is to discover if children in the intermediate grades with defective colour vision achieve at a lower level in coloured map reading than their peers having normal colour vision.

Need for the Study

In almost every phase of human activity today the map has its place. Its chief value lies in the concise manner in which an abundance of information such as factual geographic and historical data or reference material concerning current events can be relayed. Map use has greatly expanded in recent years, for purposes such as travel orientation, for news media illustrations, and in a variety of industrial and civic endeavours. Maps are generally recognized as a means of presenting information in an attractive and accurate manner. Thus, the ability to interpret mapped information intelligently is a useful skill for today's citizen, and the teaching of the skills of map reading is one of the major jobs of the social studies teacher, particularly in the elementary school.

Kohn (1953) identified the following six abilities as determining degree of proficiency in map reading:

1. Ability to orient the map and note direction.
2. Recognition of the scale of the map and ability to compute distances.
3. Ability to locate places on maps and globes by means of grid systems.

4. Ability to recognize and express relative locations.
5. Ability to read symbols and look through maps to see the realities for which symbols stand.
6. Ability to correlate patterns that appear on maps and make inferences concerning the association of people and things in particular areas (pp. 148, 149).

At least three of these six suggested abilities for proficient map reading are dependent on the ability to recognize colour differences if the mapped information is in colour. The variations of colour vision as pertaining to academic achievement have escaped wide investigation, and according to research such as that of Dvorine's (1962) children with colour vision defects constitute a considerable percentage of our school male population. In education today the necessity to provide for individual differences among pupils is recognized, and research on identification of differences, and those teaching strategies required to cope with them, is in active progress. For example, differences in creativity, intelligence, temperament, or physiology are being explored and recommendations for workable special programmes, special classes, and innovative teaching techniques are rightfully replete in professional journals. If all children in our society are to enjoy a fair and equal chance, despite handicaps, of a satisfactory life within society, then it is essential that such research continue and that empirical evidence of superior teaching methods and school organization be implemented.

Facility with maps is an integral part of achievement in the social studies, and the success of imparting knowledge by map usage was revealed by McAulay (1964) in an experiment where one class of fourth

graders studied in a unit of geography with no special emphasis on map work while a second class's work revolved mainly around map construction and reading. The latter class scored significantly higher on a test of the concepts being taught to both groups. The Programme of Studies for the Intermediate Grades (1968) in British Columbia emphasizes the importance of map reading skills with such statements as, "It is commonplace that children should learn to understand the use of globes, maps . . . to help them build up their picture of how people live in their own environment and in distant and different environments (p. 167), " and a system of teaching map reading skills is therefore provided. Included in the general outline of training in the use of geographic tools is the use of colour to represent elevation at the fourth year level, and reading of physical maps is re-emphasized in subsequent years. It is noted also that it is "almost as complicated an undertaking to teach a child to read a map as it is to teach him how to read a book (p. 169.)" Difficulties encountered by children in learning to read maps, and in achieving the degree of proficiency outlined by Kohn, may often be connected with colour vision deficiencies. For instance, his fifth ability, that of seeing the realities for which symbols stand, often requires differentiation between two or more colours. Numerous wall maps, atlases, and textbooks such as Canada and Her Neighbours and Dent's Canadian School Atlas employ colours symbolically. Topics such as world religions, elevations, or crop production are often expressed through colour differences on maps. Again, the ability to compare maps and make inferences from them is affected by dependence on colour recognition because colours are used in symbols. Colour is also used extensively to depict differences in physical features.

It is my contention that the differences experienced among children in ability to recognize colours might affect their ability to interpret maps utilizing colour for communicative purposes. Unwittingly map designers and teachers may be doing the colour vision handicapped child a disservice because of the heavy dependence on the use of colour in both map construction and in teaching map reading skills, especially when there is an ever increasing reliance on visual media such as films, filmstrips, transparencies and colour television. The present study is an attempt to discover whether or not children with colour vision defects do perform more poorly in reading coloured maps than children with normal vision.

CHAPTER II

REVIEW OF RELEVANT LITERATURE

Research on map reading in elementary schools has devolved around three chief areas of investigation: children's ability to read maps; construction of map reading curricula; and instruction in map reading. No research on any aspect of the use of coloured maps in education has apparently been reported. Coloured maps have, no doubt, figured in many research projects, but their peculiar merits in instruction and children's ability to read them has escaped specific investigation. The present study includes a review of literature in four areas of map study in education, and also relevant colour vision research.

Since colour blindness is much more common among boys than girls, a survey of the effect of sex differences on map reading abilities will be included in the review. Two other review areas will be children's ability to interpret map symbols and legends because these are often in colour, are the ability to make inferences from maps which also are frequently coloured. Finally, a survey of the recommended grade placement of specific map reading skills will be included with a view to construction of a test appropriate to grades five, six and seven.

Sex Differences in Map Reading

Research reviewed indicates a common pattern in the relative map reading abilities of boys and girls throughout the intermediate grades. Evidence shows that girls have superior skill initially, and then with the approach of adolescence, boys develop greater facility than girls.

A study conducted by the Training College Group Committee of the Geographic Association (1941) in Britain revealed that boys, after the

age of twelve and a half, were more capable than girls in evaluating evidence which enabled them to discover which of four maps corresponded with a given picture. Brown (1960) found that boys over eleven years achieved better results than girls at all cognitive levels when reading such commonly used material as Ordnance Survey Maps, Philip's Pictorial Atlas, and Philip's Modern School Atlas. His conclusions were based on the results of tests administered to one thousand pupils in Britain.

Gengler (1967) found that boys in the sixth grade were more capable than girls in applying the terminology of geography to the symbolism of atlas maps. These pupils were asked to identify map representations when each geographic term was announced. Again, Weber's (1965) study showed that sixth grade boys demonstrate superior ability to that of girls when extrapolating possible natural influences on man from mapped information.

Both the Training College Group Committee of the Geographic Association (1941) and Brown (1960) found that girls displayed superior map reading skills at the comprehension level during the first years of exposure to map work. Arnsdorf (1964) found no superiority in either sex at the fifth grade level in ability to read maps at all cognitive levels. If, then, intermediate aged girls are initially more capable map readers than boys, and the latter supersede them in subsequent years, reasons for such a change are open to question. Boys mature rapidly during the later intermediate grades, and so they begin to approach the mental capacities of girls at this age. Improved performance is usually evident in most academic subjects.

Such a phenomenon probably affects capabilities in map reading so that by the seventh grade boys develop superior skill. Another factor affecting capabilities of boys, although not revealed in research, might be increased interest in map work, and, hence, greater incidence of working with maps. Waddington (1965) however, in her study of colour blind children noted that they "become adept at waiting and copying what other people do, or avoiding undertakings that require choice of colour. As they become increasingly able to discriminate between shades that they can see, they learn to cover up their difficulties socially and work very hard not to make mistakes." (p.29) If her observation is true, it is possible that boys, among whom colour blindness is more common than girls, might be disadvantaged in the first stages of map reading. Compensation, in the manner suggested by Waddington could occur later, and might have some effect on the trend found in reading capabilities of boys and girls.

Reading of Map Symbols

The ability to manipulate the information given in legends is essential to the understanding of maps, and the meaning of the symbols used must be clear in the child's mind if he is to make valuable use of them in map translation. Children's knowledge of symbols commonly used on maps has been researched, although no reports have specifically investigated understanding and manipulation of colour symbolism despite wide use of the technique among map designers. A survey of almost any intermediate grade geography text book or atlas will reveal coloured legends used for a multiplicity of purposes such as annual rainfall,

manufacturing areas, or physical features.

Among researchers there exists no unanimity of findings on the ability of children to read map symbols, although a growth in the skill becomes evident in successive intermediate grades. Zimmer (1967) and Hahn (1936) both reported that misinterpretation of map legends was common among school children. The former found that map operations requiring more advanced mental processes were frustrated by insufficient use of map legends and lack of skill in reading them accurately. Hahn concluded that failure in map assignments and tests was, in part, a result of insufficient knowledge of the legend function, and also lack of dependence on it for map interpretation.

Gengler (1967) reported that children's knowledge of some map symbols was greater than others. Few children, for example, were able to identify a cape, while a lake was the most translatable symbol. Hahn (1936), Howe (1931), Zimmer (1967), and Durkee (1953) agreed that both children's knowledge of map symbols, and their ability to translate keys accurately, improves throughout the intermediate grades. This permits such map instruction as appeals to the more complex cognitive abilities in the upper intermediate grades.

The importance of the map as a teaching tool was revealed by Davis and Hunkens (1968), in comparing a group of students who scored significantly higher on a test comprising a reading assignment accompanied by a map with another group exposed to a narrative only. Again, McAulay (1964) found that children who studied a unit of geography emphasizing map work scored significantly higher on a test than their peers who had

studied the same unit without special reliance on map work. However, as previously shown, successful map work really depends on accurate reading of legends and symbols, which are frequently shown in colour. It follows that inaccurate colour perception, as experienced by colour blind students, could restrict achievement in map reading through faulty translation of the key.

Children's Ability to Make Inferences from Maps

Just as understanding of a map legend often depends on a clear conception of colour, so is the ability to make inferences from maps which frequently convey facts through differences in colour. While such a means of representation is both attractive and effective, the motivational appeal and superiority of the technique over other means of representation has not been examined empirically. For the colour blind pupil coloured maps might in fact hinder map reading. This could be the case when comparison between colour variations on maps or between two or more maps must be made. There is some indication in research that children's ability to make inferences from maps is generally unsatisfactory, but that instruction increases the ability to perform well.

The essence of Weber's (1965) study was to determine the capabilities of sixth grade pupils to extrapolate the natural environment's influence on man from information on maps. The researcher reported that his sample was capable of making predictions just above the level of specifics but without elaboration. Zimmer (1967) reported a similar finding in her study which was designed to detect map reading deficiencies.

in elementary school children. She found a particular weakness in the ability to correlate and synthesize conclusions from several maps.

Problem solving behaviour in map work can be modified to become more effective through a careful selection of teaching strategies as was revealed by the research of Possien (1965) and Sorensen (1936). The former found that an inductive approach to map work requiring higher cognitive thinking was superior to two other teaching approaches in the development of effective problem solving behaviour. Sorensen found that after instruction emphasizing connections between related maps, children developed the capacity to think in terms of relationships rather than specifics. His conclusions were based on the quality of pupils' questions before and after the training.

Research evidence suggests, then, that children have difficulty making inferences from maps, but that certain teaching methods enhance their ability. The present map reading weakness might well be a fault of instructional techniques. The effect of varying quality of maps, and their impact as a communication medium, has not, however, figured in reasearch into children's higher-level cognitive behaviour. Heavy reliance on colour in maps as a means of presenting data might generally have a meritorious effect on ability to make inferences, but if the child has difficulty distinguishing between shades used on maps, the reverse could be true.

The Grade Placement of Map Reading Skills

Many researchers have conducted studies to determine the optimum student age at which to teach specific map reading skills, and others

have developed sequential curricula based on their own, as well as other's, findings. A number of studies have provided a basis for considerable agreement concerning appropriate levels at which to introduce the skills, and workable curricula have evolved. British Columbia's sequence of teaching map reading skills is similar in content and grade placement to those devised through empirical research

The three stages of mapping activities described by Davies (1962) follow a pattern of increasing difficulty paralleling the child's maturity. He suggested that curricula should be organized into the following three steps:

1. three-dimensional representation of abstract symbols.
2. reading and interpreting maps.
3. comparison of maps and making inferences from them.

The two latter steps are those which research indicates should be taught in the intermediate grades.

The fourth grade appears to be the appropriate stage for introducing the two-dimensional map and for beginning instruction on map symbols. Formal map reading utilizing those symbols should also be commenced. Young (1964) found that an appreciation of maps does not develop before the age of nine, or the grade four level. The younger child's view of them is that they show only water, land, and named locations. Casper (1961) reported that fourth grade pupils are capable of understanding the function of map keys, at the same time reading them in order to trace routes on maps. Thorp (1933) in an earlier study, reached similar conclusions and added the location of places and the incidental teaching of latitude to the list of skills. The concept of hemispheric division of the world, recognition of the same

areas on the globe and maps, and the estimation of directions are other skills recommended by Whipple (1959) for inclusion in the grade four curriculum.

Investigators generally recommend the teaching of more complex map reading skills in the fifth and sixth grades. Sorohon (1963) and Thralls (1958) found that grade six was the most suitable level for teaching of latitude and longitude in detail. Chace (1955) identified this age group as appropriate for beginning to interpret different map types such as political, weather, and relief, and also for interpreting map scales. Casper (1961) found that scale, relief, and contours should be taught in the fifth and sixth grades, and Anderzhon (1954), Brown (1960), and Towler and Nelson (1968) made a similar recommendation concerning the teaching of scale. Both the Training College Group Committee of the Geographic Association (1941) and Brown (1960) suggest that the concept of contour lines should be introduced during grade five.

In the seventh grade the skills taught in the previous intermediate grades are utilized for reading a variety of map types and for extrapolating information presented on them. Refinement of knowledge assimilated in previous grades should be emphasized. Sorohon (1963) recommended that this grade be taught the use of special maps such as weather maps. His findings are substantiated by Anderzhon (1961) who suggested instruction in maps showing spatial arrangement of phenomena. She also noted that instruction on contour maps should be reviewed in grade seven, and Sorohon recommended continued teaching in the use of latitude and longitude. Casper (1961) agreed that skills involving scale, latitude and longitude, and contour maps should be taught and re-emphasized in the upper intermediate grades.

Experts tend to place the initial systematic map reading programme at the grade four level. However, some research has investigated and found encouraging results in a primary map reading programme which includes the teaching of some specific skills at that level. Rushdoony (1961), for example, found that grade three children could benefit from an instructional programme emphasizing the introduction and development of map skills normally taught in grades four and five. McAulay (1962) reported that children as young as seven years were able to make judgments and comparisons from simple pictorial maps. British Columbia does not yet implement formal map reading studies at the primary level, and there appears generally to be some tendency to load grade four to capacity. In grade four are included such a wide variety of activities as reading legends, locating places, and determining directions. Possibly some of these elementary concepts could be included in the third grade curriculum.

This review of research on the grade placement of map reading skills revealed three levels in the gradation of instruction in the elementary grades. The first level develops map reading readiness by methods suited to primary grade learning patterns. Activities include three-dimensional representation of certain features of the immediate community and the reading of picture maps. Differences in size, shape, and relative quantitative expressions are also taught.

At the second level, formal teaching and drill of lower cognitive skills commences. Chiefly in grade four, but also in the succeeding intermediate grades, the child is taught skills like reading map keys, estimating elevation, using latitude and longitude, and estimating distances.

The third level emphasizes the drawing of inferences from maps. Such topics as reasons for differences in areal population distribution or the effects of rainfall on man's activities might be considered. Thus, the child learns to apply those skills acquired in previous levels.

Research on Colour Vision in Education

Mary Waddington (1965) in the summary of her investigation into colour blindness in your children quotes Charles Osgood as saying the field of enquiry into colour vision is "still a happy hunting ground," and she further states that "any success in it would make colour blind children happier (p. 204)." Indeed, an examination of available literature on colour vision defects indicates very limited research in areas pertaining to education.

The nature of studies of colour vision among school children is chiefly to devise tests to identify weaknesses which teachers can quickly and accurately administer, and to assess the numbers of children with defective colour vision. Bovee (1966) developed a coloured yarn sorting test, the results of which were checked using the Ishihara colour plates. He found this test to be insufficiently reliable, yet he did discover colour vision defectiveness among 6% of the boys tested. Waddington was more successful in devising a test which included the copying of colours and crayoning. She found children in special schools, such as those for the deaf and physically handicapped to have a higher instance of defective colour vision than children in public schools. For example, among children with hearing defects she found 9% of the boys to be colour blind. Schein and Salvia (1969) reported that three colour vision studies among mentally retarded children revealed an instance of colour blindness in excess of the normal population.

Brown (1952), like Bovee, found 6% of the boys he tested to have defects, and he discerned no significant difference in the degree of defect among adults and children affected. This indicated that the weakness does not become more acute with age. Post's (1963) survey, however, among British students produced an incidence of over 8% colour blindness among males, and Kherumian and Pickford (1963) substantiate these findings.

A search of the literature reveals few studies on the relationship between colour vision and academic achievement. Waddington's (1965) research revealed no correlation between colour blindness and low achievement in mechanical arithmetic, arithmetic problem-solving, or spelling. The first of a two part study on the effect of colour vision defects on the learning of the child in the first years of school was reported by Lampe (1969). A method of identifying such cases was described, and a method of correlating known colour deficient cases with the learning process was still progressing at the time of reporting. According to Gage (1963), "No really definitive studies have been made on specific ways in which colour may contribute to learning from instructional media (p. 28)." He cites the experiments of May and Lumsdaine (1958) on the relative merits of coloured and black and white films. These studies failed to show significant differences in learning in favour of the coloured films.

If colour vision does significantly affect map reading achievement, the numbers of students so affected are considerable, and, according to Post (1963), on the increase. As noted previously, there is some disagreement as to the incidence of colour blindness, but most articles and books dealing with the topic cite about six to eight percent of males to be affected. Further, Post's investigation into the incidence

of male colour blindness in various civilizations of the world revealed a much higher proportion of colour vision defects in technically advanced societies than in underdeveloped civilizations. Among Aborigines, for example, only nineteen out of every thousand males were found to be affected, while in Britain the number was eighty-eight out of every thousand. This finding is borne out by Kherumian and Pickford (1963) where as many as eleven percent of Canadian males have been found colour blind as against only slightly more than one percent of Navajo Indian males. Post suggests that the higher numbers in the more technically advanced societies is a result of the decreasing necessity to have acute colour vision, while among many primitive societies, such as the Aborigines, hunting is still a means of livelihood, and even today the least successful hunter may die. Males with poor colour vision were and are the less successful hunters. Thus, as our technical knowledge advances, and if Post's contention is correct, it becomes obvious that the instance of male colour deficiency is increasing, and if the hypotheses of this study are proven correct, possibly some provision for the colour vision defective should be made to allow greater ease in map reading.

After her involvement in testing the colour vision of more than eight thousand children, Waddington (1965) noted anxiety among those with weaknesses. They were hesitant, for example, in selecting a crayon of a specified colour, and developed an adeptness at waiting and copying others in colour selection. She believes that most affected children are aware that they see colours differently from the normal child and because of fear of ridicule are successful in hiding it. She notes also that

schools are full of colour devices such as Cuisenaire rods, beads, and coloured maps, and the use of these materials, designed for the child with normal vision, must baffle the colour blind counterpart. Bovee (1966) feels that the identification of colour blindness is of importance for the well-being of the child. He notes the emphasis on colour vision normality in the design of educational tools, and believes many children with defective colour vision experience unfair reprimands for failing to follow instructions when use of colour is called for.

CHAPTER III

METHOD OF THE STUDY

The Sample

The pupils in grades five, six, and seven at Bank Street, Margaret Jenkins, and George Jay elementary schools in Victoria were screened with the Ishihara colour plates for colour blindness by the school nurse. A total of twenty-seven pupils with weaknesses were identified. These children constituted the experimental group of the study. The members of the control group were matched with those in the experimental group on the basis of intelligence, sex, and membership in the same classroom. For example, if a boy in a given class was found to have a colour vision defect, then a matching boy from that same class, having comparable intelligence, yet with normal colour vision, was selected as a control group member.

Selection and Description of the Black and White Map Reading Test

The selection of a black and white map reading test followed a review of the research into elementary grade map reading skills. The suggested grade placement by authorities of specific skills, and their appearance in the British Columbia Programme of Studies were considered in the selection of the test. The chosen test, the map reading section of the Canadian Tests of Basic Skills, differentiates between the ability to read maps and knowledge of real places, since maps of imaginary places are used.

The Canadian Tests of Basic Skills was developed from the extensive work in test construction at the University of Iowa. All reported findings in the several editions of the Iowa Every-pupil Tests of Basic Skills

were utilized in its construction and during preparation detailed classification according to function and degree of complexity were made of maps appearing in text books. Such classification helped to determine the characteristics of the map reading items.

The Canadian Tests of Basic Skills was standardized on a sample of English speaking schools throughout the country. For each grade level a sample of about 4500 pupils was used and represented all socio-economic groups. The reliability for the test is .76 for grade five, .75 for grade six, and .81 for grade seven. No numerical index of validity is reported. The test was published in 1968 by Thomas Nelson (Canada) Limited. Most pages in the spiral bound book contain only one map with directions and questions on that map. Separate answer sheets were provided.

Adaptation of the time limit was necessary for the present study since items twelve to forty-seven (inclusive) were administered to the sample. Forty-five minutes was allowed for the completion of the test. Further, standardized norms were not utilized in the present study since comparison in achievement was sought between the control and experimental groups only.

Description of the Coloured Map Reading Test

Enquiry and review of literature revealed that no standardized map test involving the use of colour in map reading skills was available. It was necessary, therefore, to devise an instrument, that included in the Appendix, to test if colour blind children read coloured maps more poorly than their peers with normal colour vision.

During the administration of this test care was taken to seat the pupils in random order to ensure that neither group's performance would be affected by variation in light patterns on the screen.

The following steps were taken in the construction of the test:

1. A review of the British Columbia Programme of Studies, textbooks, and reference books was made to determine those map reading skills to which intermediate grade pupils are commonly exposed. A wide variety of map reading activities which depend on ability to differentiate between colours was suggested. The skills, including the ability to recognize and express relative locations, the ability to read symbols and look for realities, and the ability to correlate patterns and make inferences are dependent upon ability at a variety of cognitive levels.
2. A total of sixty-two test items was prepared for the initial test.
3. The initial test was administered to 120 intermediate grade pupils at Bank Street School. Coloured map transparencies to accompany the items were projected onto a screen. Answers were recorded on separate answer sheets. This procedure was adopted because the printing of a coloured map test is prohibitively expensive.
4. The answer sheets were machine marked and response proportions, test score means, biserial correlations, and the item difficulty for each item were provided. A Kuder-Richardson-20 reliability of .88 was found.
5. Appropriate item revisions were made and the final draft of the test contained forty-one items.

Hypotheses

1. The pupils with colour vision defects will score significantly lower marks than the pupils with normal vision on a coloured map reading test.
2. There will be no significant difference between the scores of pupils with defective colour vision and those of students with normal colour vision on a black and white map reading test.

Testing the Hypotheses

The Wilcoxon matched-pairs signed-ranks test was used to test both hypotheses.

Definition of Terms

The term map-reading skills refers to the following:

1. estimating directions.
2. locating places on a map or globe.
3. measuring distances.
4. visualizing landscape features.
5. interpreting and comparing map symbols.
6. inferring man's activities from mapped data.

The term intelligence refers to the last recorded intelligence quotient recorded on permanent record cards.

The term control group refers to that group of intermediate grade pupils with normal colour vision selected on a basis of matched pairs with those students comprising the experimental group. Matching criteria were equivalent or nearly equivalent intelligence, sex, and membership in the same classroom.

The term experimental group refers to those intermediate school age pupils who made two or more errors in reading the Ishihara Test of colour vision.

The terms colour vision defect and colour blindness refer to the inability to detect colour differences which can be distinguished readily by the observer with normal vision.

The term Ishihara Test refers to a series of cards on which a variegated pattern of coloured dots is printed to form a figure or letter of one colour outlined against a background of a different colour. The observer with normal colour vision can generally distinguish the

figure with ease, while the colour blind observer may either fail to see any figure or see a different one. The success of the test depends on the proper choice of colours and their arrangement in the pattern.

CHAPTER IV
RESULTS AND CONCLUSIONS

Results

Pupils with colour vision defects in grades five, six, and seven were identified in three Victoria schools. These individuals were matched for intelligence and classroom membership with their peers having normal colour vision. The study was designed to compare the achievement of pupils with colour vision defects in both coloured map reading and black and white map reading.

Table 1 lists the scores of the experimental (colour blind) and control (normal) groups on the forty-seven item black and white map reading test and the results of the Wilcoxon Matched-pair Signed-rank Test. No significant difference was found to exist between the groups in the accuracy of reading black and white maps. The mean mark for the experimental group, as shown in table 3, was 21.70 and for the control group the mean was 22.89. Accuracy in the discrimination between colours, then, would appear to have no effect on ability to read black and white maps.

Table 2 lists the scores of the experimental and control groups on the forty-one item coloured map reading test and the results of the Wilcoxon Matched-pairs Signed-rank Test. The control group scored significantly higher than the experimental group, at the .01 level. The mean mark for the experimental group, as shown in Table 3, was 18.88 and for the control group the mean was 23.44. The degree of accuracy in the discrimination between colours, then, would appear to have an effect on the ability to read coloured maps.

TABLE 1

Scores of Matched-Pairs on the Black and White Map Reading Test and
Results of the Wilcoxon Matched-Pairs Signed-Ranks Test

| Matched Pair | Experimental Group | Control Group | Difference | Rank of Difference | Rank of Smaller Sum |
|-----------------|-----------------------|------------------|------------|-----------------------|------------------------|
| A | 28 | 32 | -4 | -9.5 | |
| B | 23 | 30 | -7 | -16 | |
| C | 23 | 27 | -4 | -9.5 | |
| D | 29 | 33 | -4 | -9.5 | |
| E | 27 | 16 | 11 | 22 | 22 |
| F | 36 | 21 | 15 | 23.5 | 23.5 |
| G | 21 | 23 | -2 | -6 | |
| H | 28 | 18 | 10 | 21 | 21 |
| I | 24 | 24 | | | |
| J | 16 | 19 | -3 | -7 | |
| K | 21 | 22 | -1 | -3 | |
| L | 33 | 32 | 1 | 3 | 3 |
| M | 25 | 17 | 8 | 18.5 | 18.5 |
| N | 15 | 15 | | | |
| O | 14 | 32 | -18 | -25 | |
| P | 22 | 31 | -9 | -20 | |
| Q | 13 | 14 | -1 | -3 | |
| R | 22 | 17 | 5 | 13 | 13 |
| S | 21 | 22 | -1 | -3 | |
| T | 26 | 19 | 7 | 16 | 16 |
| U | 21 | 26 | -5 | -13 | |
| V | 26 | 25 | 1 | 3 | 3 |
| W | 25 | 33 | -8 | -18.5 | |
| X | 12 | 27 | -15 | -23.5 | |
| Y | 14 | 10 | 4 | 9.5 | 9.5 |
| Z | 11 | 18 | -7 | -16 | |
| AA | 10 | 15 | -5 | -13 | |
| | | | | | T=129.5 |

 $\alpha .05$

T < 90

TABLE 2

Scores of Matched-Pairs on the Coloured Map Reading Test and Results of the Wilcoxon Matched-Pairs Signed-Ranks Test

| Matched-Pair | Experimental Group | Control Group | Difference | Rank of Difference | Rank with Smaller Sum |
|--------------|--------------------|---------------|------------|--------------------|-----------------------|
| A | 30 | 31 | -1 | -2.5 | |
| B | 26 | 30 | -4 | -10 | |
| C | 26 | 24 | 2 | 6 | 6 |
| D | 26 | 26 | | | |
| E | 35 | 19 | 6 | 13 | 13 |
| F | 24 | 22 | 2 | 6 | 6 |
| G | 22 | 23 | -1 | -2.5 | |
| H | 21 | 27 | -6 | -13 | |
| I | 21 | 28 | -7 | -16.5 | |
| J | 17 | 24 | -7 | -16.5 | |
| K | 20 | 27 | -7 | -16.5 | |
| L | 20 | 28 | -8 | -20 | |
| M | 19 | 21 | -2 | -6 | |
| N | 19 | 23 | -4 | -10 | |
| O | 19 | 33 | -14 | -23 | |
| P | 19 | 27 | -8 | -20 | |
| Q | 18 | 14 | 4 | 10 | 10 |
| R | 17 | 18 | -1 | -2.5 | |
| S | 17 | 24 | -7 | -16.5 | |
| T | 17 | 23 | -6 | -13 | |
| U | 16 | 17 | -1 | -2.5 | |
| V | 14 | 29 | -15 | -24 | |
| W | 14 | 30 | -16 | -25 | |
| X | 13 | 21 | -8 | -20 | |
| Y | 11 | 11 | | | |
| Z | 11 | 14 | -3 | -8 | |
| AA | 8 | 19 | -11 | -22 | |
| | | | | | T = 35 |

 $\alpha .01$

T < 69

TABLE 3

Mean Marks and Standard Deviations of the Control Group and Experimental Group on the Black and White and Coloured Map Reading Tests

| Test | Group | \bar{X} | S |
|-----------------|--------------|-----------|------|
| Black and white | Experimental | 21.70 | 5.93 |
| Black and white | Control | 22.89 | 5.63 |
| Coloured | Experimental | 18.88 | 5.48 |
| Coloured | Control | 23.44 | 4.74 |

Limitations

In the present study no attempt was made in the selection of the sample to include pupils representative of particular socio-economic or ethnic groups. Neither was it composed of pupils of a specified level of intelligence. The sample was drawn from three schools in Victoria from lower and middle class socio-economic districts, but no enquiry was made into the status of individuals chosen for the study. Therefore, in view of the possible lack of representativeness of the sample used in this study application of the results to the school population as a whole should be made with caution.

Application of the results of this study should also take into account the limitations of the Wilcoxon Matched-pairs Signed-ranks Test. When ties are numerous the Wilcoxon Test loses power and fails to detect real differences. In the present study there were, however, only two sets of ties in each test.

Educational Implications

The present study produces evidence indicating that colour blind children experience more difficulty than children with normal vision in reading coloured maps, but not in reading black and white maps. Studies by Waddington (1965), Bovee (1966), and Brown (1952) indicate that the numbers so affected are about six percent to eight percent. This would indicate that in the normal intermediate class in Victoria one would expect to find about two colour blind pupils. Testing for colour vision defects is not a routine aspect of the school district's health service in Victoria, and teachers are normally not aware of those pupils having

colour vision defects. The nurse who conducted the colour vision examination for this study contacted the parents of the handicapped pupils and found that in twenty-four of the twenty-seven cases the parents were unaware of the defect. In two cases both the children and parents knew of the defect, and in the last case, the parents only were aware. This would seem to indicate that colour vision defects are not readily apparent. Therefore, it might be advisable to include a colour vision test among routine school health services.

The examiner noted increased restlessness during the administration of the coloured map reading test, a phenomena which Waddington (1965) also noted when she required colour blind children to work with colours. Further, the school nurse, when administering the Ishihara colour vision tests for the present study, noted an atmosphere of subdued disquietude manifested by assumed nonchalance among many of the handicapped pupils. Colour blind children may experience some stress as a result of their condition. Children who normally perform well in school subjects may be frustrated by inadequate perception of maps; teachers might blame them for an unsatisfactory attitude; because of unrecognized limitations, assignment results might be unfair to the colour blind child. Teachers should at least be made aware of the colour blind pupils in their charge if they are to make adequate adjustments in providing for individual differences.

The value of the coloured map as opposed to the black and white as a teaching aid in social studies has apparently escaped direct investigation. Educators, as cited by Dunsenbery (1964), have recommended wide use of coloured maps in textbooks and reference books, and such suggestions

have been implemented by publishers so that today maps are colourful and aesthetically appealing. Their worth, however, should be investigated empirically to ascertain their superiority, if any, over black and white maps as aids to effective learning processes.

At the intermediate level, extensive use is made of colour differentiation for points of emphasis on teaching charts. Arithmetic text illustrations and equipment are colour-coded to distinguish between categories such as numerical place value, or to emphasize certain factual information. Earlier, primary children are asked to colour objects in specific shades, to determine how many coloured objects they see in pictures, or to group objects by colours. Effects on both the learning and personality of colour blind children resulting from such format and exercises should be investigated further.

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APPENDIX

Coloured Map Reading Test

COLOURED MAP READING TEST

DIRECTIONS

This is a test to show how well you can read coloured maps. Maps will be shown on the screen and you will be told which question or questions to answer on each map. For each item, select the LETTER of the answer which best completes the statement. Blacken the corresponding space on the separate answer sheet. Completely fill the area between the pair of lines. If you change your mind, erase your first mark COMPLETELY.

SAMPLE O

Dairy farming is carried on near

- A New Westminster
- B Kamloops
- C Penticton
- D Prince George

SAMPLE OO

Medicine Hat probably sells

- A coal
 - B gas
 - C oil
 - D salt
 - E sodium sulphate
-

1. The wettest climate would occur near number
 - A 1
 - B 2
 - C 3
 - D 4

2. The most heavily populated area is near number
 - A 1
 - B 2
 - C 3
 - D 4

3. Bananas would grow best near
 - A 1
 - B 2
 - C 3
 - D 4

4. The hottest of the four cities marked on the map is
 - A Alice Springs
 - B Brisbane
 - C Perth
 - D Melbourne

5. The coolest city in July is
 - A Astoria
 - B Guatemal City
 - C New York
 - D Miami

6. The range of temperatures shown for Canada is
 - A under 32 to 60
 - B 60 to over 72
 - C 32 to over 72
 - D 32 to 60

7. The average July temperature for the part of South America shown would be
 - A under 32
 - B 32 to 60
 - C 60 to 72
 - D over 72

8. The city having about the same amount of rainfall as Astoria in July is
 - A Guatemala City
 - B Miami
 - C New York
 - D Salt Lake City

9. The hottest and wettest city in July is
 - A Mexico City
 - B Guatemala City
 - C New York
 - D Salt Lake City

10. The colour of the zone in which most homes is located is
 - A red
 - B yellow
 - C green
 - D grey

11. Most of the waterfront is used for
 - A housing and commerce
 - B industry and housing
 - C parks and commerce
 - D industry and parks

12. In what areas are most of the important buildings found?
 - A Built-up
 - B Commercial
 - C Industrial
 - D Parks

13. A paint factory would most likely be located in the zone coloured
 - A red
 - B yellow
 - C green
 - D grey

14. In what type of area are the railroads found?

- A built-up
- B commercial
- C industrial
- D parks

15. The population per square mile at point "X" is

- A under 2
- B 2-30
- C 60-125
- D 125-250

16. The least manufacturing would be located in areas coloured

- A lightest yellow
- B pink
- C red
- D black

17. The climate at point "X" is

- A hot and very wet
- B hot and wet
- C subtropical and wet
- D Subtropical and dry

18. The heaviest growth of trees is found in the area numbered

- A 1
- B 2
- C 3
- D 4

19. The heaviest population is found near area numbered

- A 1
 - B 2
 - C 3
 - D 4
-

20. The smallest property owner is

- A Nova Scotia Pulp Limited
- B Nova Scotia Power Commission
- C Canadian General Electric Co. Ltd.
- D Gulf Oil Co. Ltd.

21. Pulp would most likely be shipped from wharf number

- A 1
- B 2
- C 3
- D 4

22. The industry located in the heaviest area of black dots would most likely be

- A pulp milling
 - B electricity generating
 - C refrigerator manufacturing
 - D oil refining
-

23. The poorest area for farming is near number

- A 1
- B 2
- C 3
- D 4

24. Vancouver Island is located in a region of

- A lowlands
- B plains
- C uplands and plateaus
- D mountains

25. The most commonly found landform in Canada is

- A lowlands
- B plains
- C uplands and plateaus
- D mountains

26. A ski resort would most likely be found near number
- A 1
 - B 2
 - C 3
 - D 5
27. Large quantities of wheat are grown in the region coloured
- A green
 - B yellow
 - C orange
 - D brown
-
28. Most of the farmland of the province numbered 2 is
- A mixed farming
 - B wheat farming
 - C ranching
 - D dairying
29. How many zones of dairying are shown on the map?
- A one
 - B two
 - C three
 - D four
30. The type of farming carried on in the province numbered 1 is
- A mixed farming
 - B wheat farming
 - C ranching
 - D dairying
31. All of the following are important industries in the province numbered 4 EXCEPT
- A ice-cream manufacturing
 - B chicken raising
 - C leather manufacturing
 - D flour milling
-
32. Land bordering the St. Lawrence River is used mainly for
- A grazing
 - B feed grains and livestock
 - C dairying
 - D mixed farming
33. An industry of the Annapolis Valley would be
- A manufacture of paper
 - B fruit canning
 - C flour milling
 - D meat packing
34. Newfoundland produces large quantities of
- A paper
 - B fruit
 - C flour
 - D meat
-
35. In 1713 the land around Hudson Bay belonged to
- A France
 - B Britain
 - C Spain
 - D not shown
36. In 1713 British Columbia belonged to
- A France
 - B Britain
 - C Spain
 - D not shown
37. The country with land farthest west was
- A France
 - B Britain
 - C Spain
 - D not shown

38. The Great Lakes area belonged to

- A France
 - B Britain
 - C Spain
 - D not shown
-

39. Most of the land between the Canadian Shield and Lake Ontario is used for

- A fruit farming
- B tobacco growing
- C market gardening
- D dairying

40. Tobacco is grown

- A along the north shore of Lake Ontario
- B north of Lake Erie
- C east of the Canadian Shield
- D near Holland Marsh

41. All of the following types of agriculture are found bordering the corn belt EXCEPT

- A mixed farming
- B dairying
- C fruit growing
- D market gardening

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