USING THE SCIENTIFIC METHOD TO SOLVE GEOGRAPHIC PROBLEMS*

HERBERT G. KARIEL
California State College at Hayward

Able teachers seek to improve their teaching, and to get children intrigued about the topics they are studying. With the overwhelmingly rapid rate at which new knowledge is accumulating today, however, it is difficult for most classroom teachers to keep up with the pace. Specialists in various academic disciplines have therefore recently been working with teachers to develop new curricula which would include many of the new ideas. The new physics, mathematics and biology curricula are all evidences of this trend. They share another factor: emphasis on learning through discovery. In place of memorizing many facts and laws, students are encouraged to develop their own generalizations and to view science as on-going and constantly developing, not as static and complete.

Many teachers know little about similar developments which have been occurring in geography as well as in other social sciences. Increasing emphasis is being laid upon the development of generalizations and the understanding of observations made about the world. In geography, for example, emphasis is shifting from the memorization of facts about the names of cities, mountain ranges and rivers to the understanding of principles underlying the location of various physical and cultural features, and the relationships between them.

Experienced teachers are often helped to learn about these developments through in-service training, workshops and summer courses. Prospective teachers may also learn about them, and practice the newer approaches so that they may later apply them in their own classrooms. Students who participated in the projects reported here have had this opportunity, and have found that elementary school pupils enjoy discovering the principles of location of cities, for example, and working out the possible locations for major cities from general knowledge of the area.

Underlying this approach is the trend in geography as a social science toward increasing use of scientific method. Although most teachers are familiar with the scientific method as it applies to the natural sciences, few of them have learned to apply it to the social sciences such as geography, sociology or economics. A brief review of the major points involved may serve as a basis for discussing the projects which students carried out in learning to apply the scientific method to the study of a geographic problem.

WHAT IS THE SCIENTIFIC APPROACH?

The "game of science" begins with the scientist's asking questions about a particular phenomenon which he has observed. He wishes to find out *how* it behaves and *why*, in the sense of determining relationships between it and other phenomena. In thinking about possible explanations, he

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attempts to discern patterns of regularity among his observations, drawing upon existing knowledge and theory. He formulates a series of "hunches" or "educated guesses" which, when formalized as proposed statements of regularity, are termed hypotheses. He constantly works back and forth between theory and observation, testing his guesses, re-formulating them and re-testing them in the light of new observations. When necessary, he revises theories to fit newly discovered facts or laws.

Application of the Scientific Approach to the Study of Geography

The study of geography is often purely descriptive; students are taught the content of different areas on the earth, or *what* is found *where*. Emphasis is placed upon the ways in which areas differ from each other; that is, upon the unique features of each area. As early as the 1840's, however, von Humboldt and Ritter suggested that the task of geographers was not simply to describe and map the face of the earth, but to go beyond this collecting of facts to search for laws which would explain or account for the distribution of phenomena on the earth's surface. In so doing, they stressed the importance of recognizing the relationships which existed among the spatial distributions of various phenomena.

Similarly, many contemporary geographers believe that it is essential to go beyond the cataloguing and mapping of their observations, and attempt to explain how and why various phenomena are located. Viewed in this light, geography is the science which studies the location and distribution of phenomena on the face of the earth. Geographers study different kinds of phenomena: physical, social, economic and political. Their concern is with the distribution of these phenomena. They are interested in the phenomena themselves only to the extent that such knowledge is needed for explanation of their distribution. For example, geographers study the location of industry. They are concerned with the process of making shoes or steel only to the extent that this knowledge is essential for explaining the location of shoe factories or steel mills. It is important for them to know that the raw materials for the making of steel are heavy, so that steel mills may be located relatively close to the sources of raw materials, and that cheap transportation would be a highly desirable factor. Since the raw materials for making shoes are lighter in relation to the cost of the finished product, closeness to the sources of raw materials would be less important to shoe manufacturers seeking a plant location.

Geographers who use the scientific approach are not interested in listing or cataloguing the content of individual areas or regions, nor do they attempt to explain any occurrence in isolation. For example, they do not try to explain why Boston or Chicago is located where it is. Instead, by observing many major cities, they seek to find a number of factors which may be related to their locations, such as transportation, communication, and the presence of industry. Relationships which are found between the spatial distribution of any of these phenomena and the actual location of major cities provide the basis for making generalizations about the location of cities. These generalizations may then be used to predict locations in which one would expect to find major cities. The predictions are tested empirically to find out whether cities are actually located where one would expect to find them if these generalizations were valid.

A Specific Example

A social education class provided the author with the opportunity to present future teachers with some of these geographic concepts. Throughout the course, two parallel objectives were borne in mind: 1) presentation of the scientific approach to geographic study and 2) application of this approach in public school classrooms. Material was presented on a college level, in keeping with the age and maturity of the students. At the same time, examples were given to show how this new approach could be used in teaching children.

As a term project, students applied their new knowledge to the analysis of a specific problem. The area and the general topic to be studied were selected by the instructor, as would usually be the case in a public school. The area chosen was the State of Washington, since most of the students lived and expected to teach there. The general topic to be studied there was population. When the topic was presented to the class, members were asked to suggest specific topics dealing with population, the distribution of which they could study. Some of the topics suggested were: percentage of older people; educational level, measured either by the percentage of males with four or more years of college or by the median grade level completed by all persons age 25 and over; and number of people employed in construction.

Since the course lasted only one quarter and time was limited, the format of the project was specified. As an exercise in application of the scientific approach, it involved the aspects usually considered to be included in the approach: selection of a phenomenon for study, termed the dependent variable, and precise definition of it; collection of data for the dependent variable for each county by drawing upon existing knowledge; mapping of the data, showing the distribution by county for the entire state; formation of hypotheses to account for this distribution; collection of data for the independent variables—the phenomenon hypothesized as related to the independent variable; testing of the hypotheses and drawing conclusions.

One of the student projects is discussed here in order to illustrate how the projects were carried out. Because the emphasis was on method and approach rather than content, the topic chosen and the conclusions reached by the student are of lesser concern.

The topic chosen by the student was the distribution of male teachers in the State of Washington. Beginning with this broad topic, it was necessary for the student first to define it more precisely and in form compatible with available data. After collecting data on the ratio of male teachers employed in each county from the 1960 Census of Population, she ranked the counties from highest to lowest. She then computed the mean, and divided the array into four equal-sized groups, with two below and two above the mean. Using this grouping, she prepared a map showing the distribution (Figure 1).

Her next task was to search for possible explanations of the spatial distribution depicted by the map. Formulating hypotheses was for her, as for most students, one of the more difficult steps. In class, an hypothesis had been described as being, in essence, an "educated guess"; in this instance, one which might account for the spatial distribution of the dependent variable, or phenomenon being studied. It was also pointed out that to

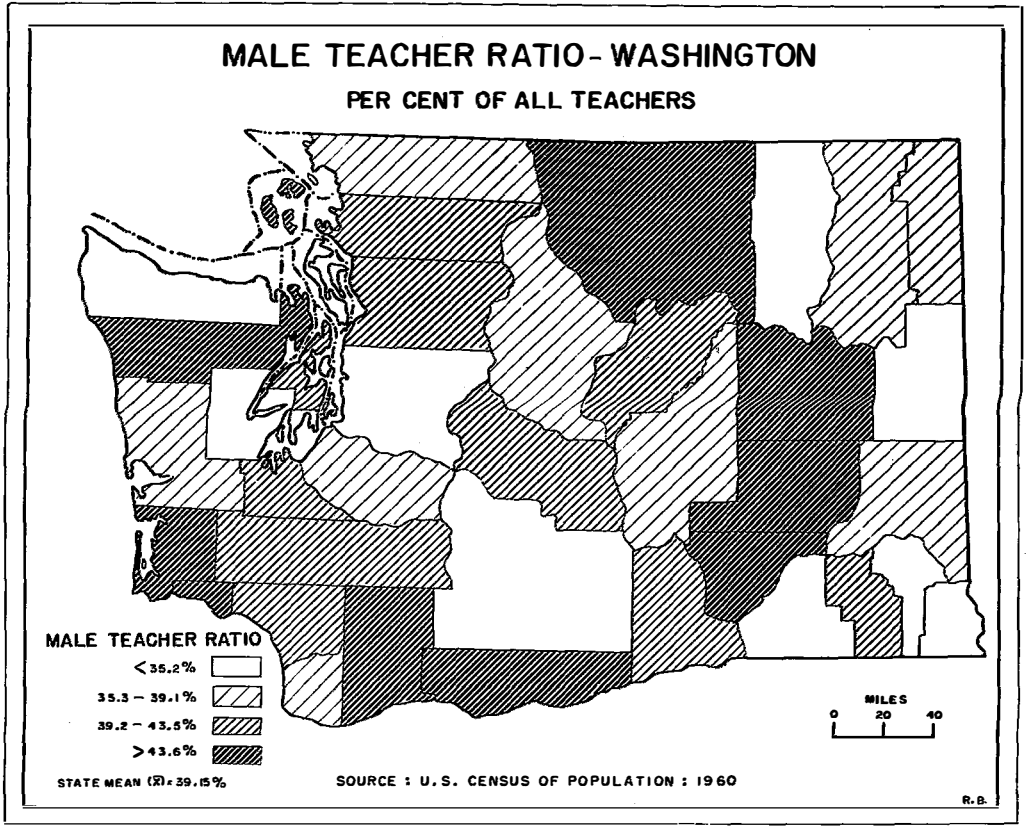
MALE TEACHER RATIO - WASHINGTON
PER CENT OF ALL TEACHERS
MALE TEACHER RATIO
< 35.2%
35.3 – 39.1%
39.2 – 43.5%
> 43.6%
STATE MEAN (X̄) = 39.15%
SOURCE : U.S. CENSUS OF POPULATION : 1960
MILES
0 20 40
R.B.

Figure 1

"account for" or "explain" a phenomenon meant to find other phenomena which were distributed in a similar pattern. In areas where there were greater amounts of the dependent variable, there would also tend to be greater amounts of the independent variables selected (or, in the case of an inverse relationship, lesser amounts).

Studying the map depicting the distribution of the dependent variable helps to suggest other phenomena with similar distributions which may be selected for testing as independent variable. It is apparent that extensive knowledge regarding the distribution of many phenomena over the entire state of Washington is necessary as a basis for formulating valid hypotheses. For example, there are wide variations in the amount of rainfall throughout the state, with large amounts along the coastal portion and smaller amounts in most portions seast of the Cascade Mountains. Vegetation and crops also differ from the forested coast to the drier inland areas. Population is concentrated in the Puget Sound area, with other smaller concentrations around Spokane, Yakima, Richland and few other areas.

On the basis of her knowledge about the state, the student selected three phenomena which she believed might be related to the male teacher ratio in an area: 1) the proportion of the population living in urban places, 2) the median salary for teachers, 3) the number of named lakes and streams. She believed that there would be a higher ratio of male teachers in those counties with higher median salaries, since a male teacher, who would probably have a family to support, would seek employment in an area which offered a relatively high salary. She also thought that male teachers might be attracted by fishing opportunities, and so chose the number of named lakes and streams as a second independent variable. In the choice of the third variable, she reasoned that more male teachers would be attracted to urban places than to more remote or rural areas.

Various methods had been suggested in class for testing hypotheses. Since few students had taken a statistics course, no statistical tests of the hypotheses were used. Instead, scatter diagrams or contingency tables were constructed, and the hypotheses tested by inspection of these. If the distribution of dots on a scatter diagram was generally elliptical, the hypothesis was considered to have been supported by the evidence (*Cf.* Figure 4 and Figure 2). Figure 4 is a scatter diagram depicting the relationship between the proportion of population living in urban places and the male teacher ratio in each county; it shows a generally elliptical pattern. In contrast, Figure 2, which shows the relationship between the median salary of teachers and the male teacher ratio, shows what appears to be an almost random distribution of dots. The same can be said of Figure 3, which illustrates the relationship between the number of named lakes and streams and the male teacher ratio.

Inspecting her scatter diagrams, the student decided that her first two hypotheses were not supported by the data. For the third one, although a relationship was found, it was the inverse of that which she had hypothesized; that is, the male teacher ratio tended to be higher in counties with a smaller proportion living in urban places. In her conclusions, she suggested possible reasons for the lack of significant findings for the first two hypotheses and for the possbile importance of the relationship found for the third.

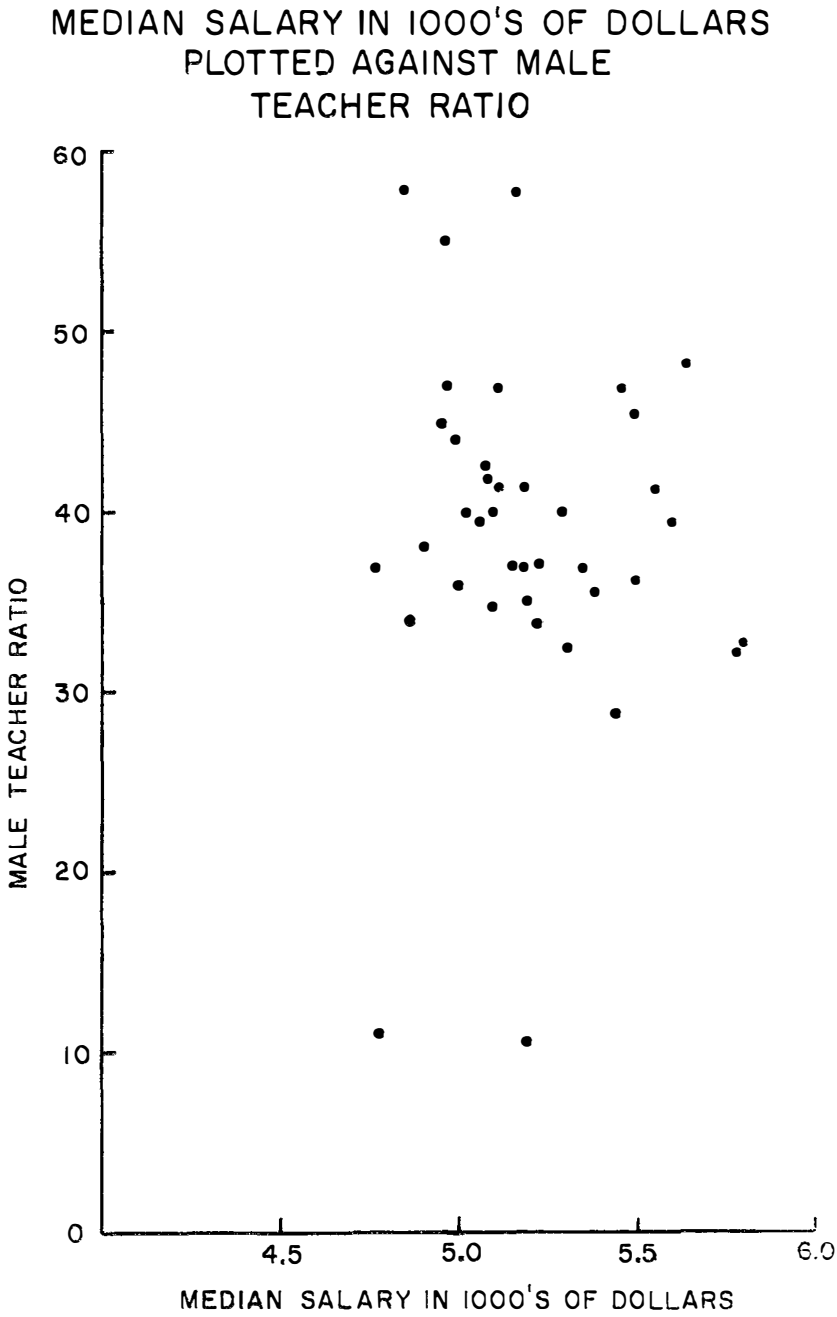
MEDIAN SALARY IN 1000'S OF DOLLARS
PLOTTED AGAINST MALE
TEACHER RATIO
MALE TEACHER RATIO
60
50
40
30
20
10
0
4.5
5.0
5.5
6.0
MEDIAN SALARY IN 1000'S OF DOLLARS

Figure 2

NUMBER OF NAMED LAKES AND STREAMS
PLOTTED AGAINST MALE
TEACHER RATIO

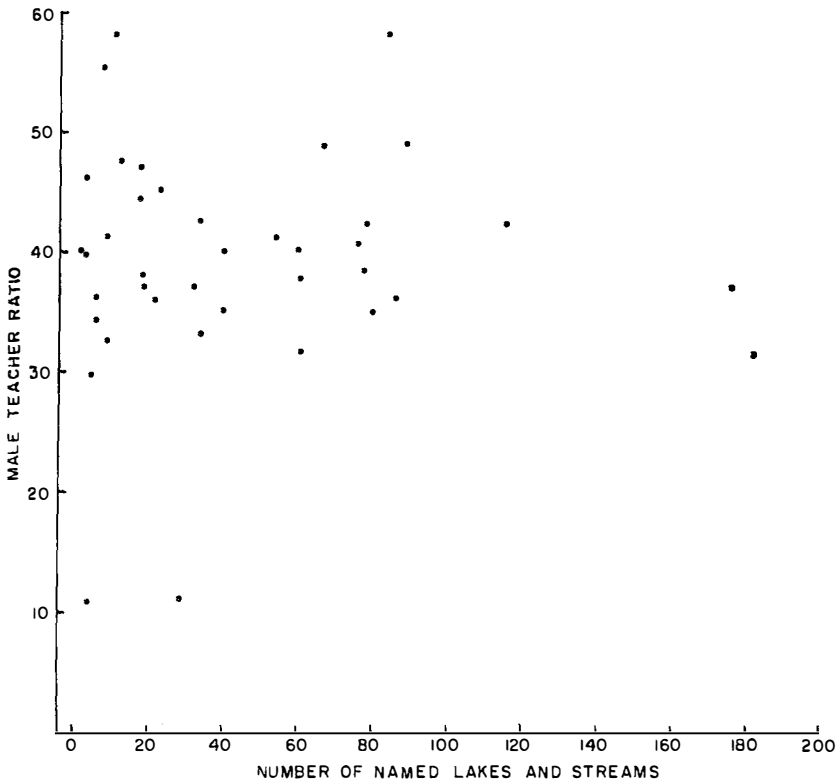

Figure 3

PER CENT OF POPULATION URBAN
PLOTTED AGAINST MALE
TEACHER RATIO

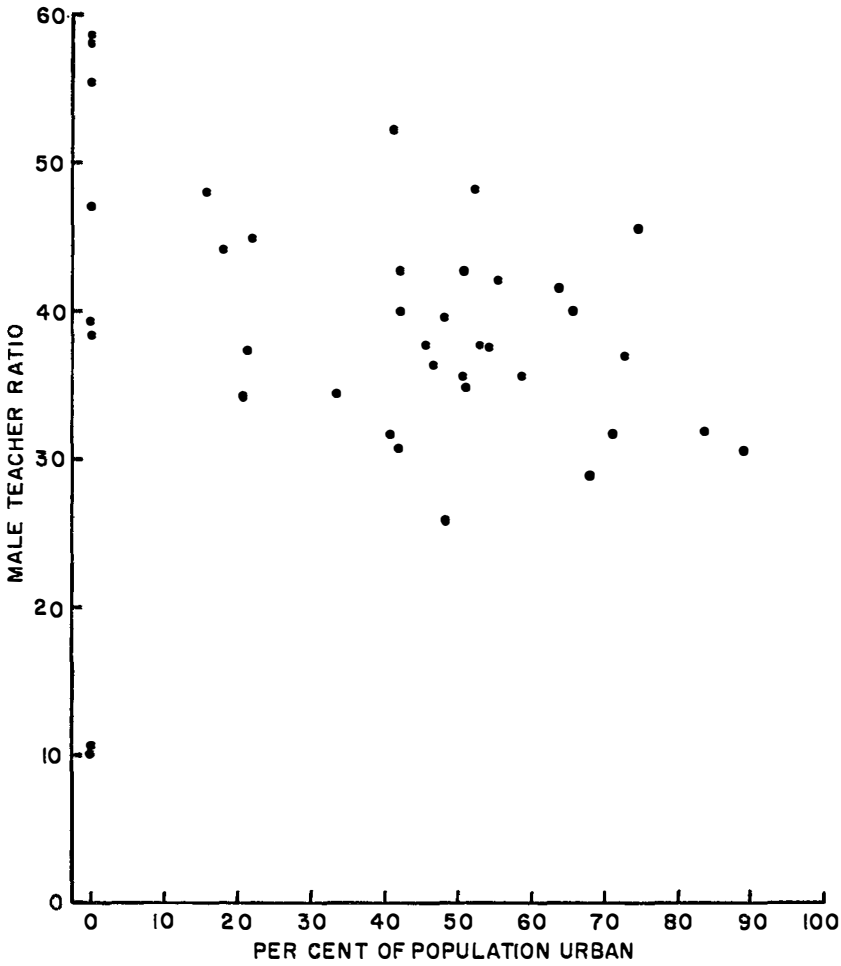

Figure 4

She realized that, further, more detailed study would have to be done before any definite conclusions could be drawn.

Learnings Resulting From the Projects

For many students, the completion of this project was a struggle. In spite of, or perhaps because of, the effort put forth, the majority of students felt that the project had been valuable and that it should be continued with future classes.

Student learnings emerged in four broad areas: 1) consideration of a viewpoint in geography involving the study of variations in the spatial distribution of phenomena on the face of the earth; 2) practice in applying the scientific approach to the study of a geographic problem, in keeping with this viewpoint of geography; 3) learning of many study skills needed to carry out the project and 4) gaining and understanding of ways in which this knowledge might be applied in public school classrooms.

1) In general, students were reluctant to recognize and accept a view of geography which did not coincide with preconceived ideas, however hazy and ill-defined these may have been. They knew that the study of geography involved learning place names, imports and exports, and similar geographic facts. They did not see, however, that these facts could be interrelated within the framework provided by the scientific approach. Because this approach to the study of geography was unfamiliar, it was difficult for most students to grasp it in the short space of a single quarter. It was believed that progress, nevertheless, in introducing the notion of searching for relationships among the spatial distribution of various phenomena as one which is basic to geography.

In a concrete way, students realized that knowledge of geographic facts, although not an end in itself, was essential to successful completion of the projects. As they studied many phenomena in their own state, they found that more thorough knowledge of these facts would have enabled them to formulate hypotheses more intelligently, and to discard before testing some hypotheses which proved to be untenable. They also found that carrying out a project of this type involved learning many geographic facts at the same time.

2) Students learned to apply the scientific method in geographic study, and to consider the subject matter within a problem-solving framework. They found that what might appear self-evident was not necessarily valid, and had to be tested before being accepted even tentatively.

3) Students also acquired or improved a number of study skills and realized that such skill must be taught as an integral part of the curriculum if they are to be mastered and used. Completion of the term project required such activities as the collection of data from census reports, ranking data and dividing it into groups, making maps, constructing scatter diagrams and contingency tables, and writing up the completed project in a form acceptable as to contents, proper use of English, and neatness.

Similarly, students in an elementary or secondary classroom would be expected to use reading and library skills in accumulating information about an area, arithmetic and map skills in organizing and visualizing information,

and comunication skills, both oral and written, in summarizing and reporting the findings.

4) Applicability for the classroom teacher should be the justification for including such a project in a social studies education class. Throughout the quarter, therefore, students were encouraged to draw parallels between their own present class experiences and the experiences of their future pupils. They were continually asked to think of ways in which the scientific approach could be applied in teaching at different grade levels.

In the intermediate grades, one area of the world is often selected for study. It is commonly divided into political or physical regions which are studied one at a time. For example, the continent of South America may be studied either by countries or by physical regions such as the coastal lowlands or the highlands of the Andes. The teacher can encourage pupils to suggest topics such as transportation, manufacturing, cities, population, rainfall, and vegetation for investigation within all regions. As each topic is studied, hypotheses may be formulated about the relationship between it and other topics. The degree of sophistication of the hypotheses would depend upon the pupils' maturity and ability. As study proceeds, the validity of the hypotheses would be tested by finding out whether generalizations about the location of phenomena derived from the study of one area, appear to be applicable to other areas. Older or more capable pupils might be able to derive abstract principles of location for a particular phenomenon. From these, they could hypothesize its expected location in other areas. Such an approach is reported by Bruner.[1]

> A sixth grade class, having been through a conventional unit on the social and economic geography of the Southeastern states, was introduced to the North Central region by being asked to locate the major cities of the area on a map containing physical features and natural resources but no place names. The resulting class discussion very rapidly produced a variety of plausible theories concerning the requirements of a city—a water transportation theory that placed Chicago at the junction of the three lakes, a mineral resources theory that placed it near the Mesabi range, a food-supply theory that put a great city on the rich soil of Iowa, and so on. The level of interest as well as the level of conceptual sophistication was far above that of control classes. Most striking, however, was the attitude of children to whom, for the first time, the location of a city appeared as a problem, and one to which an answer could be discovered by taking thought . . .

Jakubek[2] has reported using the scientific approach to the study of a social problem with a high school social problems class. The problem chosen, namely, the spatial distribution of automobile accidents by county throughout the state of Iowa, concerned the students directly. They hypothesized four factors which might be related to spatial distribution of automobile accidents: total population, proportion of population living in urban areas, proportion of population of age 65 and over, and per capita liquor sales. The hypotheses were tested by visual comparison of the maps of each independent variable with the map of the dependent variable. Students concluded that the spatial distribution of each of the first two independent variables was sufficiently similar to that of the dependent variable to accept

[1] Jerome Bruner, *The Process of Education*, Cambridge: Harvard University Press, 1960, pp. 21-22.

[2] Otto F. Jakubek, "Geographical Investigation of a Social Problem: A Study in Scientific Method," *The B. C. Teacher*, November, 1961, pp. 60-61.

the hypotheses.. For the third. they found what appeared to be an inverse relationship. They rejected this hypothesis and revised it to conform to their findings. They rejected the fourth hypothesis as showing no apparent relationship.

Even at the primary level children can learn to seek out relationships among the distribution of phenomena. In the primary grades, where emphasis is usually placed upon the study of phenomena close to the child's experience, the location of such phenomena as shopping centers, fire stations, schools, bus routes, and factories may be studied. Children can form the habit of asking *why* these are located where they are, and of looking for explanations. It is apparent, for example, that fire stations must be located so that any section of a city can be reached quickly, and that all the fire-fighting equipment for a large population should not be housed at one location. Stated more abstractly, there is a relationship between the location of buildings and the location of fire-fighting equipment.

Asking why and how various phenomena over the face of the earth are related to each other and what the general principles underlying the location of such features are can lead to understanding in the study of geography. By capitalizing on curiosity, teachers can help their students to discover relationships among these phenomena in the world in which they live and to integrate the facts they encounter into a meaningful framework. Approached in this manner, the study of geography contributes to the child's entire sphere of knowledge, instead of being restricted to learning a series of isolated facts, most of which are soon forgotten.