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# Expected Student Outcomes in Earth Science Investigations

John F. Thompson

# Expected Student Outcomes in Earth Science Investigations*

JOHN F. THOMPSON
*Associate Director, Teacher Preparation*
*Earth Science Curriculum Project*

One of the basic precepts in science teaching is the Futility Factor: no laboratory investigation is ever a complete failure . . . *it can always serve as a bad example.* There will always be *some* kind of result when students do investigations. Whether the outcome is expected or not is another question. Occasionally in a classroom investigation the "wrong" outcome is the only result. At times like this we doubt the results obtained even by the authors of the investigation.

To examine the problem of expected versus actual outcomes, let us look at five groups of people who expect certain results: (1) teachers, (2) parents, (3) administrators, (4) curriculum makers, and (5) students.

Teachers' outcomes are usually based on both their personal operational teaching philosophy and the teacher's guide for the materials. The two are not always in agreement.

Parents normally expect students to learn some science while doing the investigation and to get good grades.

Administrators generally expect that the youngsters will learn some science and that the results of the investigation will not prove detrimental to the overall operations of the school.

The curriculum makers expect students to learn some science and to be able to transfer the learning to inquire into the world around them, using scientific processes.

Finally we come to the most important group of all and one that is normally left out of the picture, the students themselves. It is always interesting to ask students what they expect from a given investigation. Their first expectation is usually a good grade, as we have succeeded admirably in making youngsters grade conscious. Second, students expect to have a little fun with the investigation. If fun is not built in they will manage to create it, sometimes in a way not compatible with the teacher's expectations for classroom behavior. Kids also expect to learn some science.

Learning science seems to be a common thread running throughout the expectations of all five groups. Let us look at what we mean by learning science, using as an example the temperature field investigation in Chapter 5 of the ESCP text, *Investigating the Earth.* The purpose of this investigation is to give the youngsters some experience and "feel" for an energy field in general before they study gravitational and magnetic fields of the earth. To briefly summarize the lab, each student is given a thermometer which he places on his desk top. At a given instant all of the students read the thermometer

*Paper delivered at the 1968 Iowa State Education Association meeting and share the data. The students are then asked to make a contour map of this temperature data. The same thing is done at floor level and at eye level.

When most of the class turns in a write-up similar to Figure 1, the question of expected student outcomes arises. The expected outcome would be a correct contour map of the temperature field. What was received was not a correct map. What does a teacher do at this point? He could say that the lab has failed to meet his expectations as well as those of the people who created it. Therefore the investigation is no good, should be rejected, and the students should go on to another experience.

Another teacher response would be to give the students all of the rules for contouring and have them redraw the map. Or a teacher could correctly draw the contour map on the overhead projector or chalk board and show the students where they made their mistakes. Still another approach would be to put some simplified data on the overhead and have the youngsters make a contour map of this data and gradually increase the complexity of the data to that gathered during the investigation. Another alternative is for the teacher to start with the student's contour maps and develop the idea of correct contouring from that point. There are undoubtedly other ways to handle the situation.

Since the example above actually happened while I was teaching this laboratory to a group of eighth-grade youngsters, I can provide an account of my particular response—which was to begin to develop the idea of contouring from the students' maps. I asked the students what the lines meant on their drawings. Almost without exception they said the lines represented equal temperatures, that is, all points on a line represented the same temperature. The students were then asked what the temperature was at a point on the line between two known points. They were able to indicate the correct temperature but also indicated that the line may be slightly above or below that point since they had no data in that area.

The next question was, "What was the temperature at the point where a 27°C and 28°C line crossed?" One response was that it was 27°C, another was that it was 28°C. A more enterprising student stated that it was 27.5°C. A few said they didn't know because there were no data at that point. Another youngster indicated that it couldn't be both 27°C and 28°C and "Maybe the lines shouldn't cross!" A debate followed about the point of lines crossing. Some agreed lines shouldn't cross, but they didn't see how they could draw contour lines without having them cross. After further discussion among the students, they decided that maybe they could make a map where the lines would not cross and still account for all the data points.

The students took the data home and redrew the maps, an example of which is shown in Figure 2. These refined maps were closer to generally acceptable contouring. However, even here the youngsters did not establish a contour interval as such. Some of the lines are half a degree apart and

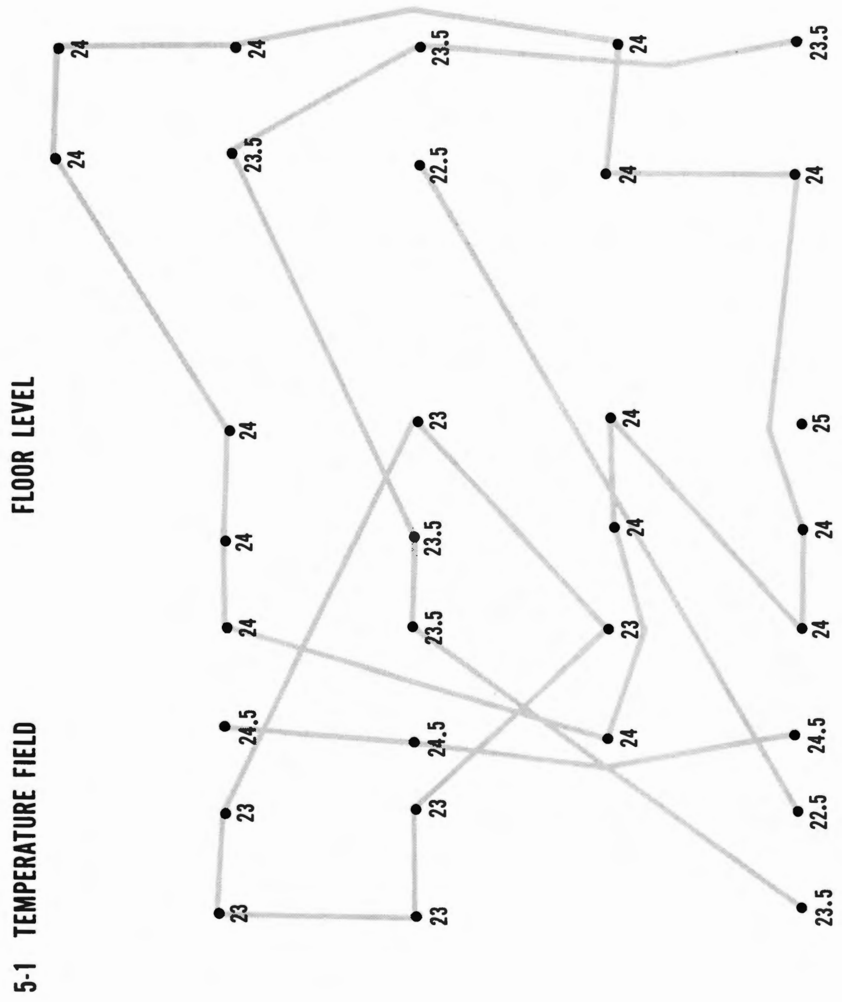


Figure 1

some are a full degree apart. How far to push this point would depend upon the outcome you as the teacher would desire. As a map representing a temperature field, it probably was represented reasonably well as shown in Figure 2 with no further modification required.

Up to this point we have talked only about contouring the temperature field map. As you will recall, the purpose of this investigation is not to teach contouring, but rather to give the youngsters some experience with a field. However, this outcome

**5-1 TEMPERATURE FIELD FLOOR LEVEL**

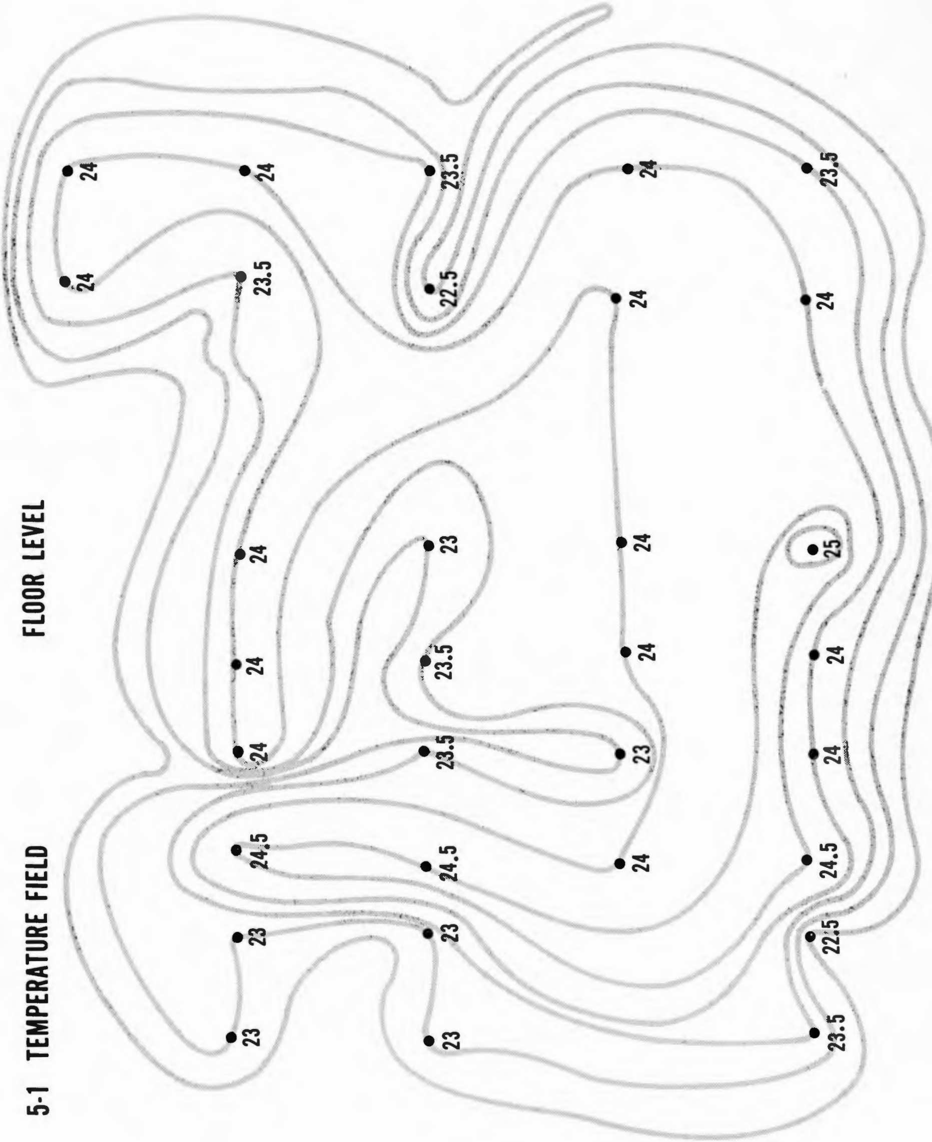


Figure 2

will not manifest itself until the youngsters have had an opportunity to familiarize themselves with various concepts related to contouring. This done, we then began to look at the lines and data from the standpoint of an energy field. The field concepts came through fairly quickly. When the three levels of temperature readings (floor, desk top, and eye level) were put together in a stacked manner, the youngsters had an even better feeling for the three-dimensional aspects of the field. A subsequent exercise using a light meter to determine characteristics of a light field produced no problems in either contouring or interpretation of a field. The concept of a field proved simple for students in the gravitational and magnetic field investigations which followed.

In this investigation the youngsters got into some rather heated discussions among themselves. It was an interesting experience from their standpoint. They enjoyed the give and take of having to defend and attack the results of the investigation. Since I asked them to draw the contour maps to the best of their abilities, nobody could fail. The youngster who drew an inaccurate map (to the best of his ability) had accomplished the assignment whether his map was "right" or not. If I had evaluated the youngsters on the accuracy of the first maps (Figure 1), almost everyone in the class would have failed. At the end of the experience, however, every one passed. When the youngsters rated all of the investigations at the end of the school year, this investigation received a high rating. The students considered it interesting and fun and they remembered it six months later.

One of the expected student outcomes in investigations should be mistakes. Mistakes that youngsters make *can* provide some of the best learning experiences. Insight into the investigation under study is generally far more astute when mistakes are made and *analyzed,* as opposed to an investigation where everybody gets the right answer without much thought as to why.

Student questions generated from this experience included: What is the difference between a heat field and a temperature field? (In the ESCP text the idea of heat and temperature is not dealt with until the next chapter.) What are other kinds of fields, and how do you measure them? How many points in the field do you need in order to produce an accurate map? Can a field only be three-dimensional or are there two- or one-dimensional fields? Student-generated questions such as these often provide the best evaluation of outcomes of the investigation—even better than a written test.

In considering the expected student outcomes in any investigation, it is probably necessary to take a broad look at the situation rather than one or two specific outcomes. If the students are inquiring into the problem at hand, this is a desirable outcome. An answer to their inquiry is desirable whether correct or not. The fact that some of the youngsters are learning processes of science should be an expected outcome. Mistakes should be an expected outcome, to be capitalized upon to generate an even deeper learning experience. It is reasonable to expect that the youngsters will know something more about their environment as a result of the investigation than they did before they started.

The interaction among the students, teacher, and materials should be an expected outcome. The investigation and classroom procedure should be such that it stimulates fun and interest for the students. Behavioral objectives should include *all* of these, rather than just a few that are easily measured. If all of the above are expected outcomes in earth science investigations, it is difficult to see how any youngster can earn a very low grade on such an experience. When we base the grade on the final answer to an investigation, the problem of grades becomes sticky. The reason is simply that grades are normally supposed to reflect the amount the students have learned through the experience.

If you consider all of the expected outcomes indicated here, you will realize that the specific answer to a question is only one small part of learning. Students know what they have learned. Unfortunately, teachers don't so we have to try to find out. We are not always successful in doing so, but this does not mean that we shouldn't try. We have all experienced receiving a low or high grade in some particular activity or course, but if we were to evaluate ourselves we would give ourselves a different grade, based on how much we did or did not learn. Unfortunately, the means of evaluation did not reflect the kind of learning that we experienced. The same thing is true with youngsters in the classroom.

Investigate this problem yourself. Ask your own students what they expect from their earth-science course or a lab investigation. Let them be as free-wheeling as possible in their responses. Beforehand make your own list of possible outcomes. Do not indicate to the youngsters what your list says. Put the two lists together (theirs and yours) and try to base your evaluation on both lists. It should provide a different perspective to the learning experience. We need not sacrifice any quality in education by taking this approach. If anything we stand to increase the .20 correlation between school work and education.

# Iowa Outdoor Education Center Planned

Hawkeye Naturama, a proposed recreation center designed to improve outdoor recreation and outdoor education experiences for all of Iowa's citizens as well as out-of-state tourists, is in the initial development stage. The 62nd (1967) Iowa General Assembly appropriated $1 million for cooperation with the Corps of Army Engineers to begin development of a lake area centrally located near the Saylorville Impoundment at Polk City.

A recreation area involving 5,000 to 6,000 acres and a tree-bordered 900-acre permanent water level lake have been proposed. The timbered hillsides along Big Creek near the Des Moines River at Polk City will provide a picturesque setting for the development. The nearness of the site to Iowa's intersecting interstate highways makes it readily accessible to 81 per cent of Iowa's residents with a three-hour drive.

Outdoor education, outdoor living, and sports activities will provide many forms of relaxation.

*Outdoor Education*

To save the few remaining natural areas in Iowa, it is important that Iowans learn to live with nature without destroying it. Counselors trained (OUTDOOR—Continued on page 13)