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ABSTRACT

At the 1973 program of the National Association for Research in Science Teaching, 50 research investigations completed during the years 1966-73 were reviewed for comparison with the trend of research activities completed during 1955 through 1965. Recent research is characterized by interaction between teachers and students in classroom and laboratory with a small amount of practical use of scientific knowledge by students. Studies of science teaching in a context broader than schools and methods of non-motivated students were emphasized. The author pointed out the importance of research in the following aspects: (1) students' ongoing lives; (2) students' purposes, drives, habits, and means of achieving psychological equilibrium; (3) out-of-school influences on students dynamics of living and learning; (4) development of new instruments and methods for studying students; (5) review of potential resources in science; and (6) designing of educational programs by using "things" from science as resources that students can use in their daily lives. (CC)

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RESEARCH IN SCIENCE TEACHING IN A LARGER CONTEXT

By
Ralph W. Tyler
Center for Advanced Study
in the Behavioral Sciences

THE OHIO STATE UNIVERSITY
ERIC Information Analysis Center
for Science, Mathematics, and Environmental Education
400 Lincoln Tower
Columbus, Ohio 43210

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RESEARCH IN SCIENCE TEACHING IN A LARGER CONTEXT*

Ralph W. Tyler
Director Emeritus
Center for Advanced Study
in the Behavioral Sciences

It is a privilege to be invited to address this Association. Authentic and effective science education is essential to a democratic, modern industrial country. Citizens are not adequately prepared to deal with the issues that confront them today unless they understand the role and contributions of science in developing the modern world as we know it, and its potential role to maintain and improve our society. There are many indicators that science education is not yet either fully authentic or highly effective in preparing the lay citizen for his responsibilities. Although research in science teaching will not alone improve this situation, it can identify and illuminate the problems and suggest promising attacks upon them. Hence, members of this Association are key figures in a world-wide effort.

Research Reviewed in 1965

Eight years ago I was asked to review the abstracts of research in science education appearing in the United States Office of Education reports for 1955 through 1961. I was also provided with abstracts of many of the studies completed during the years 1962-65 and was requested to make a critical appraisal of these investigations. My report

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*Presented at the Program of the National Association for Research in Science Teaching, Detroit, Michigan, March 29, 1973.

was presented to the Green Meadows Conference in 1965.[1] At that time I found that not more than ten percent of these studies met reasonable technical criteria. Attempts were made to generalize findings from populations poorly defined or not defined at all. Variables were ill-defined, measures of them were often of low validity, and techniques of analysis and interpretation seemed to have been by recipe rather than to have been selected in terms of the applicable conditions. But I found these technical inadequacies less distressing than the weaknesses in the content and the logical structure in at least four out of five of the studies reported during that period.

About one-fourth of the investigations were fact-finding surveys with no attempt at generalization. About twenty percent were collections of opinions about the values of topics, objectives, courses, equipment and facilities, and ways of teaching. Such studies can provide facts about what people believe, but in themselves they are not bases for generalizations.

The largest number, more than thirty percent of the investigations, were attempts to study the comparative values of different courses or different methods of teaching. These studies treated courses and methods of teaching in such large categories that, typically, the variance in achievement within classes using the same method was as great or greater than the variance between courses and methods. An experienced observer knows that the title of the course or the textbook covers a wide range of actual teaching-learning operations. Similar wide variations

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[1] It was also published in the Journal of Research in Science Teaching, Vol. 5, pp. 52-63.

are noted in such categories of teaching methods as lecture demonstration, textbook recitation, individual laboratory work, and so on. Most of these studies did not involve clearly defined variables from which meaningful generalizations could be drawn. Furthermore, most of them did not employ achievement measures that clearly appraised the progress of students toward the objectives stated.

Few of the reported investigations represented systematic research relating to the objectives of science education, and fewer still dealt with theories of learning compatible with different objectives of science teaching. Another serious deficiency was the short time span covered by most of the investigations. Most educational objectives require a long time for development, and the expectation is that what is learned will become a permanent part of the individual's repertoire of behavior. Hence, some research should be devoted to long-term studies of development and retention.

After reviewing the research investigations of that period, I certainly shared the thoughtful evaluations made by William W. Cooley and Kenneth E. Anderson, analyzing the research in the teaching of science published in the period July, 1957, to July, 1959, who expressed the view that the potential value of research for improving science teaching was not being realized and a considerable explanation seemed to lie in the lack of a cadre of professional research people deeply concerned with research in science education, who devote major time to this work and who among themselves and with scholars in other fields are seeking to gain greater perspective, more adequate conceptualizations to guide their study, and better instruments for research.

Review of Recent Research

Although I have not had time to make such a comprehensive analysis of the research investigations in science teaching that have been published during the past eight years, I have reviewed fifty of them. It seems clear that current research studies are of higher quality than the earlier ones. Technical criteria are much better met, variables are more clearly defined and more adequately controlled. Greater recognition is given to the variety of outcomes resulting from science teaching and to the complexity of the classroom processes. Current research depends much less upon the work of graduate students than was true earlier. A cadre of professionals is now engaged in these studies, and their competence and sophistication are evidenced in the substance and quality of their investigations.

However, most of the current work still seems to be guided by the view that effective teaching of science results only from the interaction between teacher and students in the classroom and laboratory, this interaction being directed by the objectives, content and activities of the science curriculum. In many cases science teaching seems to be defined as "shaping the student's behavior to conform to the particular objectives of the teacher of the curriculum." These conceptions are inadequate to explain the behavior of many students. Some, but by no means all, come to school with the purpose in mind of trying to learn what the school tries to teach. Although some of these may not be deeply interested in science and the learning activities involved, the teacher and the materials are often sufficient to arouse a degree of interest to attract some attention and stimulate the effort to learn.

For these students, current research studies are furnishing knowledge about their learning that is illuminating our understanding of science learning and teaching.

But during the past four years I have been talking with students, parents and others in low-income communities and find that very few of these school children go to school each day with the idea that there is something in the school that they will find useful to learn. Many of them view the school as a place where they are required to spend time and their efforts are directed to getting through the school day without too much discomfort. This is in contrast to their attitude toward learning to adjust and repair the home TV, learning to be a checker in a supermarket or other opportunities to learn things they consider interesting or useful. These observations have led me to make some preliminary explorations of a context broader than the school in which children and youth are learning. I have begun these observations and conversations because this broader context appears to influence the learning in school of some students. It is becoming clear to me that we have been greatly preoccupied with investigating learning as this process is commonly preceived by the teacher or curriculum maker, in which the task is to direct the learning of students in the classroom and laboratory. We have largely neglected to look at the way learning is viewed by the student himself. Yet the map of the learning process as seen by the individual learner is a significant part of the context in which education, including science education, takes place.

Exploring the Larger Context

Working with young people in backgrounds of extreme poverty, I am impressed again and again with the fact that all children, unless brain damaged, are learning. Learning is as natural for a human being as eating. Without learning an individual could not survive even the first year of life. There are no non-learners. But children and youth differ markedly in what they learn, and I believe that research can help us understand more adequately the factors that influence what a student will learn and the effort he will expend in the process.

A normal young person has an ongoing life of his own, in which the home, school, and community environments are places where he spends his time, but few of the children and youth with whom I have been working and talking think of these places as essential to their lives, but rather, they perceive them as contributing to or interfering with their purposes or their satisfactions. What a child or youth perceives in school, what he attends to there and how he behaves appear to be strongly influenced by this ongoing quasi-independent individual life.

It is fairly easy to identify children at the two extremes in their readiness to give attention to classroom and laboratory activities. There are those who consider these activities as important or at least necessary, and those who consider them irrelevant or even hindrances to their own purposes, drives or habits. Some perceive in the same way everything connected with the school, others have different attitudes toward certain subjects or teachers than toward others. In my conversations, I raised questions about science and found that some students had a different attitude toward science than toward the school generally,

but these deviations characterized a minor fraction of the children.

Among the students who fall between these extremes I noted a number who talked in ways that suggested they were giving attention to the school science activities. These I could classify into two broad categories---those who found interesting some of the activities of the classroom or laboratory and those who identified something worth learning in their classes. Those who attended to the activities only when they found them interesting appeared to have learned only spottily or casually, while those who perceived something worth learning in science classes, reported that they made fairly systematic efforts to learn.

When trying to learn, these teen-agers varied in their practices. Some would listen and/or read, then try to remember what they had heard or read. Some would perceive certain ideas or techniques of science as things that were useful in their own activities and would try to learn by trying to use them. Some would find out from friends or other students how they tried to learn and would follow their examples. Some would seek more specific instructions from the teacher. I was impressed by the number of these students who did not follow the learning activities of the curriculum in ways intended by the curriculum builders. Because their own purposes, drives and habits were primary, the impact of classroom and laboratory activities seemed to be significant primarily (perhaps only) when the students perceived them as helpful or at least congruent.

I tried to find out whether these young people ever practiced outside of school the science learning activities that were carried on in

the classroom or laboratory. It appeared that when the student perceived an activity as useful for his own purposes, he could recall practicing it outside of school. Also when he found the activity enjoyable or satisfying, he continued it. Furthermore, some students said that they practiced outside of school because they thought they should or had to do so. By and large, however, the amount of practice reported outside of school was small.

Extra-School Influences on Children and Youth

In this exploratory effort, I tried to get some notion of the forces influencing this ongoing life of the individual child or youth. Obviously, any dependable answers to such a question require much more careful and systematic study than I have undertaken. It is also true that I am familiar with the prevailing conceptions of behavioral scientists regarding social influences on the individual. However, I believe that the conversations of these young people furnish some indications of the factors that influence their attitudes, beliefs, purposes and habits. The most frequently mentioned influences were the attitudes and activities of their own peer groups. How their friends and associates perceived the world, what they thought was important, what activities they carried on and how much effort they put forth seemed to be the accepted norms for most of those with whom I talked.

In a number of individual cases there appeared to be a particular person, usually older, with whom the student at least partially identified. This older person's attitudes and behavior seemed to have special attraction and great influence.

For younger children, the attitudes and activities of the home seemed to be more influential than those of the peer group, but for

most of the teen-agers, the home influences were reported as less important than the peer group in establishing norms. The attitudes, practices and beliefs of the community beyond the home and peer group appeared to be influential in certain areas, and not in others. Attitudes toward the school and occupations, practices relating to health and to "the law" were mentioned as being influenced by the attitudes and practices of the community.

If many of these young people are to gain an education in science, we need to have much more knowledge than we do now of the dynamics of living and learning that include the out-of-school as well as the classroom and laboratory. More adequate knowledge would furnish both a basis to devise strategies for intervention that could be focused on critical places in this larger context and also provide important information to be used in designing programs of curriculum and instruction that will better serve the students not now really benefiting from science teaching.

Science Education Is For All

If research in science education is to seek to understand the learning of students who are not now interested in science, we should be clear about the reason for devoting energy in this direction. One may well ask why science teachers should be concerned about reaching students who are not interested in science and do not put forth the effort to learn. Until recently, the prevailing school practice has been emphasizing the sorting of students fully as much as their education. Our tests and grading systems have sought to rank or rate students rather than to indicate what they have learned, what difficulties

they are having and how they might direct their efforts to overcome these difficulties. Hence, from the first grade on, some pupils received high marks that encouraged them to go on while others received marks of "poor" or "fail" and were discouraged. This sorting corresponded roughly to the availability of positions of various levels and ranks in our society. Even as late as 1900 more than half of the U.S. labor force was unskilled and only five percent were professionals and managers.

Now, however, not only has the uneducated person limited job opportunities but the complexities of most arenas of life--citizenship, health, consumption, family responsibilities--all require education for effective functioning, and the potential contribution of science education is important. But, for most Americans today, the contributions of science education do not arise from their becoming scientists, nor from their knowing all that the scientists know, nor even a random sample of that knowledge. We need to think of science as a resource from which laymen can draw in ways that will help them live their lives more meaningfully, deal with their problems more effectively and participate fully in the common life of our society. Hence, we need to understand what the lives of students are and how they may find and use in science "things" that can be positive resources for them in carrying on their lives.

I am suggesting that knowledge about the ongoing lives of students not now being reached by science is not of value only to intervene in the ongoing life in ways that will direct him into the present science curriculum but also that we reexamine on a continuing basis the fields

of science asking the question, "What from these fields can serve as resources of substantial help to the non-scientist in living his life and dealing with his problems?" This line of research is clearly related to and dependent on the knowledge obtained from investigating the learning of young people in the larger context.

This continuing search of science fields is not as simple as it may seem at first glance. From the total enterprise called science can be obtained concepts from which one can construct a cognitive map of the physical and biological world, generalizations (relations among concepts) that can help one understand or explain many common phenomena or predict their development, facts and sources of facts that may be useful in dealing with particular situations or events, instruments or machines, questions or problems that serve to direct continuing scientific inquiry, methods or techniques of investigation that are not only useful tools to the scientist but some of which can be used by the layman in his quest for knowledge or control of particular phenomena, objective approaches to problem solving that help to free one from the limitations of unexamined assumptions or perceptions, and so on. Undoubtedly other categories of "things" that science can provide can be found and the items within the categories are continually being modified or expanded while their value to the student will be changed both by new developments in science and the changes taking place in the contemporary life of the student. For this reason I think of both of these as continuing lines of research.

Furthermore, as these two lines of research develop, a third one can be mounted. As research identifies interests, purposes and

activities of different students or groups of students, and other research gives a fairly comprehensive picture of potential "things" that students might learn from science, possible experiments are suggested that draw upon some of these "things" from science to help students learn to use them in pursuing their lives.

Relation to Classroom Learning

The three most serious learning problems as perceived by classroom teachers are motivation, retention and transfer. Since the student learns only the behavior he carries on, he cannot be forced to learn. Hence, motivation that gets him involved in active learning is essential. Knowledge of the student's life outside the school, his purposes, interests, attitudes, activities and habits furnishes the teacher with information that is useful in selecting learning objectives and developing learning experiences that are consistent with the student's ongoing life.

The classical statement regarding retention is that over-learning results in the permanent retention of what is learned. That is, retention results from much practice. In too many science classes, practice is limited. But, when science learning in the school is helpful to the student in his everyday life, he is likely to practice what he is learning as frequently as the opportunities arise. Furthermore, transfer of what is learned in school to the appropriate situations outside of school can be promoted by encouraging the student to use what he is learning in science in ways that promote his purposes, satisfy his interests, and help him carry out his activities. When the science curriculum is developed to provide resources of this type, the transfer

is easily accomplished. In fact, the gap between in-school and out-of-school concerns is greatly narrowed. Hence, the research that is being suggested should help to overcome these serious classroom learning problems of motivation, retention and transfer.

Knowing One's Students

The function of research relating to education is to provide a basis for understanding the educational process or parts of it and for planning and developing educational programs. It is important to note that educational research rarely furnishes an answer to a specific question about an educational practice. Much more often, research provides a basis for practice in terms of the concepts it furnishes the practitioners, the outline it formulates of the dynamics of the processes with which the practitioner is concerned and the relations it establishes among the concepts and the estimates it gives of the parameters of the dynamic models that are proposed. That is to say, the value of research lies in providing the practitioner with broader and more detailed maps of the terrain of education than he would have developed from his own experience alone. The lines of research proposed should help to develop these maps.

There is another potential contribution of the proposed research--namely, the methods and tools by which the information about a student's ongoing life, and about the forces influencing his behavior, may be obtained. The teacher gains some help in planning and conducting his science courses by knowing in general about the characteristics and parameters of the out-of-school life of children and youth, but he still needs to know more specifically about his individual students. The

methods and tools that he may use to study his own students are likely to be developed by the researcher rather than by the teacher. This contribution should not be overlooked.

Concluding Comment

I am suggesting that in order to understand the learning of students who are not now trying to learn in science classes we need the results of research concerning the ongoing lives of these students, and their dynamics, which includes their purposes, drives, habits, means by which they achieve psychological equilibrium, and the like. We need research regarding the out-of-school influences on these dynamics. We need to develop instruments and methods for studying students that teachers can use. We need reviews of potential resources in science for these students. We need experimental studies in which educational programs are designed to utilize "things" from science as resources students can use in their ongoing lives.

A major problem confronting science education in America today is to reach students who do not now really learn--that is internalize--anything of importance in science.

I believe that research in this broader context can help.