and only shadows are here. Take a last look at the yellow one before leaving . . . remember the name . . . check it out next time . . . GOOD pictures.

"Run to the library . . ." linger at the desk to plan a new announcement about the Shadow Play that the third grade is giving . . . examine the schedule . . . fill in the events for the coming week . . . post it back for all to read. Consult with the librarian: "When can Ed's Grandma come? She's home from Greece with lots of exciting things!"

"Run to the library . . ." put a note in the Letter Box for Alice:

"Dear Alice: Have you read *The Cat and His Friend, the Whale* by Towers? I did, and thought it was very exciting!"

—Mary

Put a Book Riddle on the bulletin board: "Who found and then lost a buried treasure?"

"Run to the library . . ." hurry fast . . . see the posters . . . the exhibits . . . feel the new books . . . love again the old . . . linger long . . . and reach anew for a world that lies so close about. "Run to the library . . ." run . . . run.

Science Teaching and Creativity

ROBERT K. WICKWARE

What are some of the issues involved in bringing about creative teaching in science? This article attempts to identify several of these issues. It also stresses the importance of the teacher's developing a climate in which creative activities, thinking and practice will flourish.

"YOU KNOW, I've got an idea; do you suppose I could . . .?" "Could I get a few things from the science storeroom . . .?" or "Could I work over at the science corner for a little while . . .?" or "Could you tell me where to find some information on things to kill insects . . .?" or "Could I get a committee started and meet the next period? I've already talked to Pep and Jim and they say they'll help . . ."

Creativity in Science

Perhaps the idea is only one of explaining why the fountain pen we were looking at yesterday didn't need to be refilled, or perhaps it is the idea that Bert had about how to wipe out Japanese beetles in the community, or perhaps Bob is "just thinking." Perhaps the significant thing is not that John had a specific idea, but simply that he wanted, in his own words "to watch this bubbling a little longer, for it seems to me that something different is happening, and then maybe I can show you something pretty interesting." Or it may be that having a Canadian nickel in the bottle of things to be sorted by a magnetic derrick someone made will be the beginning of a whole new set of ideas about magnetic materials.

What is the significance of ideas and

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their follow-up in our science teaching? What do we, or can we, do about them? What are some of the problems which hinder our using children's ideas as freely as we should? What are some of the conditions we need to recognize as those which on the one hand facilitate and on the other hand hinder creative activity? What is the significance of ideas in the growth of science as a vital factor in our everyday living?

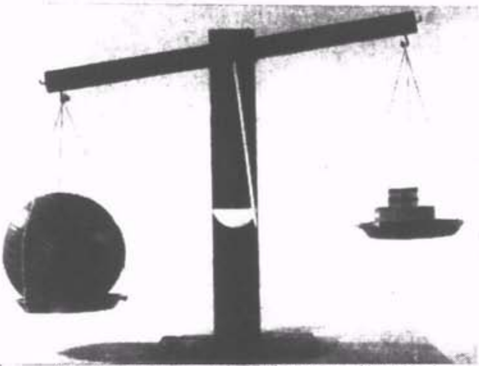
Science has been dealing in ideas for centuries. Men and women, young and old, have been pursuing ideas, searching for materials to use in new ways, harboring ideas which went against cultural traditions, and developing ideas and puttering around with hunches which seemed so useless at the time as to make the person seem a wastrel. Hence science teaching which does not utilize and develop creative thinking on the part of children, young people and adults is as barren as living things without means of reproduction. Although the term creative science teaching will be used in the following paragraphs, it is in reality both redundant and specious. Science is so completely dependent upon creativity that most scientists and historians of science would not recognize or place anyone in the category of scientist unless his creativity were evident and notable in the achievements with which he or she is credited.

Creativity is an active process, not a passive one. It implies motion, and further than that, continuing motion. At its best the dynamic quality of creative activity leads to further activity rather than to stability. A chemist might cite it as more related to a chemical reaction than to a physical combination, in that the end product is something new and unique and not just a separable mixture of the original components. In a modern simile one might liken the whole process of creativity to the well-known chain reaction. One might add parenthetically that such a process uncontrolled or berserk, may easily get the individual out of balance and maladjusted in his environment. But controlled and understood it should enable the individual to react with his environment on a continuously more satisfying and productive plane of living. What then is the role of the school, and specifically that of the science teacher, in this process? Let us consider some of the problems which face teachers in helping children develop and use their creative ability in science.

The Climate for Creativity

Most individuals, especially children and young people, by the very nature of the experience of reacting with their environment have at least a modicum of creative ability. Hence the first essential in a creative science program seems to be a climate in which there is a sensitivity to ideas and a permissiveness enabling children and young people to develop their ideas in a creative way, to experiment with real materials and increasingly to identify their own purposes and satisfactions.

It is even necessary that this climate be one in which experimentation and creativity are more acceptable behavior than routine conformity. Such a cli-

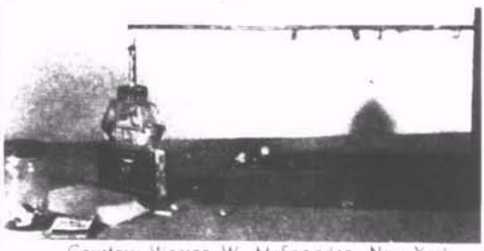


Courtesy Warren W. McSpadden, New York
CHILDREN have developed and tested many ideas with this simply constructed balance.

mate would involve many aspects, some of which are peculiarly important in the science program. One of these which frequently seems neglected in thinking of science is the freedom to make mistakes and the freedom to accept and profit from failures. We have so long, and correctly, assumed that success experiences are essential in the development of children that we have almost excluded experiences in failure in situations which do not involve social condemnation. Such experiences may contribute to the successful adjustment of the individual in real life situations. Mistakes and failures are such a commonly observed phenomenon of genuine experimenting that realistic science experiences can in this way probably make a unique contribution to children and young people's development.

Part of this understanding of failure and mistakes can and often does come from realistic studies of any of the great scientists. A more lasting contribution to the individual will no doubt arise through his own failures and mistakes in experimenting and in carrying out other creative activities in science. Any genuine experiment planned and carried out by the student himself on something *of importance to him* involves almost inevitably some element or risk of failure. Watching a student try to develop an efficient and inexpensive wet cell or storage cell is often a lesson in frustration and its resolution. If it is not the concentrations of the solutions, it is the original cleanliness of the plates or the looseness of one or more connections which is effective in "gumming up the works." A clearly printed instruction sheet from any of the standard laboratory manuals eliminates almost all of this frustration and possible confusion (when directions are followed). However, the end result in terms of the individual's growth in genuine understanding and creative ability is open to serious question.

Problems in real life have not been carefully deleted of elements of risk or confusion; therefore the more closely the problem or experiment is related to real life situations the greater is the risk of frustration. Traditionally science teaching has been concerned with handing down an organized body of knowledge. The firsthand experiences (almost exclusively within the school



Courtesy Warren W. McSpadden, New York
A SIMPLE idea in conduction prompted this piece of equipment. The burner is an old ink bottle with a piece of tin can shaped around a pencil soldered to the top for the wick holder.

Courtesy Warren W. McSpadden, New York

COTTON batting layers with tempera powder sprinkled between the layers can help in developing the idea of rock folds, mountain building, coal veins and many other concepts of the layers of the earth.

laboratory) of students have been concerned with the repetition of a set of traditional experiments or with a verification of statements or theories presented either in a standard text or by a standard instructor. Textbooks and laboratory are set up to eliminate extraneous and confusing data and conditions when a certain topic is treated. This is an artificial environment almost completely divorced from the real environment from which the data of science actually springs. If a transfer to solving problems in real life is desirable then teachers will do well to consider thoughtfully whether this risk of failure or error is not a worthy part of the creative process.

A climate for creative activity in the field of science, as in the field of aesthetics, often involves simple or sometimes complex conflicts with cultural patterns, group mores or routine classroom methods. Children, young people and adults must then be helped to understand these conflicts and, perhaps even more basic, to respect the individual and his right to develop his own ideas. For example, one little girl who has been watching Eddie put two flashlight bulbs in the circuit, promptly comes up to the teacher and says, "Eddie is doing it differently than you did. Please make him stop!" This child needs to be helped to see that Eddie is simply trying out an idea he has and that by so doing he may discover something very interesting and important to all of the group. Or the science class that draws up plans to plant shrubs and perennials on the school ground as part of a study of plants and their relation to their environment (ecology) may be met with the reaction that the school grounds were landscaped by the architect and he knows what is best. (In this particular case the landscaping amounted to a smattering of trees and shrubs, many of which are now defunct.) What is the role of the expert in knowing all of the answers? How in our culture can we use the expert in developing rather than inhibiting the creative process? How can teachers help children and young people learn to experiment and be creative under such a role for the expert?

Another conflict of creative activity with a cultural pattern involves the emphasis in our culture upon conformity. Both Eddie's situation and the situation involving ecology represent in some aspects a conflict with the need to conform to the established way of doing something. Commager in "The American Mind" comments sharply on this need to conform as one of our cultural patterns. Many desirable improvements in communities, specifically housing, sewage developments and many others, lend themselves to a creative study in science. If we, as teachers, can help to minimize this anxiety over the hazard of breaking into the established patterns, much greater success can be achieved. Perhaps this emphasizes as clearly as anything could the need for teachers to understand the social milieu. Effective social interaction will always be an important part of the success of any enterprise in science whether it be a simple series of experiments for an eight-year-old or solving a problem on the secondary level such as eradicating flies in the community.

Many of us as teachers need help from competent social scientists or those competent in social psychology. We need to examine our own hesitancy to allow certain creative projects or activities to be carried through to their logical conclusion as action in a specific school or community situation. If such an analysis of the social problems involved can be made, then the children and young people can be helped to make a more effective application of their science data and conclusions to actual, real-life situations. This action phase of the science program is surely one that has long been neglected. The resolution of this problem will make one of the most positive contributions possible in enabling people to sense the ways in which science can actually raise the level of living in their region and community.

Purposes and Satisfactions in Creative Activity

In science the purposes of creative activity may run the gamut from just plain fun and physical excitement to actual resolution of some problem such as serious erosion on the playground or testing the contents and efficacy of certain products used from day to day by members of the group. But surely as children and young people learn to identify their purposes and derive joy and satisfaction in this knowledge, creative activity will contribute more to their development as self-assured and socially responsible individuals. At first the purposes may be only very vaguely identified. They may not necessarily be identified by the individual himself; the teacher may have to play a significant role in helping individuals. As individuals develop this sensitivity so will the group increasingly identify their group purposes.

In one instance, a discussion by a group of children on ways of solving the problems created by the poison ivy on the playground led to a number of creative attacks on the problem, as well as developing a sense of group purpose and sensitivity to the role of a group in such an enterprise. Helping these children identify and become articulate about their purposes was an important factor in helping the group carry out the work themselves on a creative

Courtesy Warren W. McSpadden, New York

OLD cookie tins on adjustable standards such as these can help children experiment with causes, effects and possible controls of erosion.

plane, rather than to have asked the janitor or someone else to do it. Furthermore, helping children see their purposes change as they do a creative piece of work enables them to keep a continuing sense of perspective and perhaps in the end to realize greater achievement than they originally anticipated.

Don was making a simple electromagnet out of a spike and some bell wire. But he cut too much wire. So he "figured" he could put it on a stick and have a little fancier one. Then someone suggested that he could make a derrick with an electromagnet on the end. Again with much "figuring" as to how he could use such a machine, a derrick emerged, first as a plan, then as a reality. At each stage however he had taken time to re-align his purposes with his needs and his original interest considered. He finally said, "Gosh, I really have something now. I sure never knew I'd make that good a one when I started." His joy and satisfaction were shared by each one who had shared his changing developing plans.

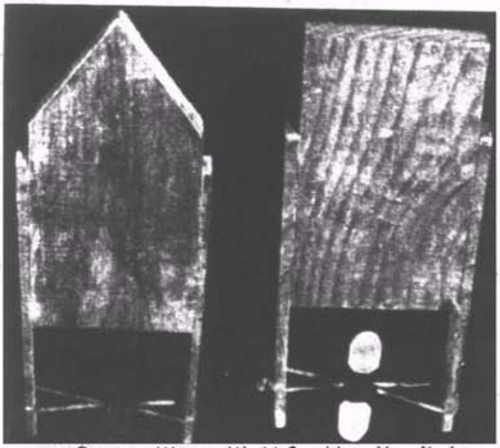
In the modern world, as modern children know it, the bizarre and the fantastic play an ever-growing role in the purposes of experimenting and making things in school and at home. How to maximize their positive aspects and minimize the negative requires skillful guidance. Perhaps more extensive reading in the "space comics" by teachers would enable them to understand realistically the point of view they hear constantly from young space enthusiasts. Perhaps teachers too will be signing up for reservations on the first trip to the moon.

Materials for Creative Experiences

One of the fortunate aspects of working in science is that it deals with the materials and forces of the environment. Hence the materials of science are the materials to be found all around us. Theoretically at least there should then be no problem in having materials readily available for science teaching; but too many classrooms are without materials for firsthand experiences in science. Perhaps one of the factors in the lack of real materials in the classroom lies in the fact that modern books have somehow become a substitute for the basic materials of the environment. Actually books are the end products of creative experiences. Children, young people and adults need however to interact continuously with materials in order to give meaning to books. Weightless levers as used in problems in science texts are so common that a student in an actual situation, considering a long pole heavy enough in its own right to raise an object, faces the dilemma of almost having to believe it can't be so.

Another factor lies in the lack of simple equipment for carrying on experiments and organizing experiences with everyday materials. While it is assumed that some equipment is necessary in using materials, much equipment lends itself to simple construction and improvisation, both basic parts of creative activity in science. The construction of simple equipment such as that pictured in the accompanying photos is not only a creative activity in its own right, but is even more significant as a continuing part of the room equipment. Children will always want to know if "you are still using that balance Joe and I made three years ago." A few years of such creative activity can make definite inroads on the equipment needs of any classroom. Budgets for science teaching equipment and material needs are essential, but perhaps spending allotted funds for microscopes, chemicals and other items which cannot be constructed will enable a classroom to be more adequately stocked over a period of some years. Much material for constructing equipment is readily available through collecting trips, even to the scrap yards and dump heaps as legitimate sources of materials. In elementary classrooms the development of a science corner with a small work space, shelves and boxes or kits to hold the materials collected on various topics will help to minimize the confusion of materials scattered about and soon lost to effective use.

The solution of the problem of equipment and materials is surely basic to the effectiveness of our work in science teaching. There are many approaches to solving it. The lack of materials and equipment can in some instances lead to the use of otherwise ignored areas of resources outside the classroom. One teacher, in an actual instance, helped children preserve food in the classroom and in the lunchroom kitchen in order to be able to send to Europe and other war devastated areas the tin cans of food contributed by parents for the lunch program. She and her children realized that their gardens were full of food which could be used in the lunch program for many weeks. They also knew that only tinned



Courtesy Warren W. McSpadden, New York

ONE boy thought these models would help others to understand the importance of streamlining. Both boats are the same weight with identical paddles.

food could go to Europe. Hence a creative attack on the problem yielded not only good lunches for weeks to come, food for hungry people, but also gave the children realistic experiences with air pressure, sterilization, vitamins, food values and perhaps above all the fact that data of science is useful and pertinent to our everyday living and to the building of a healthier, happier world. Equipment in this instance was at a minimum, but science understandings and values flourished as seldom before.

Getting Out of the Routine *of Uncreative Teaching*

What happens to produce a creative situation in the classroom or in the laboratory? Why do opportunities for creative experience always seem to occur with certain teachers or in certain localities? One can almost hear readers saying that examples like those quoted never develop in my school or community. It is not unreasonable to assert that certain things do help to develop creative approaches to learning. First among these will always be genuine planning with the children and young people of the group. Teachers who have enough personal and educational security to be willing to plan honestly with children will find themselves with more creative possibilities than can be carried out adequately. In many actual instances it has developed that teacher pre-planning, when reacted upon by students, takes such a different turn that the original plans are unrecognizable. Yet in each instance where genuine interactive planning took place the end results of such planning by the group were not only creative but amazingly mature in the attack on the topic or problem.

A study of the human body at the college level was deemed important by students and instructor. A preliminary plan submitted by the instructor to a planning council, made up of the instructor and representatives from each of three class sections, was discussed and frankly criticized. The instructor's approach seemed illogical to the students (though completely logical to the instructor) and they felt that the subject matter experiences involved were not the ones to enable them to get at their real problems and questions. The final plan of the planning council when presented to the three sections met with almost instantaneous approval. However certain problems in carrying it out were immediately evident. The chapters in the text did not necessarily follow the outline; library references were made available and used. The instructors did not feel competent to deal with all the problems listed; state health department lecturers were called in. Many other such problems needed to be solved. The final study of the human body was organized chronologically, from conception through senescence. This represented a major departure from the traditional "systems of the body" approach. Final evaluation indicated much more successful learning than in previous studies of the human body under the systematic approach.

Second in importance in developing a more creative approach to learning would surely be individual study of each of the children in a group. Sensing individual needs and development through such study has seemingly been most effective in helping teachers redirect their efforts into more creative channels.

Situational testing, wherever a testing program can be used effectively, is a powerful factor in helping both students and instructors evaluate the usefulness and value of the data they know. Such simple test items as "Why hill up corn and not hoe it close to the stalk?" helped one class sense that they were not learning much they could use in everyday experience. Situational testing as used here is simply the use of practical real life situations as the basis of testing problems. Comments of "unfair, it isn't in the book," usually greet first attempts, but continuing attempts become both a challenge to the instructor and to the student to study in such a way as to make data useful.

Questionnaires or opinionnaires to lay people, prepared, distributed and tabulated by members of the group have also been effective. Such an opinionnaire entitled, "Content of experiences in science which would have been helpful to you in solving your present problems of living and working," proved beneficial in giving a student group a totally new perspective on the content of the science program.

Many other ways of re-orienting both teachers and students are possible. Space limitations preclude specific detailed examples. The problem of reorienting programs or simply developing more creative individual experiences is still basically one of responding thoughtfully to individuals, their desires, their needs and their problems. A most profound respect for the individual on the part of the teacher is implied in furthering any creative activity of groups or individuals. Perhaps developing genuine respect for the individual, however one does it, is the most basic preparation for teaching in a creative manner .

This discussion has not been intended to provide simple answers as to how to bring about creativity in science teaching. The matter is not a simple one! It seems rather more important to identify some of the issues involved, perhaps begin to clarify some of their implications in science teaching and then to rely upon the creative ability of the *reader* to develop a climate and an environment in which creativity can become a part of the activities, thinking and practice of a specific group in a specific school in a specific community. What works for one may not work for another.

However, it is hoped that the preceding discussion may be of some help to teachers in their eternal quest for the best way to help their group in growing up to be well adjusted, creative and effective citizens. The world is sorely in need of these citizens who can make a creative contribution toward a better and a peaceful world in the years ahead.

Creative Teaching *(Continued from page 139.)*

not follow the customary order—with the resulting knowledge and interest far exceeding what is commonly got.

The chief factors now preventing creative teaching are, first, the departmental subject-matter teaching still common in our secondary schools and colleges.

The second main hindrance is the implicit teaching of the ordinary graduate school that research is the one sole and proper aim for higher education. This attitude gets instilled into college teachers and they in turn then do what they can to instil it into prospective secondary school teachers. Fortunately, our secondary school teachers particularly in the social sciences and in English are overcoming this bias. It does, however appear that we must extend the activity program core work throughout the six years of junior and senior high school. This gives creative group work its great chance, while it relieves the departments of those who are not interested in as specialized work as the departments would like to offer. It appears, all things considered, that the secondary school core is the next great advance if creative teaching is to prevail. — *William Heard Kilpatrick*, professor emeritus, Teachers College, Columbia University, New York City.