Perspectives

SCIENCE AND EDUCATION: A SHAKY PARTNERSHIP

I am frequently overwhelmed by the number and variety of instances in which the terms "science" and "education" are combined to the possible detriment of both. It is, nonetheless, my lot to be described on occasion as a "science educator." The implications of the term have been a source of both inspiration and consternation, in part because the term suggests the achievement of an interdisciplinary expertise that may not be verifiable. One could infer that this is a Scientist involved in educating, or an Educator teaching science. The term is most often applied to persons in universities and colleges who are involved in the preparation of science teachers, which justifies neither of the above inferences. A possible connotation in the literal sense is that the term should describe a person who is sufficiently "literate" in the sciences and sufficiently skilled as a teacher to act as an accurate and *effective* conduit for science knowledge and scientific process skills between the research scientist and the student of science at any level. This should attest, further, that the Science Educator could model that effective behavior in such a way that others would be able to acquire it through imitative or more complex developmental behavior.

The state of science literacy suggests the competence to read and comprehend scientific literature and to display that understanding through verbal and written communication; but that should be only half the task of the science educator. The other half should entail the competence to diagnose and prescribe for the science-learning needs of persons across the entire range of learners, or within some significant portion of that range; and, beyond prescription, to create and activate an environment in which the prescription is implemented and the learning need is satisfied.

Only minimal perception is required to determine that these are herculean tasks taken separately, not to mention combined. The proliferation of scientific literature forces a high degree of specialization upon the literate reader; at the same time, the state of the art in diagnosing and prescribing for learning needs suggests substantial disarray. In my opinion, it is easier to *achieve* scientific literacy than it is to *teach* it—and I recognize the contradiction in that statement. While an individual may, through individual motivation and effort, acquire a substantial body of knowledge and skill in an area of scientific inquiry, the task of the science educator frequently requires him to stimulate the emergence of the potential learner's motivation, initiative, and effort as well as understanding and skill. This challenge leads the science educator on forays into frequently unfamiliar disciplines—psychology, sociology, and psychopathology, to name a few. It may, further, lead the committed, but unwitting, science educator to grasp for the straws of logic acquired from training in the natural science disciplines to keep from drowning in the ambiguities and rhetoric that beset the social sciences in general, and education in particular. These efforts to rationalize the process of education have traditionally been labeled "scientific education."

Two manifestations of current concern with more "scientific" education are (i) the growth of systematic curriculum-making and (ii) the accountability movement in teaching, that is, performance-based education. Both of these movements, however fragile in their infancy, require a theoretical base—a presumed logic that involves examination of decisions and their consequences, and that anticipates being able to, at some future time, predict the appropriateness of particular decisions for particular cases and for the achievement of particular outcomes. These two curricculum movements are closely related and are often considered as one. Nevertheless, what they represent—in part—is a larger class of problems concerned with human cultural evolution and our potential ability to control and direct it, as well as with our desire for a quality of life that somehow supercedes what we are currently experiencing.

Educating is central to the problem. Science education and the specific kind of literacy it can provide is probably secondary. What seems to me to join the two is the credibility that scientific thinking can give to the effort to solve the problems that beset education in achieving the status of a discipline in its own right. In spite of the primitive quality of current efforts toward more scientific educating, there are few alternatives of equal standing to be found in the literature today, especially if one uses logic as the major criterion. Certainly what schools have done and are still doing to educate the young defies any consistent logic.

This issue has been joined before, and both previous and current attempts at establishing a scientific base for education have been severely criticized by concerned and skilled intellectuals. But the effort persists, and valuable as those criticisms may be in helping to identify weaknesses, the critics have not left their lofty perch to join in the gut-level effort that involves an expanding multitude of workers in the field. Some critics define science and scientific thinking so narrowly as to hold them inappropriate for use in education, and would thereby seem to discredit many whose experimental work has been crucial in revealing new ways of understanding and cultivating human development and behavior.

I am not yet convinced that there is no hope for those efforts and I shall continue to ignore the slanders that now charge educationists, curriculists and behaviorists with a naive scientism. It continues to be obvious that elitism in intellectual pursuits is not yet dead, and until it expires, the term "science educator" may have to suffice with only half a meaning. What do *you* think?

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Demonstrating Mitosis . . . from p. 107

other allele. Students form a gamete pool for each heterozygous parent by placing beads representing the two alleles in a 50:50 ratio in a beaker. Gametes are pulled out of each pool and brought together to simulate fertilization. The genotype of the zygote is recorded, the beads replaced, and the process repeated. This demonstration serves as an introduction to probability, Mendel's law of segregation, and dominance.

Independent Assortment. Independent assortment can be demonstrated by using two beakers for each parent. Each beaker contains different colored beads in a 50:50 ratio to represent the alleles as before. The two beakers contain separate gene pools formed from genes at two unlinked loci. This independent drawing of the beads from each beaker may help clarify the idea that unlinked genes assort independently into the gametes. Fertilization is simulated, the genotype of the zygote recorded, beads replaced, and the process repeated. Depending on the restrictions placed upon interaction between alleles and between loci, various phenotypic ratios can be demonstrated (Mertens 1971b).

Hardy-Weinberg Equilibrium. At a later time in the genetics course, the beads can be used to teach Hardy-Weinberg equilibrium. A gene pool can be represented by using one color of bead to represent one allele and another color the other allele. Different gene frequencies can be obtained by varying the proportion of each color of bead. Zygotes are formed by pulling out two beads at a time, recording the genotype, replacing the beads, and repeating the procedure.

Conclusions

We feel the model is a very efficient aid for teaching the processes of mitosis and meiosis and for demonstrating the principles of heredity. Both students and instructors have responded favorably to this teaching device, and many students have commented that this was the first time they had really understood meiosis. We feel the time and effort invested in working individually with students on the model has facilitated learning of Mendelian genetics.

Other attributes of the model are that it is (i) inexpensive and nonbreakable, (ii) readily assembled, and (iii) useful for small-group presentation. Students can manipulate the model with their hands, thus coordinating physically and mentally the mechanics of chromosome movements.

The model is also useful in clarifying the meaning of important terms such as diploidy, haploidy, homology, tetrad, chromatid, linkage, chromosome, locus, allele, homozygote, and heterozygote. It effectively demonstrates the process of crossing-over. Using individual beads to represent alleles, the principles of Mendelian segregation, independent assortment, and Hardy-Weinberg equilibrium can be demonstrated by forming gametes from these alleles and then simulating fertilization. The relationship between probability and Mendelian ratios can also be introduced.

We urge others to try this model and share their experiences with us. We are confident many of your students will benefit.

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Omission of Credit

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