Proceedings of the Iowa Academy of Science

Volume 49 | Annual Issue Article 94

1942

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Recommended Citation

Lindstrom, E. W. (1942) "Teaching to Think in a Field Rather Than about It," *Proceedings of the Iowa Academy of Science, 49(1)*, 461-465.
Available at: https://scholarworks.uni.edu/pias/vol49/iss1/94

TEACHING TO THINK IN A FIELD RATHER THAN ABOUT IT.

E. W. LINDSTROM

Perhaps the clearest definition of thinking *in* a field of study as the preferable educational approach is to recall Hazlitt's essay "On the Ignorance of the Learned" where he says, "If we wish to know the force of human genius we should read Shakespeare. If we wish to see the insignificance of human learning, we may study his commentators." Strong words, but they bring out the point. If not, think in terms of pure text-book learning.

Another helpful example may be found in Schopenhauer's essay "On Thinking for Oneself." Here it is pointed out that people who have spent their lives in reading and acquired their wisdom out of books resemble those who have gotten information about a foreign country from descriptions of travellers. These people can relate a great deal *about* many things; but at heart they have no connected, clear, knowledge of conditions *in* that country. While those who have spent their life in thinking, are like the people who have been *in* that country themselves; they alone know really what they are saying, know the subject in its entirety and are quite at home in it.

Thinking *in* a subject means a rigorous mental discipline giving mastery of a relatively few basic principles and knowing those principles thoroughly. That in turn means less of the usual parade of facts to be memorized, and, I hope, a minimizing of the huge number of educational courses which so burden our curricula and our catalogues. This trend has reached the level of a racket and necessitates the focussed attention of the teaching profession before we are hoisted by our own petards.

To generalize concerning educational methods and processes is not only dangerous but often exceedingly foolish because no one system is applicable to all the individualistic patterns of the human mind and the human spirit. We should, however, constantly refresh our thoughts and orient our ideas in the fundamental truths of the learning process. I have been flattered by the Program Committee into giving some of my experiences in teaching the elementary courses in Genetics over a period of a quarter century. In this course I have tried to make this field a living subject by stimulating thinking *in* rather than *about* this science. We have tried to emphasize "what is under the hood" rather than to memorize the superficial aspects of an automobile. This method is not easy; the poorer students require nearly a full term to grasp what the instructor is driving at, because they have become so thoroughly immersed in, and drugged by, the prevalent memory and regurgitation schemes.

The techniques are not new, they merely need re-emphasis and possibly further discussion. At any rate, the objective of this paper is merely to re-stimulate thinking along these lines because education, like all other disciplines of the day, is being re-evaluated in terms of integration into a changing world.

Our methods of instruction center around two principles:

(1) a thorough understanding and mastery of a half dozen concepts or principles

(2) an inductive scheme of weaving common, every-day facts into a systematic whole.

This we do by the usual techniques of lecture-demonstration-discussion in the class room, by regular sets of problems designed to stimulate creative thinking, by optional outside readings (no text book used in the course), by optional review or discussion sections, and finally by as many essay-type examinations as possible. Running through the course, but never formally expressed, is the scientific method of acquiring knowledge, largely inductive. The student soaks up the manner in which scientific observation and "the barn-yard facts of life" are woven into hypothesis, theory and finally into law. There emerges the half-dozen generalizations which we think essential for the university student. In our specific course, these are the gene-chromosome system with its applications to simple and quantitative inheritance, the story of inbreeding and heterosis, the heredity-environment problem, the integration of all these into the principle of organic evolution and finally the applications to plant breeding, animal breeding and problems of human biology. The students are conditioned to the idea of mastering these few fields.

Memory and professional jargon are at a bare minimum. Necessary formulae or mathematical approaches are first handled by 'brute strength and awkardness' and then later formalized, but only the best students are expected to master the abstract formulations and to express them in mathematical formulae.

How different from much of orthodox teachings! For example my daughter in high school algebra has just 'finished' the section on the binominal theorem. Both text and instructor go no further than to work out and memorize that long formula for expanding a binominal. Their examinations ask for the 3rd or the 7th term of a series. Nowhere is the student given an insight into the meaning or real application of that formula. How easy to approach it first by 'brute strength' taking for example, the determination of the probability of the numbers of boys and girls in families of two children, of three children, of four children, etc. I trust that this example is not characteristic of the teaching of mathematics.

How often do we teach cell-division in biology with its mere memory of terms (prophase, metaphase, etc.) leaving the student with no real understanding of the real function or dynamics of this vital process which is far more than to make two cells where one was before. The entire concept of life's stability or its lability rests upon cell reproduction, somatic or germinal.

How often do we spend hours and hours in elementary courses of biology on the detailed morphology of a grasshopper or the sex-life of a fern and slight the vital problems of human health, nutrition, physiology and heredity. Why? Usually because our teachers have learned these very details themselves in their specialized courses and have never had occasion to think deeply in the science of life. One can teach physiology, nutrition or heredity before all the details of morphology, cytology, taxonomy, etc. are mastered. Often the latter can be given as advanced courses just as well, if not better. Preferably, of course, they can be included in the so-called applied courses.

You might be interested in the very recent (1942) evaluation of "The Teaching of Biology in Secondary Schools of the United States" by the Committee on the Teaching of Biology of the Union of American Biological Societies. Teachers of biology were asked to submit "the 4 or 5 topics on which they would place the most emphasis in a high school course in general biology." The committee believes that the results of this questionnaire would reveal the "trends and present effectiveness of biological teaching in our schools." A total of 866 teachers in 15 states replied, listing twenty-two topics.

The top five items listed in order with their votes were as follows:

1. Health-disease-hygiene (397)
2. Heredity-genetics (282)
3. Physiology (263)

4. Conservation (127)
5. Structure (102)

The lowest, or least popular, topics were:

18. Eugenics (31)
19. Behavior (29)
20. Scientific method (21)
21. Biological principles (13)
22. Photosynthesis (13)

Intermediate topics were: Reproduction (90), Taxonomy (88), Ecology (88), Nature Study (87), Environment (67), Insects (53), Nutrition (52), Economic Biology (50), Life Processes (49), Sex Education (39), Evolution (39), Adaptation (37).

This list merits a fuller discussion than time permits. But it is significant that biology teachers in secondary schools are beginning to realize the functional aspects of their science. Nevertheless, there still exists the danger that in motivating students with these functional or applied phases the discipline becomes superficial and not rigorously mental. Such a suspicion easily arises when such topics as photosynthesis and biological principles land at the bottom of the list. Certainly good, basic science can be given in the applied phases of science, but the courses must so be planned.

The editors of the above report deplore the trends, feeling the data show "widespread tendencies to teach biology not as a science but (a) as a way to pleasing hobbies, or (b) as a series of practical technologies." Further they state as axiomatic in college and university levels, the rule, "The basic sciences first, applications afterward." I have a faint suspicion that the truth lies between these extreme viewpoints, certainly so at the secondary level and often so at the junior college level. When elementary 'basic sciences' are taught as an end in themselves without real integration or application to life they often have the record of killing interest in the great majority of students so that they never attain the 'applications afterward'. If these 'basic sciences' are taught as they can and should be, they may well include the two aspects, theoretical and applied. This opens the road for thinking *in* the field rather than *about* it.

It is no new experience to teachers of senior college courses that students enter with shockingly little understanding of the 'basic courses'. In my own experience, it is the rare student who can use his mathematics or his biology, to say nothing of his English and logic, in a new field when the use of those tools calls for a slightly different approach from his memorized (and forgotten) learning. Accordingly, I am less and less concerned with any prescribed order of learning, basic or applied, first or last. What is important is that the student shall have discovered how to use his mind and his learning. Mere book learning is not enough. The student, like the real citizen, must be first of all a man of intellectual action (thinking) as well as a storehouse of half-forgotten class-room ideas.

Too much reading or too much school-room learning robs the mind of its elasticity. This makes many men more stupid and foolish than they are by nature. This condition may often be discerned in men of learning, making them inferior in sound understanding, correct judgment and practical tact to many illiterate men who, by the aid of experience, conversation and a little reading and learning, have acquired a knowledge making them capable of action. They do their thinking in their activity. It is what a man has thought out directly for himself that alone has true value.

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