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Undergraduate Student Research: An Approach to Improving Student Critical Thinking

Many college instructors lament that students do not work logically through problems. Instructors at each rung of the educational ladder blame this deficiency on those on the rung below until only the students and their parents remain. Wherever the problem lies within the system, instructors in every discipline have an obligation to improve students' reasoning skills. But they can expect to face one or more of these problems.

- Students have not been trained or have forgotten the basic procedures needed to recognize a problem, collect adequate information, and derive logical conclusions.
- Students and instructors can be impatient and want immediate results. Developing reasoning skills in students can be a time-consuming, frustrating process. Your investments may not be realized immediately and will be sustained only if students receive continual reinforcement through the rest of their educational careers.
- Many instructors will have to change the way they teach. The old comfortable techniques may have to be modified in order to try an approach with unknown results and risk the possibility of making mistakes.

Framework for Problem Solving

An introductory science course where the principles of the scientific method can be performed easily through experimentation is an ideal place to introduce a comprehensive program to train students in the proper techniques of problem solving. The scientific method provides students with a logical framework to investigate and solve problems. The steps in this process are:

1. *Problem identification*: Students must be taught to be observant and to ask "why?" when they do not understand an observation.
2. *Collection of background information on identified problem*: Students must learn about resources available to investigate a problem and how to utilize them efficiently.
3. *Formulation of a hypothesis*: Students must be taught how to use the background information they have collected to develop an educated guess as to the outcome of the observed problem.
4. *Testing of the hypothesis*: Students must be taught how to design an experiment to test their hypothesis.
5. *Unbiased evaluation of experimental data*: After students complete their experiment, they must be taught how to analyze their data and draw logical conclusions.

Students must realize that if their experiment fails to support their hypothesis, they must be flexible enough to revise their hypothesis and/or redesign their experiment and try again.

Working Model

Within the sciences, many students have been conditioned to expect that an experiment can be completed within two to three hours and that it will always work. These expectations are far from reality in the scientific world where answers to simple questions may take years and millions of dollars to solve. To assist students in developing an appreciation for scientific research, acquiring problem-solving skills, and preparing for transfer to upper-division courses, the biology department at Darton College requires all students enrolled in General Biology to participate in a student research project. Each student uses a computerized work station connected to the Local Area Network (LAN) to assist with literature retrieval, data analysis, and scientific report writing. As a pre- and/or corequisite for General Biology, all students are required to enroll in a microcomputer orientation course that trains them to use a word processing and spreadsheet program.

Each research project lasts approximately nine weeks. Instructors provide students with information regarding the project during lecture and laboratory. During the course of the quarter, only one three-hour laboratory for setting up the experiment is dedicated to the project. In order for students to complete their projects, they must organize their time to work on their projects after they finish their formal laboratory for the week or at another time when the laboratory is open.

During the first quarter of General Biology, the research librarian and course instructor train students to retrieve scientific references using an on-line computer network, a CD-ROM computerized database, and a scientific index. After students have been trained in literature retrieval, they are assigned a research problem and work in teams of two to assemble a bibliography. The bibliography is submitted to the instructor on a floppy disk for review. The submission on floppy disk ensures that each team is able to use the word-processing program for the project. After the instructor approves each bibliography, each team collects appropriate references and uses the computerized work station in the biology laboratory to write the research proposal. Each proposal includes a statement of the problem, literature review, hypothesis, and a complete materials and methods section, including method of data analysis. The proposal is submitted to the instructor for editing. Edited papers are then returned to each team of students for revision. Revised papers are resubmitted to the instructor for evaluation.

Students can now set up and perform their experiment. After the completion of the experiment, each team must statistically analyze its experimental data using a statistical program on the LAN. Each team prepares a results and discussion section for its project. This section of the project is submitted to the instructor for editing. Edited papers are returned to each team of students for revision. Each team then assembles its entire research report for evaluation by the instructor.

During the second quarter, students utilize and build on the research skills they developed during the first quarter. Research projects for the second quarter require students to work individually on a problem that they select. At the end of this quarter, each student presents his/her project in the form of a poster session.

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Suanne D. Roueche, Editor
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