NABT Statement

Role of Laboratory and Field Instruction in Biology Education

Philosophy

The study of biology provides students with opportunities to develop an understanding of our living world. Biology is the study of life and its evolution, of organisms and their structures, functions, processes, and interactions with each other and with their environments. Scientific inquiry is the primary process by which scientific knowledge is gained. It involves the basic skills of questioning, prediction, qualitative and quantitative observation, classification, inference, communication. Additionally, inquiry develops integrated skills such as identifying and controlling for variables, generating procedures, planning strategies for testing hypotheses and answering questions, and for collecting and interpreting appropriate data. The knowledge of biology includes scientific data, concepts, hypotheses, theories, methodology, use of instruments, and conceptual themes.

Biologists recognize that knowledge based upon experimental results and accurate observations is gained through a variety of experiences. Thus, the role of the laboratory and field learning becomes a key component in understanding biology. Laboratory and field activities and inquiry provide students with opportunities to question, observe, sample, experience, and experiment with scientific phenomena in their quest for knowledge of living things.

The most effective vehicle by which the process of inquiry can be learned appears to be a laboratory or field setting where the student experiences, firsthand, the inquiry process. Laboratory and field study have also been demonstrated to be effective means for comprehension, understanding and application of biological knowledge. Lab and field experiences provide opportunities for teachers to model best practices in the study of biology, including application of scientific methodologies, respect for life and the environment, inclusion of learners of all abilities, and consistent adherence to safety standards. Thus, study in a laboratory and/or field setting is an integral and essential part of a biology course. The following are recommendations regarding teaching strategies, physical resources, and curriculum development that will enhance the study of biology and improve the quality of biology instruction in our schools.

Definition of a Laboratory Environment

In a laboratory or field learning environment, students work individually or in small groups on a question, problem or hypothesis. They use the processes and materials of science to construct their own explanation of biological phenomena. They observe, collect data and interpret data of life processes, living organisms, and/or simulations of living phenomena. The distinction between laboratory or field learning and traditional classroom learning is that activities are student-centered, with students actively engaged in hands-on, minds-on activities using laboratory or field materials and techniques.

Teaching Strategies

1. Direct experience. The laboratory and field components of biology instruction should provide experiences for direct student involvement which emphasize the above process skills and the

tentative nature of science. Knowledge is gained by observing cause and effect relationships among variables. It is essential for students to be provided opportunities for questioning, hypothesis formulation, experimental design, and data analysis. Also, students must be given opportunities to pursue procedural options rather than simply follow recipes. They must be provided opportunities to design and carry out their own experiments. While computer-assisted instruction and video materials contribute to biology learning, they should not be used to completely replace direct observation of living organisms or for experiments in which students learn cause and effect relationships between and among biological phenomena. School administrators need to recognize the expenses related to offering experiential, hands-on laboratory courses and strive to provide adequate funding.

2. Instructional time. Biology courses should have an integrated laboratory and/or field experience component in which students spend at least one-half of their total instructional time. Provisions for this amount of laboratory and field work should be made in the curriculum of a biology course.

3. Instruction. Each teacher's expertise should be paramount in determining appropriate lessons and sequence of instruction. Research has shown that beginning a unit of study with experiences in a laboratory or field setting allows students to construct new knowledge for themselves. These experiences can provide the basis for the introduction of more abstract concepts presented in lectures, discussions or reading assignments. Teachers should be supported in introducing such experiences at the beginning of each unit.

4. Quality of instruction. Biology laboratory instruction should provide students with frequent opportunities to observe and experiment with living materials, as opposed to nonliving specimens or artifacts. Use of preserved specimens rather than models should be incorporated when models cannot provide the same experience adequately. Every student should have direct, hands-on experiences with the laboratory materials. Resources should be available to allow all students, regardless of ability, to experience laboratory and field instruction in a safe environment.

5. Teacher education. Teachers of secondary biology laboratory instruction are expected to have a major in the biological sciences and should have formal training in laboratory and field teaching strategies (see Biology Teaching Preparation Standards for Middle and Secondary Teachers). Instruction in biology laboratory and field study should be an integral part of pre-service and in-service teacher training. Ideally, pre-service teachers should do "lab and/or field science" under the guidance of a research scientist. One cannot truly teach or truly understand process science until he/she has science research experience. Educational institutions should encourage their life science teachers to grow professionally by attending summer institutes and professional meetings, as well as taking graduate courses in biology and biology education. Administrators should seek educational funding from available sources to support and compensate teachers in their efforts to update their current knowledge and to network with colleagues from different schools.

Facilities, Classroom Environment and Teacher Load

1. Laboratory space. Adequate and appropriate facilities, materials and equipment need to be provided for students to learn biology in a laboratory and field setting. This is essential at all levels of biology instruction, including elementary school, middle school, high school, college and university. The laboratory space should be available to the teacher during the planning and preparation period and available to students for special projects, makeup laboratories, etc. outside their regular class hours. Each student should have his/her own laboratory work space.

2. Facility. The laboratory classroom should be equipped with work tables that have sinks, a water supply, and natural gas and electrical outlets available in sufficient quantity to support a laboratory/field-oriented biology course. Adequate ventilation, fume hoods, reference materials.

and laboratory size must allow all students to participate in real hands-on activities. There should be adequate space for storage of materials and secure areas for storage of solvents, reactants, or potentially hazardous or dangerous chemicals as per guidelines set by the American Chemical Society. Facilities should be inspected for structural and configuration updating every 10 years. There should also be a space dedicated to growing living specimens for study in biology classes.

3. Materials budget. The National Science Education Standards address the need for making resources available. Allocation of funds must provide opportunities to learn in an inquiry-based curriculum. To that end, biology teachers must be provided with an annual budget sufficient to purchase both expendable material and equipment necessary to conduct inquiry-based learning.

4. Safety. Approved guidelines for the safe use, maintenance storage and disposal of laboratory materials must be followed. This includes classroom instruction on safety and emergency procedures. NABT's position statement The Use of Animals in Biology Education (or safety guidelines from organizations such as OSHA, NIH, the American Chemical Society, Flinn Scientific, etc.) and appropriate safety procedures for using plants and microorganisms should be followed. Each laboratory room must be equipped with appropriate safety equipment, such as safety goggles and laboratory aprons for all students, a first-aid kit, a fire blanket, and an all-purpose fire extinguisher. A safety shower and eyewash station should be available within a 20-second walk if exposure to hazardous chemicals is a risk. Safety goggles, if used by different students, must be disinfected. The state Department of Education guidelines for safety procedures should be rigorously followed. Administrators must ensure adherence to applicable safety standards. Professional development for teacher in lab/field safety should be a high priority, along with funding to provide appropriate safety equipment, ensure proper disposal of hazardous materials, and provide sufficient space for students in the laboratory classroom.

5. Class size and supervision. A student-to-instructor ratio in the biology laboratory classroom must permit safe and effective instruction. Class size should be determined by the physical design of the classroom and should not exceed 24 students in a laboratory setting for any reason when students are assigned to a single teacher. Smaller limits should be set if students with special needs require more assistance from the teacher.

6. Teaching load. Due to the extra time and preparation that laboratory courses require, life science teachers should not be assigned more than five classes per semester. Since each laboratory requires a different repertoire of organisms, equipment, materials, supplies, solutions and planning, and also demands lessons plans and grading time, teaching load should not be more than two process-oriented science course preparations and have no more than 24 students assigned to each class. Teachers should have their own science classrooms and have access to those classrooms during their preparation times. Time must also be allowed within the teaching day for the setup and dismantling of laboratory preparations. Where possible, student or adult laboratory assistance should be provided, and in high school, we strongly recommend that a laboratory manager (or instructional aid) be hired to assist in preparation, setup, and dismantling of laboratory materials for experiential learning lessons.

Curriculum Development

Most laboratory and field activities used in the schools are prepared commercially; NABT urges these other developers to provide instructional activities that meet the above guidelines. The most productive curricula will be those with an abundance of active learning, such as laboratory and field investigations, upon which the teacher can base further indirect learning experiences, such as lectures, discussions and assignments.

Adopted by the NABT Board of Directors September 1990. Revised 1994, 2005