Student Assessment

The third phase of the model involves the use of assessment tools to determine if the students meet the criteria for the objectives. The nature of the assessment may be as varied as the environment used to transmit the subject matter. Common assessment tools such as paper-pencil tests, performance tests, oral tests, etc., are used. Regardless of the technique used, the overriding emphasis should be on determining if each objective is measured.

If the instructor has outlined in careful detail the objectives at the lesson level, valid student assessment is made easy – each objective specified as expected student outcome. Within each objective is written the conditions upon which the student is expected to perform the skill. Also, within each objective is the minimum criteria you will expect as evidence of satisfactory performance of that objective. Questions can be constructed to measure each student's ability to perform each objective; however, questions are not the only means of measuring objectives.

This procedure has an added incentive to the instructor, as it provides a framework from which to evaluate students' performance. Likewise, it insures that assessment instruments (tests) are based on the objectives of the course. If students are cognizant of the objectives and the test is designed to measure the objectives, considerable improvement can be made in many courses.

SUMMARY

The Performance Based Model was discussed in three segments: (1) performance objectives, (2) classroom instruction; and (3) student assessments.

Performance objectives were defined as clear, concise statements of expected student outcomes. A distinction was made between the levels of objectives; the discussion was centered on the lesson level. The Magerian method of writing performance objectives was presented. Magerian objectives have three characteristics: (1) they are measurable, (2) they specify the conditions under which performance is to take place, and (3) they state the minimum criteria necessary for successful achievement of the objectives. Examples were presented to illustrate this type of objective.

Classroom instruction, the second phase of the model, was discussed. It was noted that close relationship exists between the performance objective and the instructional activities needed to help each student achieve the pre-stated objective.

Finally, a case was made for using performance-based-instruction to improve the assessment of student outcomes, i.e., to determine student progress.

Performance-based-instruction will provide a tool whereby the instructional process can be improved.

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PLATO: Computer-Assisted Instruction in Animal Genetics

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Increasingly, students are using computers in science education, both as computational tools and in computer-assisted instruction (CAI). Computer-based education is founded on the premise that learning is facilitated by immediate feedback. CAI offers a unique opportunity for combining the computational capabilities of a computer while individualizing student instruction. Perhaps the most versatile CAI teaching system is PLATO (Programmed Logic for Automatic Teaching Operations), developed at the Computer-based Education Research Laboratory of the University of Illinois.

The PLATO System

With the PLATO system, the teacher, student, and computer form an interactive team. The teacher prepares the instructional material, the student responds to this material as it is presented by the computer, and the computer evaluates and monitors the student's performance. PLATO is effective for teaching because it permits large numbers of students to interact with the computer on an individual basis; it permits the students to progress at their own rate of comprehension; and it gives the students a patient tutor that can simulate complex phenomena, drill basic concepts, and diagnose and treat weaknesses.

PLATO maximizes the time the teacher has to handle individual differences in the students' mastery of the subject matter. This is an advantage over most conventional pedagogic methods. In addition, by allowing the student to interact on a one-to-one basis with the computer and the teacher, to take an active role in learning, to learn by discovery, and to progress at his own rate, PLATO has led innovatively in improving the effectiveness, efficiency and quality of education at the college level.

The most recent version of the PLATO teaching system is known as PLATO IV. The system includes terminal equipment (hardware) and computer programming (software). Lesson writing for PLATO uses a programming language based on the English grammar and syntax. The language is called TUTOR and is designed for teachers with no previous knowledge of computers. The instructional material is authored and edited "on-line" from any terminal while "time-sharing" the system with other authors and students. Thus, the lesson material can be easily revised by the teacher to update and improve instruction.

Development and testing of the PLATO system has been in progress since 1960. About half of the 400 PLATO IV terminals presently being used are on the University of Illinois campus at Urbana-Champaign. The remaining half are in nearby locations in these towns and scattered throughout Illinois, the rest of the United States and even in foreign countries.

At this time, there are about 1500 hours of lesson material available on PLATO for student use, with an additional 1200 hours of instruction in preparation. Approximately 3500 lessons are available for use on PLATO, ranging from Accountancy to Veterinary Medicine (1, 6, 7).

PLATO IV Equipment

Through dramatic departures from the traditional system of education, PLATO IV allows the student to assume an active role and to learn by discovery. Each student console consists of a keyset to transmit the student's input (or response) to a central computer, and a plasma display panel which can show computer-generated graphic information and computer-selected photographic color slides to the student (Fig. 1).

The keyset has the same characters and arrangement as a standard typewriter with the addition of several special function keys, e.g. NEXT, HELP, LAB, DATA, BACK, etc. The visual display is a 8½" square, transparent, flat glass plasma panel. The plasma panel consists of a grid of fine gold wires on two transparent, glass plates. One plate has 512 horizontal wires and the

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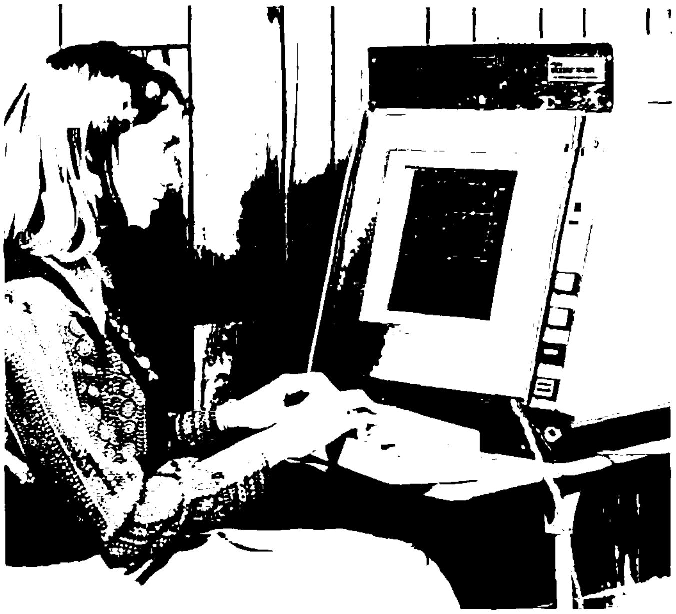

Figure 1: PLATO IV student terminal

other 512 vertical wires. This provides a grid of 262.144 individually digitally addressable intersections. The space between the glass plates is filled with neon gas. When one of the points is "excited," for example by a key press or under computer control, the gas at that point is lighted, creating a dot.

The writing speed of the terminal is 180 characters per second, faster than a teacher can write on the board. The PLATO IV terminal has the capacity of displaying up to 2,048 characters on the plasma display panel, which has permanent storage of information without flicker and which requires no refreshing. The terminal has a mean response time of .2 second to student input.

In addition to the computer-generated display, the student also has visual communication from PLATO by means of a slide selector. Each terminal is equipped with a random-access image-selector which superimposes slide images and display graphics by means of a back projector through the plasma panel. Each video device has a capacity of 256 (16x16) colored slides, in microfiche form, that are randomly addressable by the computer with a mean access time of less than .2 second (Fig. 2).

As optional features, there is a random access audio disc that allows for more than 4,000 messages totaling up to 21 minutes in length, and a touch panel that permits the program to be activated by touch. The audio feature is operated by a pneumatic device, under computer control, with an average access time of .5 second. The touch panel has a grid of 16x16 individually addressable positions by touch. The student simply touches the area of the display panel that is appropriate, and the computer responds with whatever has been programmed for that particular set of coordinates. Simultaneously, then, the system can talk to the student, show him slides, display text and graphics, and accept responses via typing or even merely touching the screen.

The PLATO IV terminals are controlled by a Control Data Corporation CYBER-73 computer system (Fig. 3). Terminals are connected, in groups of 32, to the computer over a single TV channel with a maximum capacity of 1000 terminals per channel. The extended core storage allows rapid access to large amounts of lesson material. Magnetic disks contain a library of thousands of lessons. Estimated costs for the new system are between \$.50 and \$.75 per student per terminal hour. These cost estimates are based on optimum use of the system and include costs of computer, communication lines, terminal equipment, and instructional material development. When fully developed, PLATO IV is expected to serve over 1,000 students and teach 200-300 lessons simultaneously.

Lessons on Animal Genetics

Described here in detail are two CAI laboratory lessons for undergraduates or graduates studying the mathematical principles of population and quantitative genetics as applied to animal breeding (2, 3, 4, 5). Both lessons, written for PLATO IV in the TUTOR programming language, demonstrate through computer simulation the relative importance of the factors determining

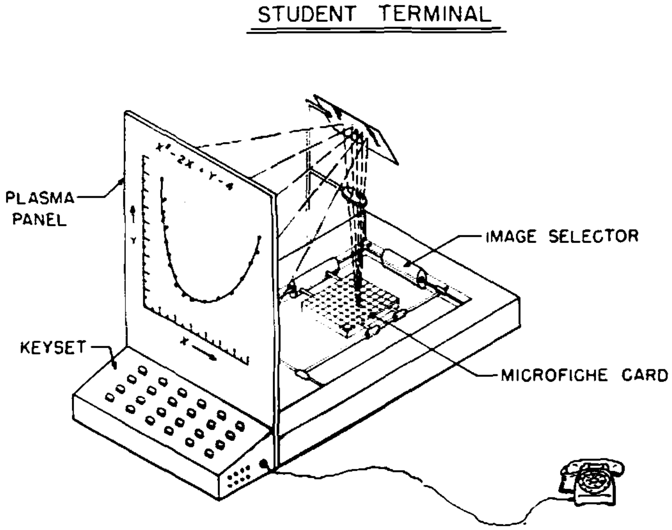

Figure 2: Schematic diagram of plasma display panel.

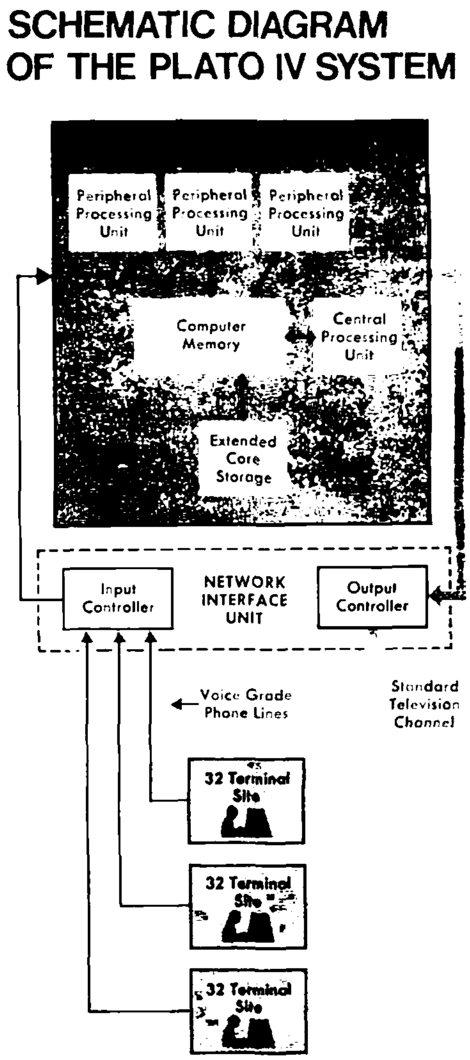

Figure 3: Schematic diagram of the PLATO IV system.

genetic improvement in livestock. The students are able to simulate the genetic results while studying the influence of each individual component. Prior to each lesson, the student receives a flow chart of the lesson, a brief written introduction to PLATO, and a guide to the laboratory exercise.

A third lesson, on genetic counseling, deals with two cases of genetic blood disorders and one of calcium malfunctioning in bone development. The former two cases apply to autosomal recessively inherited anemias in humans, sickle cell anemia and beta thalassemia; the latter case applies to an autosomal, recessively inherited bone-formation disorder in cattle, osteopetrosis. The lesson is intended for medical and veterinary students who have had introductory genetics and some clinical experience, and it is intended for use in courses dealing with medical gentics or those relating to that area. This article will discuss only the lessons on population and quantitative genetics, because they deal more directly with the teaching of animal genetics.

The lesson on population genetics demonstrates how each of three predictable forces – mutation, migration, and selection – affects the change in the frequency of genes in a population. Each force is studied independently to determine the influence of its components: number of generations, rate of the force, gene action, and initial gene frequency.

In the flow of the lesson the student first sees the title page and the table of contents (Fig. 4) followed by a brief description of the objectives of the lesson. If this is the first time in the lesson for the student, he is urged to proceed through the "calculator" option so that he can make use of it in the lesson. Next, the student may see how each force operates in an animal population to change the frequency of the genes determining a trait, say coat color. He chooses the force that he wishes to study (mutation, migration, or selection) and is branched to the appropriate area and then into the simulation and graphing routine.

Each subprogram is joined to a graph sequence so the student can discover the long-term effects of the force on gene frequency and can vary its components independently. For each graph, the student determines the scales on the axes by specifying the range of generations over which the force will be operating (Final n and Initial n) as the abscissa and the range of gene frequencies (Max q and Min q) as the ordinate.

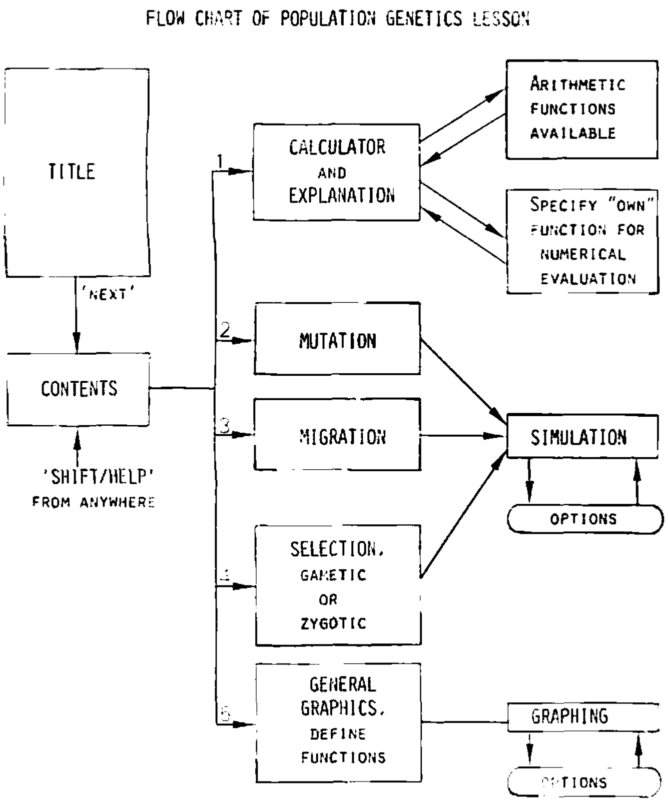

Figure 4: Flow chart of population genetics lesson.

Suppose the student wants to study the effects of selection on gene frequency of a qualitative trait such as black or red coat color in Holstein-Friesian cattle. In selection, the change in gene frequency following the i^{th} generation (Δq_i) can be shown theoretically to depend on the relationships among the selection coefficients (S and T), and the gene frequency in the i^{th} generation (q_i). Suppose the gene to be eliminated is the recessive allele which, when homozygous, makes Holstein-Friesians red where black is preferred (T = O, S = 1) in the herd. If 1% of the initial randomly mating population is undesirable (q_O^2 = .01; therefore, q_O = .1), continued selection for ten generations (about 50 years with dairy cattle) will reduce the expected percentage of red and white cattle to .25, and, hence, the gene frequency by half (q_{10} = .05). This result is expected, because under complete selection against the recessive allele, the gene frequency is reduced 50% in $1/q_O$ generations (Fig. 5).

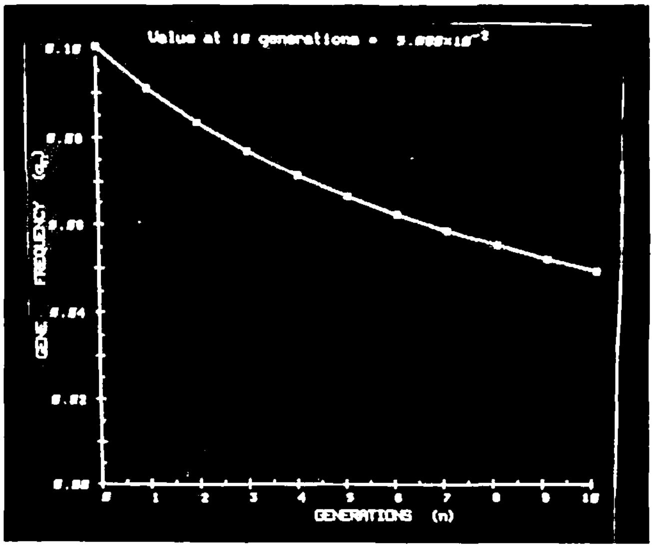

Figure 5: Results of simulated genetic selection against red coat color in Holsteins.

Through computer simulation of the results of selection, the student may discover the relative importance of each component in affecting the change in the gene frequency (Δq_i) by varying S, T, and q_i independently. Two or more plots can be shown on the same graph to demonstrate how varying one component (q_i, for example), while keeping all others constant, may change the results. For example, continuous selection in an initial population with 25% undesirables (q_O = .5) results in a final gene frequency of q_{10} = .083, a reduction of 83%. Thus, the student will discover that the value of q decreases rapidly when q is large, but its rate of decrease slows as q becomes small.

The object of the lesson on quantitative genetics is to teach how the annual genetic gain for a particular selection method is influenced by its components: selection intensity, generation interval, relationship among family members, family size, and heritability.

After a brief introduction to the differences between qualitative and quantitative traits (Fig. 6), the student is ready to use PLATO to discover, through genetic simulation, the relative importance each component of selection has on the annual rate of genetic gain. From a list of ten traits (two for each of five species: dairy cattle, chickens, swine, beef cattle, and sheep) the student chooses a trait he wishes to change by selection. He next chooses one of seven systems of selection (individual selection, selection on the average of multiple records, family selection, fullsib testing, halfsib testing, progeny testing, and individual-plus-family selection). In all, the student has a choice of 70 combinations of traits and methods, not all of them practical, for example, fullsib selection of cattle.

Suppose the student wants to compare selection for milk yield in dairy cattle based on individual first lactation performance with selection based on the average of multiple records. The

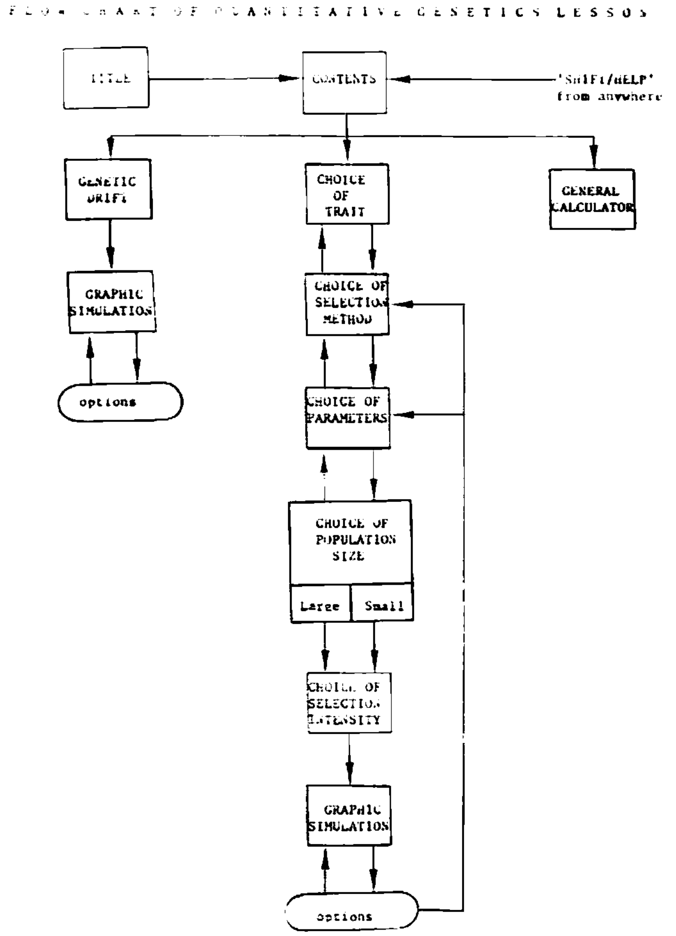

Figure 6: Flow chart of quantitative genetics lesson.

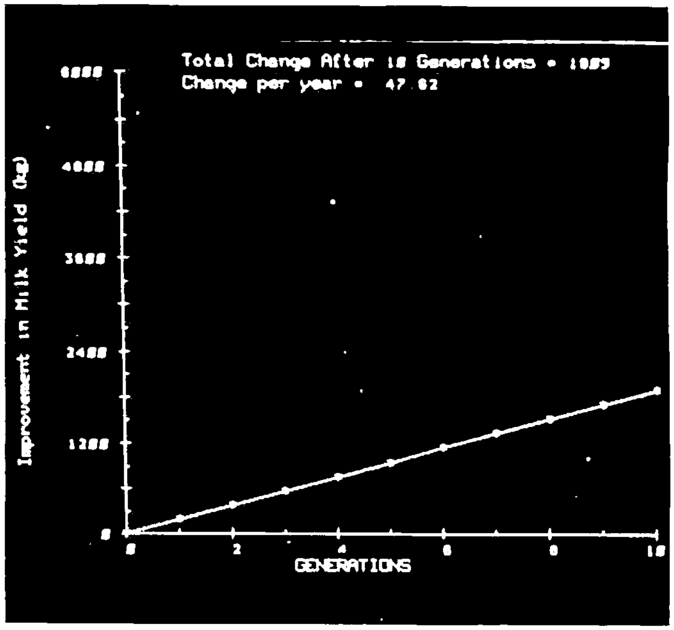

Figure 7: Results of simulated genetic selection for milk yield in first lactation records.

names of the components involved are: selection intensity (i), heritability (h^2), phenotypic standard deviation (sd), generation interval (y), number of records (m), and repeatability (c). If the student is unsure of the components involved, he may branch to a help sequence which will give the formula, showing which components are needed. He is provided with appropriate values of some components (h^2, sd, y, and c) but must supply values for others (i and m).

By entering different sets of values for the components, the student can see the results of each genetic simulation and discover for himself the best method of selection. PLATO will simulate and plot the genetic gain in each generation, relative to a base line of zero. Because the values of the components are constant, genetic gain is linear. One generation would suffice, but a plot over several generations emphasizes this point.

Retaining the best two of ten cows gains genetically 1905 kg. of milk, simulated over ten generations, or 47.6 kg. per year (Fig. 7). Selection for ten generations on the average of two records gains 2130 kg. of milk, or 42.6 kg. per year; on the average of three records, 2225 kg. of milk, or 37.1 kg. per year.

Thus, the student may discover for himself that selection on the first lactation is more efficient, on a generation-interval basis, than selection for the same number of generations based on the average of the first two or three lactations. This result can be understood because each additional lactation requires another year, thereby reducing the genetic gain per year.

Summary

Two computer-assisted laboratory lessons on animal genetics have been designed and written to help students better understand the mathematical principles of population and quantitative genetics. The lesson on population genetics is designed to help students discover the relative importance of the factors that may change the gene frequency in a population through the predictable forces of mutation, migration, and selection. It has been found that students understand the principles of population genetics better when given a population with which they can mutate, migrate, or select against the genes and see the effects within seconds.

The lesson on quantitative genetics is designed to give students a better opportunity to understand the factors that affect rate of genetic gain in response to selection for quantitative traits. Using ten traits and seven selection methods, the factors can be varied independently, to illustrate their effects individually, through computer simulation. The results can be plotted for any admissible trait-method combination, so that the student may see the relative importance of each of the parameters without being burdened by arithmetic. If the student uses different sets of values for the parameters, this simulation procedure will help the student to discover for himself the principles of quantitative genetics.

The use of the computer allows the instruction to be versatile and provides the student with immediate feedback to his response. It is hoped that these lessons will provide an exciting way of acquiring and reinforcing knowledge of animal genetics by allowing the student to DO genetics via computer simulation.

For further information about the PLATO system, write to Dr. Donald Bitzer, Director, Computer-based Educational Research Laboratory, University of Illinois at Urbana-Champaign, Urbana, IL 61801.

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