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9. ABSTRACT

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Development of generative competency-based instructional systems in agronomic education[1]

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Development of generative competency-based instructional systems in agronomic education[1]

Patricia C. Brams, Jay Shores, and Eugene Brams[2]

ABSTRACT

Higher order generative solutions to complex agronomic problems can be attained within accountable open instructional systems. Examples show that increased degrees of openness can be achieved by enlarging the learners' effect on the learning activities and/or evaluation. The degree of complexity of the cognitive or affective objective determines the appropriate degree of system openness, the greatest degree of openness being commensurate with the highest order generic objectives.

Additional index words: Competency-based instructional systems, Agronomic education.

AGRONOMISTS are already familiar with many of the concepts related to systems (cropping systems, management systems etc.). Thus, they may find it valuable to apply a similar systems approach for teaching agronomy. This paper offers paradigms of instructional systems which are designed to answer the current and anticipated problems of concerned students and teachers of agronomy. These systems are competency-based, in which topics are arranged in a sequential order, behavioral objectives are specified for each topic, and achievement of these objectives is the criterion for evaluating student competence. A prime purpose of this paper is to exemplify the use of closed and open competency-based systems in teaching agronomy with the hope that more open systems will be devised to generate creative problem solving by students.

An essential attribute of a competency-based instructional system is that it can be personalized to meet specific objectives. It can be a flexible integrative system which answers the needs described by Black (3), and Letey and Page (8) for interdisciplinary courses in the environmental sciences, such as the meshing of agriculture and engineering around an environmental core. For example, the priority objectives of such an instructional system could be determined cooperatively by agricultural and engineering staff and students, with appropriate learning activities planned to meet mutual goals.

A second attribute of competency-based instruction is that it can make the fullest use of existing resources. If, for example, federal funds shrink, reducing aid to foreign students for study in the United States (5), systems specifically designed for students in foreign countries incorporating their available local resources can be designed economically for transport overseas. Foreign students now studying in the United States can be trained in instructional design, serving as a linkage to reteach colleagues on their return overseas. In addition, campuses in this country can make optimal use of physical facilities and staff talent by incorporating them in planned instructional systems which gain effectiveness but not cost.

Thirdly, competency-based instruction may allow more active participation of students in educational experiences suited to their individualized needs, learning styles (1), interests, and pacing (6). Thus, agronomic education can be visualized from the students' vantage and lead to meaningful learning and increased interest in agronomic studies.

Lastly and of particular significance is that competency-based instructional systems may be designed to incorporate the students' generative abilities. Thus, their creative higher order cognitive and affective goals (8, 7), such as the ability to analyze, synthesize, and evaluate which are essential to creative problem solving in agronomy may be attained without significantly jeopardizing the accountability of the instructional program. These higher order objectives may be stated in behavioral terms so that they may be used in a competency-based system. For example, if synthesis is the higher order objective, students may be required to plan, design,

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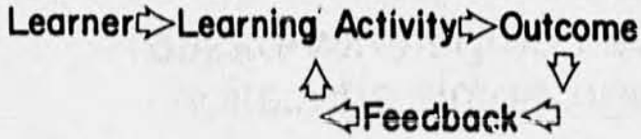

Fig. 1—A simplified view of the instructional process.

Fig. 2—A simple closed instructional system.

construct, or manage (all behavioral manifestations of synthesis). If the goal is evaluation, they may be asked to judge, compare, or choose. Bertrand (2) has suggested that agronomists devote a major effort to fostering these higher order objectives.

With regard to accountability, the systems approach applied to the instructional process requires that instruction be viewed as dynamic interaction between students and programmatic materials. As the program has explicit predetermined objectives and assessment occurs systematically within the operation of the system, there is a high degree of accountability to assure meeting student needs and program effectiveness. For accountability of higher order objectives assessment may become a matter of student, professor, and/or peers determining whether these behavioral objectives have been met. In this mutual evaluation process, some degree of accountability may be lost, particularly if evaluation criteria are qualitative and can not be as easily assessed in concrete terms as the lower order behavioral objectives.

Simplistically, an instructional system may be conceptualized as four components: the learner, learning activities, outcomes, and a feedback loop as shown in Fig. 1. The feedback loop may serve either of two purposes, to recycle the student who has not met assessment requirements through the system, or to cue the designer that the outcomes are consistently unsatisfactory and new information must be fed into the learning processes to produce a more viable system. In either case, the feedback loop effects subsequent operations to achieve optimal system effectiveness. In addition, an instructional system operates within a learning environment. Optimal functioning of the system depends on the environment in which it is used. For example, physical conditions and teachers' attitudes can affect the system.

APPLICATION OF COMPETENCY-BASED INSTRUCTIONAL SYSTEMS IN AGRONOMY

Let us apply the systems concept to specific objectives in teaching agronomy and examine the process of opening competency-based instructional systems to allow the generative abilities of students, abilities to synthesize solutions by combining inputs from the environment with previous knowledge. Openness of instructional systems increases as the learner increases his effects on the system by choosing, designing, and participating in the learning activities and/or evaluation of the outcomes. Openness does not merely refer to flexibility within the system. Openness means that students interact with the environment, bring external information not prescribed, but of their own choice into the system to achieve the objectives or learning. Openness means that achievement of the goal or evaluation is verified by peers and instructors brought into the system for that purpose. Unlike closed systems which are self-contained, open systems permit unlimited information from the outside and can therefore generate a greater variety of creative solutions to problems.

Closed Systems

First, let us examine a simple knowledge objective, identification, which can be accomplished in a closed system as represented in Fig. 2. Objective 1 states: The student will be able to identify 10 different agronomic crops with 80% accuracy, given demonstration plants.

Here all learners experience one learning activity, which is repeated if performance is not satisfactory by recycling the learner through the feedback loop. In this instance, the feedback loop is a managerial process of the student, not a recycling of information to improve the operation as referred to earlier.

Using objective 1, the system may also be expanded to allow a choice of alternate learning activities, thereby increasing student's selection, and variability and effectiveness of the feedback loop as described in Fig. 3.

In Fig. 3, the learner has a choice of means to his goal, and if his performance is not 80% accurate, he is recycled through any of the alternate activities

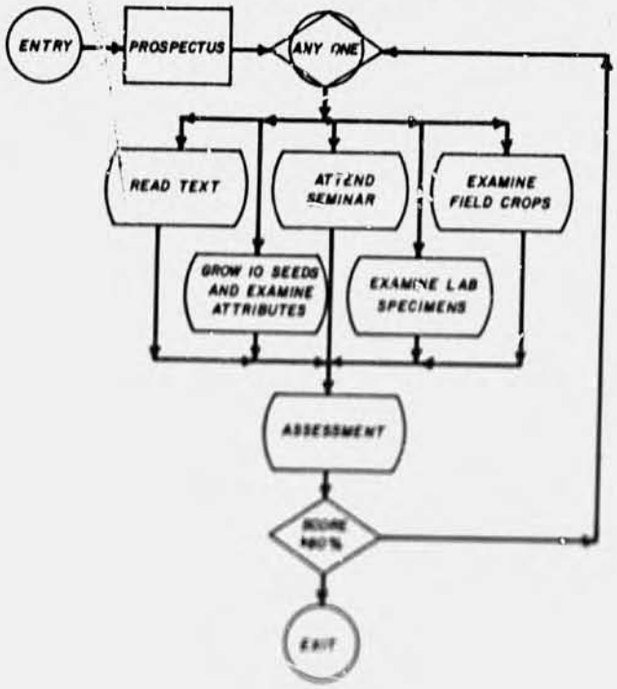

Fig. 3—A more complex closed instructional system.

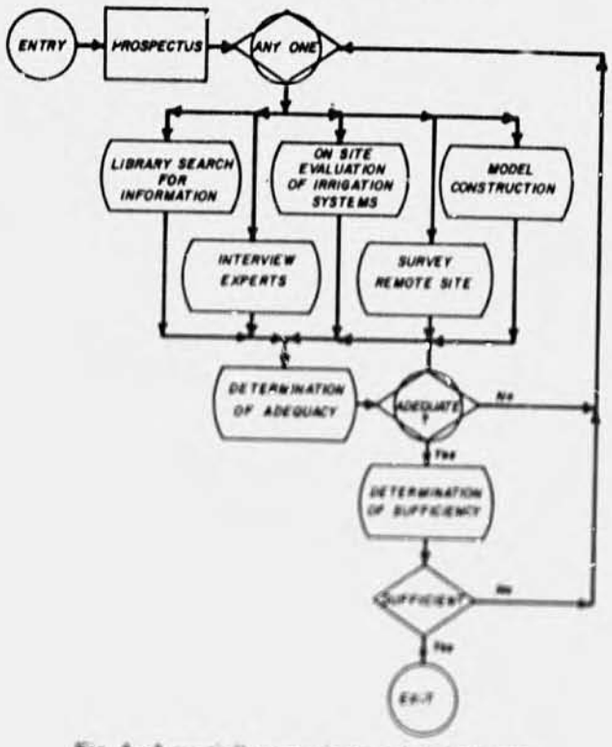

Fig. 4—A partially open instructional system.

he may choose (attend seminar, examine field crops etc.). This system allows more choice in learning activities, more personalization, and fuller use of available resources, and maintains objectives which are specific and invariant, thus preserving accountability. However, this is an expanded closed system allowing greater learner choice and feedback alternatives in the learning activities than in Fig. 2, but still essentially prescriptive in its learning activities and evaluation process, and therefore remains an essentially closed system.

Fig. 3 represents part of a larger planned series of learning experiences, and the time necessary for completion will vary according to the number of recyclings required, as well as the student's learning pace. The goal of competency-based systems is that they are not time locked but allow students to proceed at their own pace. Success in mastering the behavioral objectives is the goal rather than time requirements.

Open Systems

Now let us analyze an instructional system for problem solving which involves higher order objectives. Problems do not always have one correct answer which is easily quantified so that closed systems do not suffice (Fig. 2 and 3). Instead, a system is needed which allows qualitative criteria for evaluation (5) such as described in objective II. The attempt is to encourage the student to generate creative means to fulfill the objective.

Objective II states: The student shall devise a feasible method of irrigating rice terrace soil using the rice water and resources available in a lesser developed country (LDC). An instructional system for this objective is described in Fig. 4.

In this instance, there is a similar choice of learning activities as in the closed system in Fig. 3. The learner may achieve the objective by a choice of several learning activities. For example, he may choose library search, model building, or a visit to an irrigation project nearby to glean insight into a method applicable to the problem. However, in Fig. 4, the openness of this system lies in the evaluation procedure, in which the criteria admit many possible creative solutions. Here the student decides when he has adequately solved the problem. At this point, he submits his solution to a test of sufficiency in which he and the instructor and/or peers assess his outcome according to predetermined criteria which have been agreed upon by students and instructor. Unlike the closed system, these criteria may be qualitative, such as feasibility of the solution within available resources of the commun-

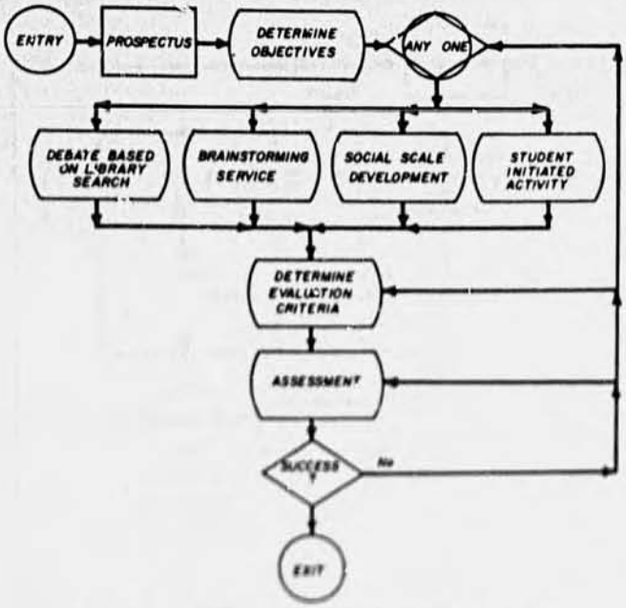

Fig. 5—A primarily open instructional system.

ty, commensurability with social mores, durability, and effectiveness. The assessment, therefore is not necessarily a score, but an agreement that the solution is sufficient as evaluated by predetermined criteria. If all of these criteria are not met, the solution may not be sufficient, and student and instructor may choose to rectify the deficiency by recycling the student through any of the learning activities offered or one designed to meet that particular need.

The highest order knowledge objective is to evaluate (4), which involves comparisons of theories, generalizations and facts, appraisal, and judgmental action presented logically. Part of the evaluating process includes determining what questions must be asked and answered to solve the problem. This practice adds to the students' repertoire of methods of problem solving. Through this activity, he is not only solving a specific problem, but learning how to learn.

The following objective is an example of evaluation. Objective III: The student will evaluate the use of "wonder seeds" of the Green Revolution requiring a high degree of technology for optimal yield for use by a farmer with limited educational and material resources, as compared with gradual improvement of existing management systems using indigenous varieties and methods. An instructional design for this objective is shown in Fig. 5.

This is a primarily open instructional system for the student affects both the learning process and evaluation. Note that in addition to choosing one of several suggested learning activities, the student may initiate his own activity as long as it coincides with the predetermined objectives. Learners may proceed individually or in groups. As in Fig. 4, the student is likewise involved in the evaluation process.

The systems approach permits matching the nature of the objective with the suitable degree of openness of the instructional design to achieve maximum effectiveness.

CONCLUSION

Von Bertalanffy's (9) description of the generic attributes of open systems from his general systems theory coincides with the aims of agronomists to provide the kind of instruction which they cited previously as needs in teaching agronomy. He states that open systems interact with the environment importing negative entropy for growth. The final product of the system is not summative, but constitutive—as a whole it is more than the sum of its parts. A system exhibits equifinality—the attainment of the same end by different initial states and different means. When a system finally reaches an ordered steady state it can advance to a higher steady state with increased input from the environment.

Applying these concepts from his general systems theory by incorporating them into open competency-based instruction, it is possible to find solutions to problems of agronomic education cited earlier by teachers and students of agronomy. Open instructional systems may be used at all college levels. Like any instruction, the more competent the student is in basic concepts and experiences, and the more relevant the objectives of the system, the more productive the output. Therefore, success may often be more expedient and of higher quality in graduate level courses, but its use is not excluded at lower levels. Analogous to systems theory, educators aim for an open instructional system in which the student grows by input of experience. He is enriched by a variety of learning activities from which the learning outcome is constructive—not just a repertoire of concepts, but a meaningful synthesis which can be creatively applied to problems. The learning outcome is an organization of behavior which provides the foundation for future learning.

Simply, we aim to design instructional systems which will:

1) include reproduction of simple knowledge by closed systems and the generation of imaginative solutions to complex problems by opening the systems.
2) permit the learner to choose and design alternate methods of achieving objectives and to participate in judging his competency in meeting these objectives.

The challenge for educators in agronomy is to design more competency-based open systems which generate personalized instruction for the learner, provide accountability, optimal economical use of resources, and develop students who can meet the problems of agronomy with creative application of knowledge.

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