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ABSTRACT

Construction of a model of a generalized computer managed instruction (CMI) system is discussed. Structural components essential to programs of individualized instruction are listed and analyzed, and problems with them identified. The Wisconsin System for Instructional Management Model (WIS-SIM) is then described and diagrammed, and its instructional cycle explained. The roles of testing and test scoring, performance profiling, specifying performance expectations, diagnosing and identifying instructional needs, and guiding the instructional process and selecting appropriate educational experiences and settings are summarized. Methods are suggested for assessing the effectiveness of the instructional staff. (SK)

THE STRUCTURE AND MANAGEMENT OF INDIVIDUALIZED INSTRUCTION

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The Structure and Management of Individualized Instruction

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Education has been hardpressed to keep pace with the cultural, social, and technological changes which have occurred during this century. In response to frequent criticisms that existing educational systems were ill-conceived and ill-equipped to meet the realities of a changing world, educators have attempted to implement and evaluate a multitude of educational plans all aimed at improving the instructional or learning processes. A pervading theme among these many attempts at innovation has been that of individualized instruction. Proponents of individualized instruction consider that a teaching-learning situation which focuses upon the needs and abilities of the individual, rather than on the group, is a preferable means of conducting the educational process. Earlier attempts at individualized education met with only limited success because the resources of educational systems were frequently inadequate to meet the program objectives or because the attempts were too specialized or too localized to be of any significant value except to a few.

Educators are, however, continuing with attempts to implement strategies of individualized education hoping to provide a more effective alternative to traditional instructional practices. Recent programs designed to individualize education, such as Individually Guided Education (Klausmeier, 1971), Project PLAN (Flanagan, 1971), and Individually Prescribed Instruction (Cooley and Glaser, 1968), have met with promising success. Essential to the functioning of such programs of

individualized education is the teacher's ability to cope effectively with the large volume of information required in the management of these programs. Due to the fact that differing instructional strategies may be used at differing times with large numbers of students, monitoring the progress of students and deciding upon optimal instructional objectives and tasks becomes an extremely complex and difficult endeavor. This condition is compounded as more areas of the educational program are individualized. Experience in working with these complex programs has led to an increased awareness that computer-based management information systems are essential to their effective implementation and operation.

This paper will, briefly, consider the structural components essential to programs of individualized instruction leading to a model of a generalized computer managed instruction (CMI) system. Lastly, extensions of the CMI model which suggest applications in the evaluation of the instructional program will be discussed.

STRUCTURAL COMPONENTS OF PROGRAMS OF INDIVIDUALIZED INSTRUCTION

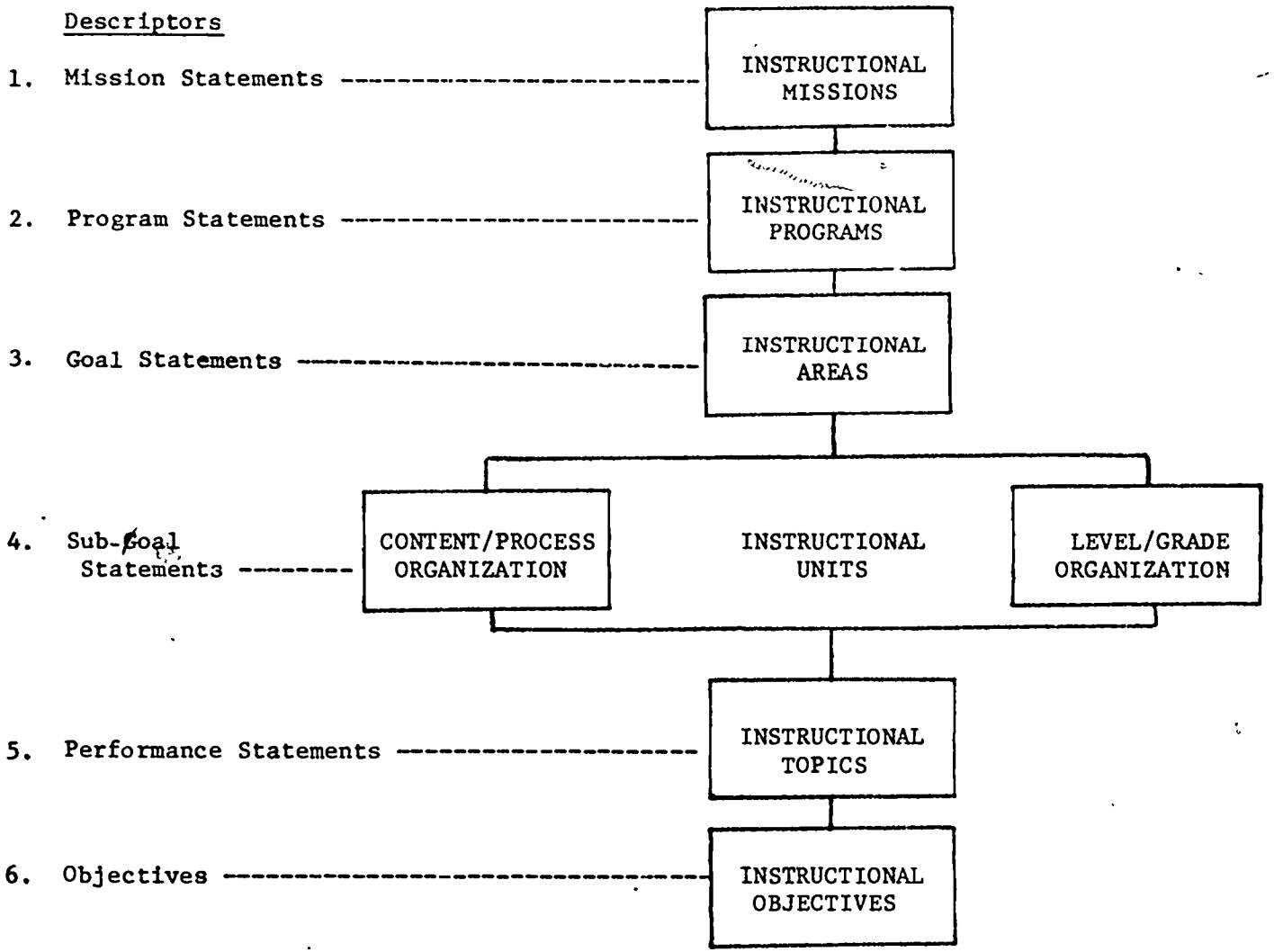
The primary emphasis of any system of individualized education is directed toward the growth of the individual learner. To achieve this aim, individualized programs, unlike more traditional modes of instruction, stress the importance of self-initiative and self-direction. The individual learner, rather than being the passive object of instruction, is frequently encouraged to become an active part of the teaching-learning situation. Teachers, while remaining in charge of instruction, provide opportunities for individuals to set their own objectives, assess their own abilities, and to prescribe courses of action for themselves which will lead to goal attainment. Further, in planning instructional activities, teachers take individual pupils' differences

into account and gear their efforts toward the achievement of objectives at the individual level. An intended outcome of such adaptive, individualized systems is to provide meaningful learning experiences for each pupil, where individual needs and interests can be effectively served. Systems of individualized education are thus geared to individual abilities, interests, and needs, and not to a group instructional program which is inflexibly applied to all pupils in a class. Each individual's abilities and limitations are noted, beginning levels of performance are identified, and courses of action leading to the attainment of specified objectives are prepared. The instructional process focuses upon the individual, and subsequent assessment determines the degree to which prespecified objectives have been attained. This process, which includes both teacher and pupil involvement at each stage, points to the key components of an individualized education system. These components are now discussed in more detail.

Prerequisite to any individualized education program is the existence of a well-defined set of instructional objectives. These objectives are defined through a hierarchy of instructional components (see Figure 1). This hierarchy is an organization from general district or school instructional missions to specific instructional objectives. Instructional missions are translated in instructional programs which reflect curricular content. These are further defined into instructional areas which classify program content into focused components with broad objectives. Instructional areas can be further divided along two distinct classifications. Areas can be divided into content/process instructional units which represent strands of instruction. Areas can also be divided into level/grade units, which focus upon a chronological or organizational hierarchy. These instructional

Figure 1

HIERARCHICAL DEVELOPMENT OF INSTRUCTIONAL OBJECTIVES

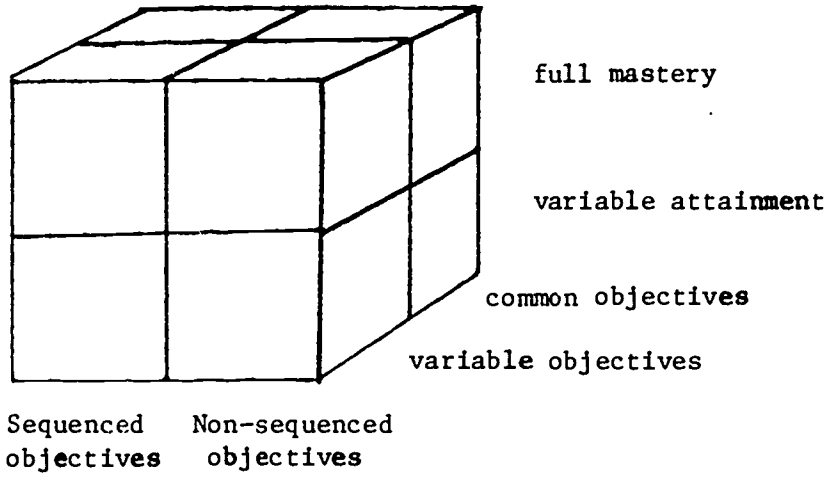


units are subdivided into instructional topics or collections of related instructional objectives. Topics may reflect either a content/process or level/grade relationship. The most specific level in this hierarchy is the instructional objective which states the actual behavioral outcome expected for each instructional activity.

Within this hierarchy, individualized programs of instruction may be classified along other dimensions. Klausmeier (1974) has identified a three-dimensional model useful in classifying programs of individualized education. The three dimensions included in this model, as illustrated in Figure 2, include sequencing or non-sequencing of objectives, common or variable objectives, and full mastery or variable attainment. These three concepts in combination define eight possible types of individualized education programs.

Figure 2

Dimensions Defining Programs of Individualized Education



Instructional objectives or topics within an instructional program may be interrelated in predetermined ways, establishing for the program a network of prerequisites. If such prerequisites exist within a program, the objectives are sequential. Not all objectives need be related sequentially, however; many may be relatively independent of others, and can be attained at any one of several points in the program of individualized learning. Some instructional programs are characterized by the absence of prerequisites and are said to be nonsequential in nature.

Another related concept useful in analyzing individualized instructional programs is that of compatibility of instructional activities and compatibility of instructional objectives. Compatibility is concerned with the efficiency of the instructing and learning processes. Analysis of the instructional program may identify some objectives which can be effectively taught at the same time and are therefore compatible. If one objective is a prerequisite to another objective, then they are not compatible and should not be undertaken at the same time. Some instructional activities may be useful in teaching toward more than a single objective, thus pointing to compatible objectives. The concept of compatibility is useful in identifying clusters of objectives which might logically be taught together and may form a basis for establishing instructional topics within a program.

Students in an individualized instructional program may not be required to work toward mastery of all objectives. Some objectives may be common in that all students are required to attain them while others may not be so required, allowing for a program with variable objectives.

Programs of individualized education may also vary in the mastery level required of individual students. Full mastery describes a program wherein all students in a program are expected to achieve the same level of attainment on a given objective, whereas in an instructional program with variable attainment, the level of achievement required may differ from student to student.

An important step in the development of a system of individualized education is the specification of performance standards. Each goal or objective in the total system must be interpretable in terms of the behaviors necessary for its achievement. The same performance standards need not be common to all pupils, nor need they be rigidly applied without exception. Rather, these criteria may be sufficiently flexible to allow for the wide range of individual abilities which generally exist among any group of pupils.

Performance standards in systems of individualized education are frequently embodied in criterion-referenced tests. As the name implies, such tests contain a criterion, or a set of criteria, which a pupil must satisfy in order for the objective to be attained. The criterion may be evidenced through observation and performance testing. The task of establishing criteria is clearly made less complex when system goals or objectives have been carefully planned and specifically stated.

In this section, some structural components of individualized education programs and some of the many ways in which these programs may differ have been identified. While all such programs are based on measurable objectives, they may differ relative to the sequencing or nonsequencing of objectives, in full or variable mastery, or in common or variable objectives. Instructional objectives and activities defined

relative to the sequencing of objectives and the efficiency of the instructional process may be either compatible or incompatible. The notion of performance standards as they are related to the mastery level objectives specified for an instructional program is included as a necessary component.

THE WISCONSIN SYSTEM FOR INSTRUCTIONAL MANAGEMENT (WIS-SIM) MODEL

The discussion of individualized education to this point has assumed an idealistic stance. While the system seems logically sound and intuitively pleasing, many logistical problems arise when one considers implementing such a system in a typical classroom. Most of the problems relate to routine matters of record-keeping and information retrieval. As discussed earlier, a system of individualized education may include common or variable, sequenced or nonsequenced, and full or variable attainment types of objectives. Keeping track of even a single student becomes a considerable clerical task, and one that prevents the classroom teacher from using time effectively on the more important matters of instructing and counseling.

The process of assessing beginning levels of performance for any given curriculum unit and resultant diagnosis for each pupil are no less time consuming. When the guiding or prescribing of instructional activities for each pupil follows these steps, the task confronting a single teacher becomes very great. The instructional phase of the system, followed by the criterion-referenced testing necessary to ascertain levels of goal attainment, further compound the teacher's task in managing the system effectively. Even if one assumes that a teacher is capable of leading a class of pupils through one iteration of the system, subsequent feedback and further iteration soon reduces the effectiveness and

and efficiency of the system. Should the teacher decide to intervene and make modifications of earlier decisions, the situation inevitably becomes even more complex.

The management of a comprehensive system of individualized education in a manual mode, then, does not appear to be a particularly viable method. Rather, the dependence of individualized programs upon automated information storage, processing and retrieval mechanisms seems evident. It is through the support of computer systems designed to assist in the management of individualized instructional programs that these programs are likely to be successfully implemented.

In this section, the processes of computer managed instruction are integrated into a generalized model which will account for the major structural and process delineations of programs of individualized education. The model is an extension of earlier considerations presented as the Wisconsin System for Instructional Management (WIS-SIM) model (Belt and Spuck, 1974), and a more extensive treatment is to be found in Spuck, Hunter, Owen, and Belt.

Systems of computer managed instruction are designed to provide management information to school personnel as required for instructional decision making. The main function of an instructional management information system is to improve decision-making relative to the instructional program of the school, leading to maximized educational benefits for each child while making efficient use of the available human, material, and financial resources.

The Instructional Cycle

The instructional cycle in programs of individualized education may be depicted as in Figure 3. Five processes (P 1-5) and two decision

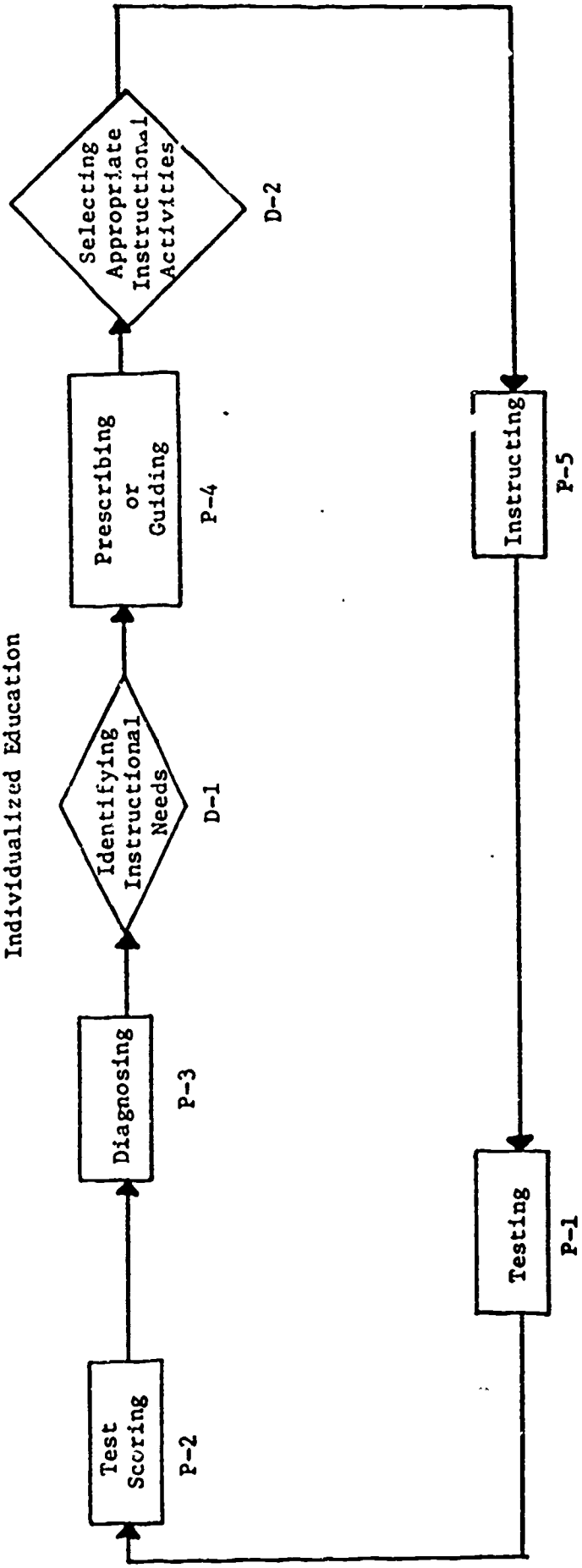


Figure 3

The Instructional Cycle in Individualized Education

(D 1-2) areas are included in this representation. Initially, testing (P-1) takes place; this testing is to provide information as to the placement of students within the instructional program. These placement or break-in tests are scored during a process (P-2) called test scoring. Results on the tests are compared with mastery or performance levels which have been specified for each student and for each instructional objective. It should be noted that the testing and subsequent test scoring need not refer solely to paper and pencil tests, although this format is common, particularly in break-in or placement testing. Other forms of testing which might be utilized are performance tests, work samples, and teacher observation.

On the basis of information derived from test scoring, it is possible to determine for each student their status within the instructional program; that is, those objectives which have been mastered and those objectives which have not been mastered. The process of diagnosing (P-3) provides information leading to the diagnostic decision of identifying instructional needs (D-1). For each child and for each child's program, those objectives which the student has not yet mastered, but for which they have met all prerequisites, may be determined. Thus, need is assessed by comparing the actual performance of the student with the performance expectations which have been established for him relative to the instructional program. Since more than a single objective may be identified in the diagnostic process, it may be necessary for the student and/or teacher to determine which objective represents the greatest need at that time.

The teacher may compare the instructional need of the individual student with the instructional activities which are available to assist the student in learning the content included in the objective. Prescribing

or guiding (P-4) is a process designed to provide information useful in selecting those instructional activities (D-2) which are most appropriate for meeting the student's instructional need. The selected activities are carried out during the instructing process (P-5), after which testing again takes place to assess whether or not the student has met the instructional objectives. This test is scored and the instructional cycle is repeated.

While not explicitly presented in Figure 3, feedback within the instructional cycle is possible. If, for example, during the instructing process, it becomes evident that the selected instructional activity is not, in fact, appropriate, a new instructional activity may be selected without repeating the entire cycle.

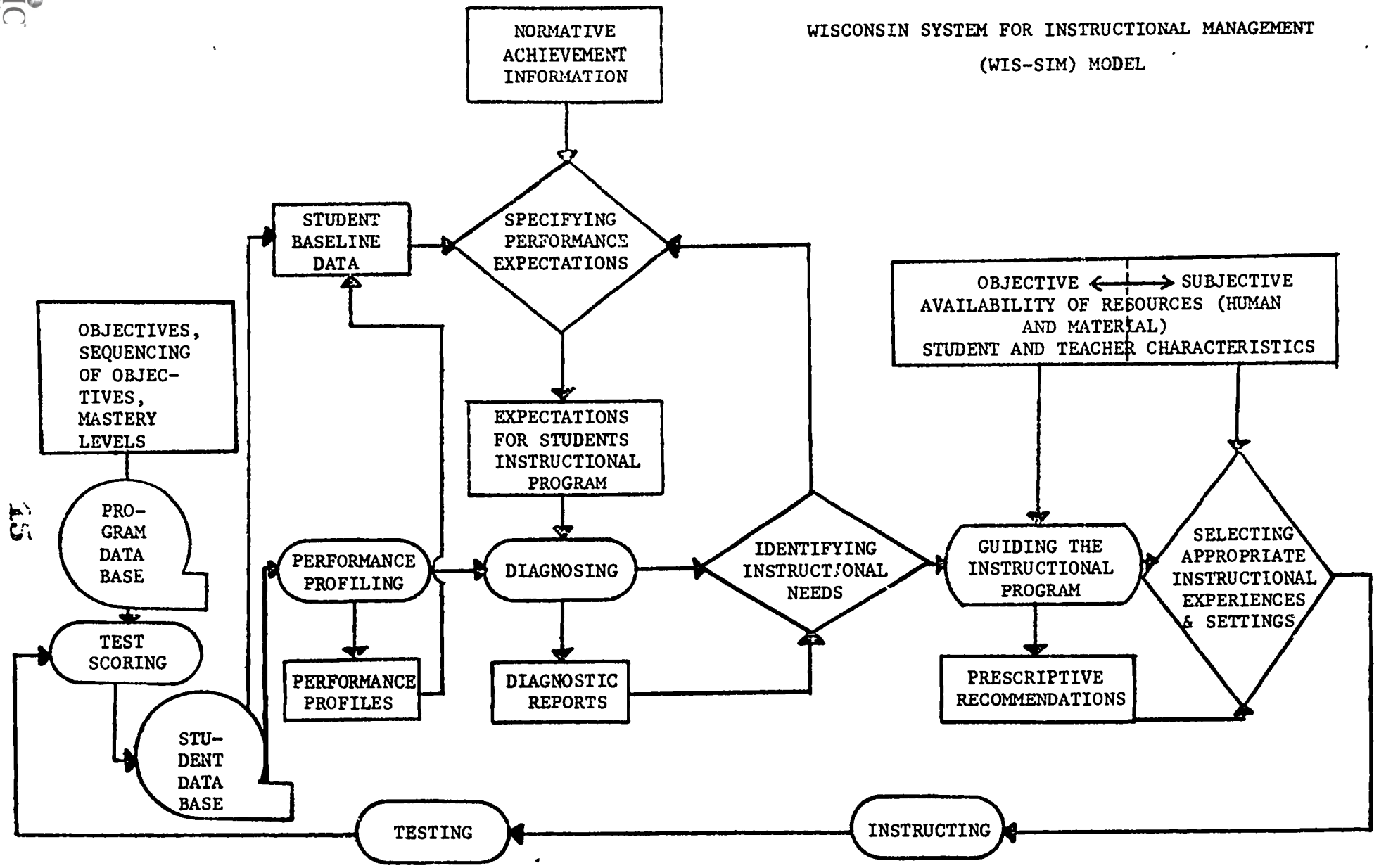
The WIS-SIM Model: An Overview

The complete WIS-SIM model is presented in Figure 4 in diagrammatic form. This figure incorporates the process of achievement profiling and the data bases referred in the operation of the instructional management system. Processes are represented by the rounded-rectangle symbol, decisions by diamonds, and data bases by the computer tape symbol. Rectangles are used to indicate information which flows into or out of the system. Information resulting from system processes is usually in the form of reports which are subsequently used as input to instructional decisions. A major new decision area, specifying performance expectations, which was not present in the instructional cycle model, has been added. This decision results in a set of expectations for each student's instructional program.

Figure 4

WISCONSIN SYSTEM FOR INSTRUCTIONAL MANAGEMENT

(WIS-SIM) MODEL



Testing and Test Scoring

Testing begins and ends the instructional cycle. Testing as a pre-assessment or placement process determines whether or not a student has met the performance standards associated with a given objective or set of objectives prior to the beginning of the instructional cycle. At the end of the instructional cycle, testing again takes place to determine whether or not a student has mastered the content of a particular set of objectives.

Tests must be scored. Test scoring is a process wherein test item responses or test performance is compared with the mastery levels or performance standards which have been set for that test and for that student. As noted previously, not all tests need be of a paper and pencil variety. Other forms of testing which could be utilized are performance tests, work samples, and teacher observation/certification. In any testing situation, however, it is essential that the mastery level or performance standards be explicitly defined.

Performance Profiling

Performance profiling is the next process in the WIS-SIM model. Profiles are reports of prior individual or group achievement with regard to a set of objectives included in the instructional program. Considerable flexibility in the production of these reports is generally provided, thus allowing the person requesting the report the freedom to define the group or individual to be profiled and the range of objectives within the program to be included. Included as uses of performance profiles are achievement reports which might be sent to parents or utilized in parent-teacher or student-teacher conferences. These profiles

could also be performance summaries of classroom, unit, or school over a period of time for review by decision-makers at these levels.

Specifying Performance Expectations

The first of the three decision processes included in the model is specifying performance expectations. Through this process, goals are set for each student's instructional program. These goals may be set for short or long periods of time, as is appropriate to the student and the instructional program involved. Information input into this decision area includes student and normative baseline data. Algorithms may be built into the system which are based on such individual profile information as past achievement and personal factors related to the student's learning. When the individual expectations for a student are set, this information must be included as a part of the student data base so that it will be available as required within the computer-based system. The decision of specifying performance expectations involves tailoring the instructional program to the needs of the student as required in programs involving variable mastery and variable objectives. The formulation of expectations leads to the specification of an individual instructional program for each child.

Diagnosing and Identifying Instructional Needs

The purpose of any system of individualized education is to serve the educational needs of individual pupils. In essence, the identification of needs is synonymous with the process of locating current weaknesses or problem areas in the total configuration of a pupil's knowledge within an instructional program. The process of diagnosis, as shown in the

WIS-SIM model, results in the identification of such needs. As Figure 4 indicates, the diagnostic functior of the WIS-SIM model is based upon two sets of inputs from other components of the total system. Pre-specified expectations, as they relate to a given objective set, and the data provided by the performance profiles, when pooled, provide the basic information necessary for decision-makers to identify existing discrepancies in a pupil's knowledge with regard to a specific curriculum area. In general, diagnosis occurs through the comparison of actual performance with performance expectations.

Guiding the Instructional Process and Selecting Appropriate Educational Experiences and Settings

The process of diagnosing leads to the identification of instructional needs. Through the process of guiding the instructional program the instructional manager makes a determination as to the appropriate educational experiences and settings to meet the identified needs. The WIS-SIM model is conceptualized so as to take into account a wide range of both subjective and objective information. Operating as factors which may influence the selection of instructional activities are such teacher variables as skill in teaching and preference for teaching certain instructional activities, such student factors as aptitude, learning style and learning handicaps, as well as such interactive factors as the existence of personality conflicts between students or between a student and a teacher. As the WIS-SIM model shows, a very important consideration made at this point is the availability of both human and material resources for the effective discharge of the selected instructional activities. This is a point frequently overlooked or not commented upon in the literature on CMI systems. While the diagnostic function may

suggest certain types of prescribed activities, few or none may be possible within the bounds of existing resources. As stated earlier, it is important then that CMI systems such as WIS-SIM be formulated on the principles of "total systems," such that decision-makers are aware of the ramifications of each process for every other process.

Instructing and Testing

As Figure 4 indicates, selection of appropriate educational experiences and settings precedes the instructional process. The selected instructional activities should be implemented in a manner which reflects the individualized concern of the WIS-SIM model thus far. Teachers need to be sensitive to the progress of students and be assured that the selected activities and setting is facilitating the students' mastery of the objective. If problems are identified it is clearly desirable that the instructional approach be modified, as possible, to alleviate these problems. Once instruction is completed, the total CMI cycle is repeated. Test scoring at this point becomes a post-test for the instructional objective identified earlier. Results are compared with expected performance standards and attainment of the objectives leads to the student's consideration of a new objective. Inability to meet the required level of attainment may involve a reinitialization of the entire cycle for the same objectives, or it may, as stated previously, result in the selection of a more realistic objective. In either case, the relevant data is stored, to be available as necessary for the generation of reports within the system.

WIS-SIM may also be viewed as a model of decision-making related to the instructional program as well as a model of the management of individualized instruction for the student. It is a model

capable of being utilized at several levels within the educational program of the district. The utilization of this model could have the very direct result of assisting in the effective implementation of an individualized program for each student, through assisting in the identification of the instructional needs and selection of appropriate instructional experiences and settings for each student. The model also suggests a less direct impact on the student's learning through the continual monitoring and refining of the school's instructional program.

A system of computer managed instruction can be designed so as to retain a record of the utilization and effect of instructional activities, equipment, space utilization, and the sequencing of instructional objectives. Activities can be evaluated through a net success ratio (objective masteries divided by total usage of the instructional activity) and broken down by student classification (ability level, socio-economic status, etc.) to access the activities differential effectiveness across these student groups. Comparing the actual success rates with an expected rate creates a diagnostic assessment of the effectiveness of an instructional activity. The diagnostic assessment, or success ratio, points to areas in which instructional programs can be improved and leads to the comparison of objectives and programs which elicit the same or similar behaviors or knowledge outcomes. Through this process, instructional programs or individual objectives can be omitted, improved, or replaced if they do not meet school or district needs.

Instructional equipment and space cannot readily be evaluated as instructional activities can, but utilization reports can, over time,

display use patterns for various curricular programs. Future equipment purchases, maintenance, and depreciation can be better anticipated based upon such reports. The sequencing of objectives could be evaluated through a regression analysis of mastery/non-mastery/not attempted patterns between objectives in the program. This analysis, when computed over many students, will give a weighted value for each objective in terms of its impact on mastery of later objectives. The sequencing structure can, in this way, be verified or altered to better serve the curricular program. Through this process, instructional programs can be resequenced or non-sequenced as shown to be appropriate by the computed regression values for each objective.

The effectiveness of the instructional staff can be assessed in much the same way as the instructional program. The strengths of each staff member can be measured in terms of student/objective net success rates. These rates can be specified to reflect the various student characteristics, instructional activities, and instructional programs. Through this analysis not only can staff strengths be capitalized upon, but also staff instruction schedules can be arranged to avoid disfunctional interactions with activities.

As this system of program and staff evaluation is further developed, a program budgeting system can be implemented. Both the absolute cost and the cost benefit (of instructional programs) can be more accurately computed through the use of a CMI system. This "total systems" approach to the computer management of instructional programs can lead not only to better, more timely information to teachers, but also to instructional decision-makers at all levels.

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