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ABSTRACT

The Classroom Information System (CIS) is an effort to apply computer technology to the problem of managing information in the classroom to relieve teachers of clerical duties, and also to provide them with a daily account of each child's progress. There are two curricular components: a prescriptive learning program focusing on basic skills (reading, spelling, math); and an exploratory learning program consisting of art, play, conceptual games, and activities which develop social and self-management skills. Factors considered in designing the system were dialogue characteristics, response time of the computer, amount of teacher training necessary, and control of errors and system failure. The class of students in which this program was implemented is made up of 50 children from five to eight years in age, two teachers, and one instructional aide. All were given instruction in the use of the computer terminals (typewriter and television display types) which are located in the classroom. A teacher assigns work from the prescriptive learning curriculum to each child on a weekly basis. Children may select their own activities from the exploratory component. At the end of each week, the teacher obtains the student history report from the computer and meets with the student to discuss his/her progress. Initially, more teacher time was required for CIS planning; however this decreased as they became familiar with the programs. Students learned the system quickly and have made continued progress because of immediate feedback on their work from the computer. A bibliography, flow charts and a sample student history report are included in the appendices. (JAB)

Planning Instruction and Monitoring Classroom Processes with Computer Assistance

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Introduction

The recognition that schools must serve children of different abilities, experiences, interests, and social backgrounds has led to a sustained and growing interest in instructional programs able to adapt to individual differences. Recognizing also that continuous learning is required in a changing technological society, this interest in adaptive education has often been coupled with an interest in instructional models that seek to enhance the ability of students to plan and manage their own learning. In the development of such a program, it is necessary not only to provide a variety of educational experiences that are adaptive to individual differences but also to ensure that the instructional alternatives are effective and lead to the successful acquisition of essential skills.

The programs which have been developed to meet these objectives and the classroom procedures they require often impose an information management burden (e.g. Project PLAN (Flanagan, 1970); IPI (Lindvall & Bolvin, 1966); IGE (Klausmeir, 1972)). The teacher must maintain detailed records on individual student progress as well as be aware of the full range of curriculum options when making instructional decisions. In a busy classroom and without assistance, the teacher often is forced to make decisions after only a cursory examination of student past performance and without adequately considering the instructional options that may be available. The result is a loss in individualization and a poor utilization of the richness and variety of the curriculum. In other areas of our society with similar information management problems, the computer frequently has been employed to assume the clerical burden and to free individuals for decision-making and higher order functions. The Classroom Information System is an effort to bring this technology to bear on the problem of managing information in an individualized classroom.

The Instructional Program

The Classroom Information System (CIS) operates in conjunction with an individualized instruction program developed at the Learning Research and Development Center (LRDC) at the University of Pittsburgh. The program is designed to provide an environment that is adaptive to individual differences combining the advantages of a structured curriculum for basic skills development and an open learning environment for personal and social development. Special emphasis is placed on developing each child's self-concept and confidence as a learner and in making classroom activity an interesting and meaningful experience.

The program includes two curricular components, a prescriptive learning component and an exploratory learning component.

The prescriptive learning component focuses on basic skills and consists of individualized curricula developed at LRDC including Individualized Mathematics (Lindvall & Bolvin, 1966), Individualized Science (Champagne & Klopfer, 1974), the New Primary Grades Reading System (Beck & Mitroff, 1972), the Early Learning Program (Resnick, Wang & Rosner, 1975), and the Individualized Spelling and Writing Patterns Curriculum (Research for Better Schools and the Learning Research and Development Center, 1973). Learning activities within this prescriptive component are usually "prescribed" by the teacher based upon a student's diagnostic test results.

The exploratory learning component consists of more open-ended activities that are generally selected by the student. These activities stress the integration and application of skills acquired in the prescriptive component and the development of social and self-management skills such as cooperative interactions with peers and the planning of learning activities. Typical exploratory activities include art, sociodramatic play, conceptual games, computer programming, and creative writing (Wang et al., 1973).

In addition to the two curricular components, a Self-Schedule System (Wang, 1974, 1976) for planning learning activities is in use. The Self-Schedule System is an instructional-learning management tool designed to integrate the structured prescriptive learning component for basic skills learning with the more loosely structured exploratory learning component. In addition, the system provides students with the opportunity to develop the skills necessary to plan and successfully manage their own learning. Students are permitted to make some decisions regarding what learning activities they will undertake in school and when the various activities will be carried out. Although some of the what the student does in school will be prescribed by the teacher on the basis of diagnostic test results, some will be decided by the student independently, and some will be decided jointly by the teacher and the student.

The Classroom Information System

Objectives

The Classroom Information System is designed to serve three functions. The most important is to make available to the teacher a set of computer-based information management tools to replace the existing and cumbersome paper and pencil procedures. The system is also designed to assist in the management of student self-scheduling by providing a facility which a student can use to display and select learning activities and to record information on progress within an activity. Finally, the CIS is designed to collect detailed and comprehensive student performance data to support research on curriculum design and classroom processes.

The information management tools provided to the teacher are intended to supplant, rather than augment, existing procedures. This is a departure from earlier efforts (Cooley, 1970; Cooley & Glaser, 1969) which were intended to augment the information maintained by hand. In contrast, the CIS replaces the existing paper and pencil procedures with a more comprehensive and flexible computer-based discipline. In addition to providing a number of miscellaneous support tools such as attendance recording, the CIS enables the teacher to quickly retrieve information on student performance, to display and browse through possible instructional activities appropriate to the student, to "write" and store prescriptions, and to request one of a variety of longer term reports. With the exception of the more comprehensive reports, all functions are immediately available to the teacher through terminals in the classroom. Student activity information entered during the day is available as soon as it is entered so that activity reports are always current.

The self-scheduling component of the system is designed to enable students to display alternate learning activities, to select and initiate an activity, and to retrieve and display progress data when planning and making decisions about their own learning. A primary objective is to make these procedures simple and understandable so that young children with only minimal reading skills can operate the system without adult intervention.

To meet the needs of the researcher, the CIS is designed to collect and make available detailed student activity data. The CIS routinely records the time when learning events occur so that various rate and time studies can be conducted over long periods without the need for observers or punch clock schemes. Possible studies include investigations of student learning progress patterns, self-scheduling choice patterns, assignment completion rate, and time spent in self-selected activities. Full prescription data are also stored for use in studies on the application of the various curricula.

The Computer System

The CIS system operates on a DEC PDP-15 computer located on-site in the LRDC building. The PDP-15 can be described as a large "minicomputer" or what some refer to as a "midi." In addition to the computer, the system includes three disk drives providing auxiliary storage for data and programs, a high-speed printer for the fast printing of reports, and a card reader for the reading of tabulating cards. Individuals interact with the computer through computer terminals located throughout the building and at remote sites. Several different types of terminals are used including typewriter-like terminals from manufacturers such as Texas Instruments as well as television-like display terminals from the Datapoint Corporation and DEC. The terminals located in the LRDC building are directly wired to the computer, and the remote terminals access the computer through the telephone system.

During the typical working day, from 15 to 25 individuals at terminals may be interacting with the computer and writing or running computer programs. This time-sharing capability is made possible by a permanently installed master program, or "operating system," called ETSS for Experimental Time-Sharing System (Fitzhugh, 1973). ETSS was developed at the Center and enables the single PDP-15 computer to simultaneously support a variety of applications (Fitzhugh & Glaser, 1975) including psychological experimentation on human learning and cognition (Fitzhugh, 1974), research on computer-assisted instruction (Fitzhugh & Pethia, 1975; Block et al., 1973), as well as the Classroom Information System described in this paper.

Human Engineering Factors in the Design of the CIS

Human engineering factors must not be overlooked when designing an interactive computer system. This is especially true in new computer applications where there often is a resistance to change and an unwillingness to adopt new procedures particularly if those procedures alter normal patterns of work. A computer-based system for the classroom that is difficult to use, that is improperly paced, or which disrupts normal classroom practice will not be accepted and will fail regardless of the potential value of the services. Experience with earlier systems emphasized this need to be sensitive to human engineering factors, and these were carefully considered during the design of the CIS.

The factors considered fell in four areas, dialogue characteristics, response time, teacher training, and error and failure control. Dialogue characteristics refer to those factors affecting the nature and format of the dialogue between the user at a terminal and the computer. With the CIS, our objective was to strive for simplification so that operation of the system would be largely self-explanatory. For that reason, a "menu" approach was adopted (Martin, 1973) in which the user is presented with numbered options and specifies an option by typing it's number. A natural language approach was felt to be impractical because of the technical and semantic problems involved in programming the computer to understand even a restricted English (Yngve, 1964). Similarly, a system in which the user would be required to enter commands in the form of mnemonics or key words was rejected because of the greater time and effort necessary to learn to operate the system.

A disadvantage of the menu approach is that the presentation of options requires the display of more text than is practical on terminals with a slow display speed. This implies the need for faster terminals which, in turn, require a faster communications link between the computer and the terminal. Speeds above 30 characters per second generally preclude the use of dial-up telephone lines and are only possible with special and more costly telephone equipment or if the computer is on-site and the telephone system is avoided entirely. The latter is the case with the CIS system which uses 120 character per second display terminals which could not be operated at sites remote from the computer without a significant telecommunications expense.

In addition to self-explanatory operation, the design of the CIS user-computer dialogue was guided by a number of other objectives. Efforts were made to minimize the amount of information on each display and to use simple, common English terms. Display formats were standardized, and unnecessary information on the screen erased whenever possible. For example, error messages indicating faulty or incorrect input appear for a short period of time and are then erased. Finally, the user is required only to enter numbers followed by a carriage return with one limited exception to be mentioned later. This makes one-handed operation possible and reduces keyboard search time which is particularly important with children who may be unfamiliar with the keyboard layout.

Response time was another factor that was considered and which influenced many technical programming decisions during the implementation of the system. The importance of response time is easily overlooked, especially when the computer-based procedure may require less total elapsed time than the non-computer-based procedure it replaces. However, it is a crucial factor in all interactive systems since mental efficiency does not decline linearly as response time increases but rather drops dramatically when delays exceed certain thresholds (Miller, 1968). Generally, delays beyond two seconds tend to destroy the continuity of a dialogue and are particularly disruptive when the individual is required to retain substantial information in short term memory for the duration of the interaction. Delays beyond ten seconds are usually not tolerable if the dialogue is lengthy.

Minimizing teacher training time was another important objective that influenced much of the design of the CIS. The menu approach mentioned above was adopted, in part, because of it's simplicity and self-explanatory nature. Since the CIS is to be operated by teachers and students directly and not by intermediaries or specialists, minimal training without the need for periodic refresher training is essential. It is also unrealistic to expect a busy and frequently interrupted teacher to sit at a terminal and compose and enter a string of technical commands. The menu approach allows one-handed operation and also leads the teacher through the interaction by presenting successive alternatives stated in simple, direct English.

Finally, a concern for error and failure control led to a design that is highly resistant to computer or user (teacher or student) errors. Computer errors usually occur as total failures, or "crashes," when the system abruptly halts. Fortunately, the computer system that is used is reliable; however, the CIS was designed to ensure that there would not be data loss or database disruption should the computer fail. Although computer failures are rare, incorrect input from teachers or students occurs frequently as might be expected in a busy classroom. The CIS performs reasonableness and correctness checks on all input, particularly that entered by students. For example, students identify themselves by number. The CIS responds by displaying their name and asking if they are, indeed, the person shown. Procedures such as this are followed throughout the CIS and have resulted in a design that is largely immune to the effects of the occasional typo or faulty input.

Acquiring Classroom Data On-Line

Computer-based information management systems are usually developed for applications in which the amount of information to be managed is large. Frequently, the original entry of the data into the computer and the updating of data are sizable tasks that often are the dominant factors in determining the economic and operational feasibility of the system. Computer-managed instruction (CMI) is no exception. Although many agree that a variety of potentially useful services might be provided by a computer if timely and detailed data on student performance were available, there is the persistent problem of how to enter the data quickly and at reasonable cost. A variety of methods have been tried including optical and mark sense scanning by machine of test or work book sheets as well as the manual entry of data by teachers or teacher aides through computer terminals. None of the methods used to date are wholly satisfactory if it is desired to retain detailed data on student activities and make this data available for immediate use.

Most of the experimental CMI systems that have been developed can be viewed as telemetry systems. Data are collected on recent student activities, entered into the computer, and reports produced at regular intervals or on request. Classroom practices are essentially unmodified, and the computer operates in an adjunct role. The entering and updating of data is another burden that school personnel must assume in addition to existing procedures.

In contrast, the Classroom Information System is an attempt to integrate the computer into the classroom with no additional overhead in time or effort. Paper and pencil information management procedures are largely eliminated and are replaced by an easier to manage and more flexible computer-based system. Most important, data entry as a separate procedure is effectively eliminated. Rather than functioning as a telemetry system passively recording data, the computer plays an operating role in the classroom and collects data on instructional events as they occur. This approach is referred to as "transaction event recording" and is the basis of the computer systems now in use in many retail stores that are connected to cash registers and collect data on purchases.

The CIS is integrated into the instructional process at two key points. When developing individual student prescriptions, teachers use the computer to retrieve student performance histories, to display available instructional options, and to write the prescription itself. This enables the computer to capture prescription data which is then stored in the CIS database and later printed in hardcopy form on request. Data on student activities are similarly acquired since the student uses the computer to select an activity as part of the Self-Scheduling System. The student informs the computer when the selected learning activity is begun and when it is complete. This is subsequently verified by the teacher who enters test scores if the activity was concluded with a test. This cycle continues throughout the day as a natural part of the instructional process. The result is the acquisition of detailed and current data on student and teacher activities with little or no additional overhead.

The CIS Structure

The Classroom Information System is structured in a tree fashion. Shown in Figure 1, the structure is an "unbalanced tree" (Martin, 1975) with the "root" of the tree at the top. The tree is "unbalanced" since it is not symmetrical. The boxes in the figure represent CIS components that are reached by branching down the tree beginning from the root. At each decision point, or "node," a menu is displayed to the user at the terminal listing alternative downward branches. The structure is referred to as a tree, rather than a "network," since each node has only one higher order "parent" node. Consequently, there is only one unique pathway to each CIS component. By branching down the tree, the user reaches a CIS processing module responsible for a CIS function such as prescription printing or student attendance recording. This branching process is not as laborious as it may appear since the CIS tree is only two to five nodes deep with most processing modules reached after two decisions. Figure 1 depicts only the first two levels of this structure.

Each processing module at the base of the tree is self-contained and may be thought of as a separate computer program although some of the modules are grouped together into a single program for implementation purposes. If all the processing modules were to be simultaneously resident in the memory of the computer, they would require nearly one-half million words (18-bit words) of memory, far exceeding the capacity of the machine. Since the CIS was designed to use no more than 16,000 words of memory at any one time, successive modules are retrieved from auxiliary disk storage and are brought into main memory as required overlaying the module currently in use. This overlaying process happens rapidly and usually occurs each time the user at the terminal selects a downward branch from a menu.

The user can also quickly branch back up the tree by not specifying a branch and by pressing the carriage return key alone. This causes the CIS to present the menu from the next highest node. Successive carriage return keys result in successive upward branches until the root of the tree is reached. At any point, the user can also press a special key to request an immediate branch to the root, avoiding all intermediate nodes. These branching rules are universal to the CIS except for those modules with which students interact. These modules are loaded by the teacher in the morning and operate throughout the day. To prevent students from inadvertently "escaping" into other parts of the CIS, the normal upward branching rules do not prevail, and upward branching is controlled by a special code known only to the teacher.

<u>The CIS Database</u>

The CIS manages a variety of data organized into several databases stored on disk. In addition to a number of miscellaneous files, data are maintained on each CIS user, on each school location where the CIS is running, on the curricula in use at each school, and on the activities of each student within a school. The logical starting point of this data structure is the user description file describing each CIS user. When a person seeks access to the computer, an identification number is entered which the CIS subsequently uses to retrieve a user description file. Since the CIS was designed to operate potentially in more than one school, this file specifies the school, a number of other parameters describing the user, and those features of the CIS which the user is permitted to access. This makes it possible for the CIS to operate in separate schools each with different curricula and also to differentiate among users within a school. Teachers, for example, are permitted to access the CIS module which performs prescription writing while researchers may be restricted to data analysis and reporting modules only. Modules which are restricted for a particular person simply are not displayed as available choices, and each user apparently has access to the complete system. It was felt that this approach was preferable to displaying all choices and declaring some as off-limits. Users lacking a user description file are not permitted to access the CIS at all.

For each school, or "site," the CIS maintains a site description file. This file describes the site including the names and locations of additional files which describe the students attending the particular site and the curricula in use. Each curriculum area such as reading or science in use in a school is described in an instructional options file which exhaustively describes the curriculum. Since the various curricula in use are each organized differently and terms such as "unit" and "skill" vary in meaning, a standard CIS curriculum structure was developed on to which any curriculum can be mapped. This structure will not be described in detail here although it is similar in concept to the familiar Dewey decimal classification scheme used in libraries. At the most detailed level of this structure, each possible "standard" learning activity is listed and described. Included are a "teacher description" describing the objectives or content of the activity in terms that are meaningful to the teacher as well as a "student description" that would appear on the child's prescription sheet were the activity selected.

Because of the level of detail that is maintained in these instructional options files, the creation and entry of the data into the computer was a major undertaking. As part of the current project, instructional options files were created for approximately five years of instruction in mathematics, reading, and science. This required over nine person months of effort to write and subsequently type into the computer.

In addition to the user description, site description, and instructional options files, the CIS maintains data on each student and on student activities. As prescriptions are written by the teacher, they are entered into a student prescription file unique to each student. The self-scheduling components of the system access and display these prescriptions whenever the student requests to select an activity. When an activity is selected and begun, this fact is recorded in the student's short term history file. The short term history file contains up to ten school days of detailed data on instructional activities, their duration, and their outcome. Each night, a separate CIS program is automatically run which removes old data from each short term history file and adds it to the student long term history file. This long term history file contains a complete record of student activity from the beginning of the school year to date.

CIS Daily Operation

The CIS is used in two somewhat independent cycles. Students use the system throughout the day making self-scheduling decisions and entering progress data. Teachers use the CIS as part of the prescriptive cycle entering test scores on completed activities, displaying student short term histories, scanning the available instructional options, and selecting one or more activities to be included in new prescriptions. This cycle occurs sporadically throughout the day and is most concentrated immediately after school when plans are developed for the following day.

Each morning, the teachers log the television-like display terminals onto the computer and request the CIS system. This is a simple two-step process requiring ten seconds or less. The teachers then branch through the system to the CIS module used by the students to make self-scheduling decisions. This is again a two-step process requiring only a few seconds to complete. Once loaded, the self-scheduling module displays a request for an ID number and waits for a response. Students are then free to approach the terminals to select and initiate activities and to subsequently terminate activities. Figures 2 and 3 show the logic flow involved in beginning and ending activities.

Although teachers use the CIS during normal class hours, most prescription writing occurs after the completion of the school day. This process, shown in Figure 4, involves displaying the student's short term history if necessary, scrolling through a display of instructional options, and selecting one or more options as a prescription. The teacher can also type in text that will appear on the prescription form enabling the teacher to write any prescription and to depart entirely from the standard options if desired. Figure 5 shows a prescription sheet printed by the system that might be given to a student.

Although the prescriptions can be printed locally on a classroom hardcopy terminal, the teachers typically request the CIS to print the material on the high speed line printer in the computer room. The material is initially stored on disk, or "spooled," and then automatically printed later in the day or early the next morning. The teachers may also request one or more special reports which are run immediately or are automatically deferred and run late at night. The logical flow of these and other CIS processes are shown in Appendix A which contains flow charts detailing the operation of all CIS components.

CIS Reports

Students and teachers use the CIS to produce a variety of student progress reports. Some of these reports are computed immediately and can be printed in the classroom or on the high speed printer, and others are computed late at night and are available the next day. Figures 6 through 10 show examples of reports that are frequently used during the weekly planning seminars or when student assignment changes are necessary.

Figure 6 is a summary of the tasks completed by student 71309 during the week of November 8, 1976. The first column lists task categories for each subject area. The number under each day of the week indicates the number of tasks in the category completed on that day, and the last column provides a total by category. For example, the data in this particular report indicate that student 71309 completed a cassette lesson in reading on Monday, Wednesday, and Thursday for a total of three cassette lessons during the week of November 8th. In addition, the student completed five other tasks in reading, three work book assignments, one story reading assignment, and one test. From this report, several patterns of learning seem to be evident. The student appears to have an interest in the conceptual games area having chosen that area at least once each day. The student also appears to be reasonably consistent in completion rate with five to seven tasks completed each day.

The information provided by this report might be used by the teacher to assess task assignment distribution. For example, during the week represented by this report, the student was assigned only one task in science and spelling. This might be discussed with the student and the number of assignments in these two areas increased. The teacher may also encourage the student to try an exploratory area other than conceptual games.

Figure 7 shows two assignment completion rate reports. The reports show the number of tasks assigned (A) and completed (C) in each subject on each day of the week. The TOTAL column displays the completion rate for each subject. The summaries below the tables show the total number of tasks assigned and completed and the overall completion rate for the week.

The report for student 71309 shows that the student was assigned two tasks in reading on Monday and completed both tasks that day. One more reading task than required was completed on Tuesday and one less on Wednesday. This may indicate that the child completed one of Wednesday's assignments a day early. The summary shows that the student was assigned 27 tasks and completed 30 yielding an assignment completion rate of 111% for the week. The student completed all assignments in each subject and selected several extra exploratory tasks producing a completion rate in excess of 100%.

This information is used during the weekly student/teacher conferences when the prior week's activities are discussed. The data for student 71309 seem to indicate that the student is completing the work and can successfully pace himself to meet the weekly assignments. The teacher and the student might discuss whether an increase or decrease in assignments for a particular curriculum area is necessary to accommodate the student's interests and abilities. For a student with a 111% task completion rate, for example, the teacher and student may negotiate an increase in the amount of the work to be completed in science or spelling since there were few assignments in those areas during the week. However, for a student with a 73% assignment completion rate as is shown in the second report in Figure 7, the teacher may review the time the student spent working on the assignments and the appropriateness of the assignments in terms of their number or difficulty.

Figure 8 summarizes the number of minutes student 71309 spent on each prescriptive and exploratory task during the week of November 8, 1976. The first column lists the curricular areas. The amount of time spent working in each area is displayed under the heading for each day. The adjacent values in parentheses are the number of tasks for which no time information was recorded. This occurs when the student neglects to log in before starting a task. The TOTAL column shows the total amount of time spent on each subject during the week, and the numbers in parentheses indicate the total number of tasks for which there is no time information. The summary at the bottom shows the total time spent on all subjects for each day, the total number of minutes spent on all tasks, the total number of tasks for which there is time information, and the average number of minutes spent on a task.

Figures 9 and 10 are Short Term History Reports that detail recent student performance in a specified subject. The first column lists the task assignment date. The second and third columns show the type of task, and the fourth column indicates the amount of time the student worked on the task. If the task was a test, the test score is shown in column 5 followed by the decision in the last column, MAS (mastery) for a passing score, and NMAS (nonmastery) for a score below the criterion for passing. If the task was other than a test, the score column indicates if the assignment was completed (CMPL) or not completed (blank) in the time shown.

The CIS Field Test

CIS Implementation in the Classroom

Initial field testing of the CIS began in March, 1976. The system was slightly modified during the following summer and was installed on a full-time basis in September, 1976. The CIS operates in the LRDC Demonstration Classroom in the LRDC building. This class is one of the primary classes of the Falk School, a laboratory school of the School of Education of the University of Pittsburgh. The class consists of 50 children from 5 to 8 years in age, two teachers, and one instructional aide. Approximately one-third of the class are children of faculty parents, and about 10% receive full or part time tuition aide. The mean IQ of the group is 129 with a range of 93 to 156.

Four television-like display terminals (Datapoint 3300) and one hardcopy printing terminal (Texas Instruments Silent 700) are installed in the classroom and are connected directly by cable to the

ETSS Computer System several floors above. The display terminals have a display speed of 120 characters per second, and the printing terminal operates at 30 characters per second. The terminals are used to access the CIS system as well as for computer-assisted instruction and other purposes. Each morning at 8:30 AM, the teachers log each display terminal on to the ETSS system and request the Classroom Information System. All four terminals are used during the first half hour after which one or two terminals are released for other purposes. The remaining CIS terminals are used primarily by students throughout the school day until approximately 2:30 PM. The teachers and aide continue using the CIS after normal class hours writing prescriptions and requesting various reports. During the typical month, the CIS system operates more than 450 terminal hours in the classroom.

Teacher and Student Training in the Use of the CIS

The two classroom teachers and teacher aide received instruction in the use of the CIS in two sessions, each averaging 90 minutes in length. The first session provided an overview of the CIS, and the purpose and general functions of the system were described and discussed. In the second training session, the emphasis was on the hands-on use of the system using the computer terminals located in the classroom. The training was accomplished with a minimum of difficulty, and a scheduled third session was found not to be required.

All children in the class who had reached a prerequisite level in the beginning reading program were provided with individual CIS instruction. The prerequisite reading skills included the ability to recognize letter-sound correspondences, read sentences containing two and three word phrases, and successfully answer written questions in a multiple choice format. Some of the students had prior experience using the CIS during the initial field testing of the system the previous year. Some had used the computer-assisted instruction programs included in the math and spelling curricula and were familiar with the use of the terminals. Some had received no prior training in the use of the computer at all.

The training took place in two phases. In the first phase, the children were taught the general procedures involved in computer use, the keyboard layout, logging in and out of the system, and so forth. In the second phase, they were taught the specific procedures required to operate the CIS.

Figure 11 summarizes the time required to successfully train the initial group of 28 children in the use of the system. As is shown, children as young as five years of age were able to learn to use the CIS with only limited instruction. Since most of the third graders had used the CIS the prior year, that group required only one

10 minute session even though the system had been slightly modified in the interim.

As is true of other school subjects, there were individual differences in rate of learning. Interestingly, these differences were not age related and were as great within an age group as across age. However, in spite of the differences, all of the children were able to learn to use the system in one to three, 10-15 minute sessions.

Evaluation

The CIS system has operated in the classroom since September, 1976. Although a full evaluation is premature and additional operating experience must be acquired, the technical and operating characteristics of the system are now well understood, and a number of tentative conclusions can be made regarding the instructional benefits of a computer-based information management system for the classroom.

Technical Evaluation

The technical factors that have been evaluated include the appropriateness of the internal structure, the response times provided by the system, the operating reliability of the CIS, the time and effort required to implement the system, and the computer resources consumed by the system and required for responsive operation. However, the most significant technical finding is that a comprehensive, real-time classroom information system proved to be feasible on a time-shared, small to medium-scale computer system. This is encouraging to those concerned about the economics of classroom computing since continuing declines in cost are expected for systems of this class. Although economic factors were not directly addressed in this project, there is growing evidence that the cost problem is not insurmountable, particularly if the classroom terminals are used for other purposes with high payoff.

Internal structure. The decision to view the CIS as a collection of independent components linked by an external structure facilitated programming and debugging. The modularity afforded by the tree structure allowed multiple modules to be developed in parallel by different programmers. The size limit of 16,000 words (18-bit words) for each module was troublesome only in one or two instances and generally did not complicate the implementation. Although there was some initial concern that the overlaying process might adversely affect responsiveness, this was not found to be the case. Overlaying occurs only when a selection is made from one of the first one or two menus encountered when branching down the tree. Thereafter, all processing occurs within a single module, and no further overlays are required.

Response time. System response time, the time required for the CIS to respond to a request from a teacher or student, is generally good. The CIS design gives priority to interactions with children, and the response time for those interactions averages two seconds or less. Most interactions with teachers are equally responsive; however, certain interactions, particularly those involving the retrieval of data from a large database, require from 5 to 15 seconds and are frustrating to the teacher. The delays are the result of purely technical factors, and efforts are underway to reduce these delays even though the CIS requires less total teacher time than the prior paper and pencil procedures. There is ample evidence from this and other interactive computer applications that frequent delays in the five to fifteen second range are intolerable in a classroom computer system. This is particularly true if the delays occur randomly rather than only at points of task closure.

Reliability. Although the reliability of the CIS system has been excellent, the experience of the field test emphasized the importance of reliability in any computer-based system intended to supplant, rather than augment, existing procedures. Computer failures of any frequency or duration eventually would force teachers to maintain parallel paper and pencil procedures and records. Frequent failures would disrupt normal procedures, and lengthy failures would cause data to be lost resulting in incorrect short-term histories and self-scheduling problems. Because of this, it is difficult to imagine teachers accepting a system which fails more than once or twice a week and is inoperable for more than 10 or 15 minutes per failure.

Fortunately, this has not been the case with the CIS which enjoys high reliability. Although the system does include a facility to enter data in a batch-like manner to quickly update the database were the CIS to fail for an extended period, this feature has never been used. The ETSS computer system on which the CIS operates has a mean-time-to-failure (MTTF) in excess of 30 operating days. Excluding those failures which occur after school hours, the MTTF from the point of view of the student or teacher is over 100 school days.

Implementation. The design of the CIS required approximately 8 person-months, and the implementation required 18 person-months. Three programmers worked on the project, and programming and debugging were completed within six months. Since the development was conducted under optimal conditions using a computer system well suited to the task and with a staff that had extensive experience with similar problems, the development time was significantly less than might be expected in most other environments. For planning purposes, a more realistic estimate would be 30 to 36 person-months for implementation assuming competent programmers and unlimited access to a reliable and technically suitable computer system.

The entire CIS system is written in FORTRAN IV with a limited number of assembly language subroutines. FORTRAN was selected since the ETSS FORTRAN compiler produces fast executing code and because a library of subroutines was available from past projects. The total CIS now operating consists of over 75,000 FORTRAN source statements.

<u>Computer resources required by the CIS.</u> As was described earlier, the CIS operates on a time-shared computer system. Currently, the database requires approximately 12.5 million bytes of disk storage, and this is expected to increase to 17-18 million bytes by the end of the school year. Total monthly terminal connect time, the total number of hours CIS terminals are active, averages over 900 hours per month with about half of the total occurring in the classroom. The remaining half is generated by a variety of CIS uses including the creation and updating of the curriculum database, the running of special reports, and the nightly update of the long term database. This nightly update begins automatically at 12:05 AM at night and, depending upon time-sharing load, runs for one to five hours with a mean time of 1.25 hours.

A series of special reports are run once per week, and these require from one to three hours to complete depending upon time-sharing activity and the complexity of the reports requested by the teachers.

The computational and input/output load imposed on the computer by the CIS varies by CIS component. All CIS components are generally I/O bound and place heavy demands on disk channels since most CIS operations involve database manipulation and searching. The self-scheduling component imposes a moderate load that tends to be stable throughout the day after the initial 45 minutes when all four terminals are in use. The prescriptive component imposes a far heavier load that is most intense from 2:30 PM to 4:30 PM each day. The responsiveness of both components is largely contingent upon the ability of the computer system to support frequent execution for short periods along with heavy disk traffic. Because of this and other factors, the CIS in its present form would only be practical on reasonably high performance multiuser systems.

Operating Evaluation

The CIS was developed, in part, as a demonstration that a comprehensive computer-based information system could be successfully integrated into a classroom without increasing teacher workload and without disrupting normal patterns of work. It was apparent after a few months of the CIS field test that this objective was realizable and that the system was becoming a natural part of the classroom environment. Although several minor operating problems developed, the overall operation of the system has been largely trouble free. The major operating questions that have been explored relate to the teacher time required to operate the system, the need for "on-line" versus "off-line" facilities, the extent to which students are able to meet the operating demands of the system, and the number and type of terminals required to provide an adequate level of service.

Time spent by teachers operating the CIS. One purpose of the CIS is to provide teachers with a less time consuming instructional management procedure. Although it was hoped that the CIS would require less teacher time than the prior paper and pencil procedure, the minimum objective was to ensure that it was no more costly in time and effort. To acquire comparative data on this, the teacher who participated in the initial field testing of the system maintained a record of the time required to prescribe using both the CIS and the paper and pencil procedures. The initial use of the CIS was restricted to prescriptions in mathematics for five children, and that number was gradually increased as the teacher became more proficient in the use of the system.

The results of this comparison are shown in Figure 12. As is shown, the time required to prescribe using the CIS steadily decreased as the number of students receiving computer prescriptions increased. Within two months, the CIS times had decreased until they were approximately the same as the paper and pencil times. This steady decrease is attributed to simple economies of scale and to the teacher becoming more familiar with the system.

The CIS was modified during the Summer, 1976, to improve overall performance and to further reduce the time required to write prescriptions. As is shown in Figure 13, these modifications were effective, and prescription times decreased through January, 1977, the last month for which data are available. The CIS times are now significantly less than the comparable paper and pencil times observed during the prior year. It is anticipated that these times will continue to decrease as the CIS is refined and unnecessary prescription writing procedures eliminated.

Currently, the prescription writing process requires that the teacher must each day verify as complete or incomplete all tasks undertaken by each child. This is simply a double check to ensure that the child has properly informed the system of all task outcomes. As is shown in Figure 14, the time required to do this is significant and constitutes about one-half of the total prescription time. However, it was discovered that children rarely inform the system that a task is complete when it is not. The most common error is to forget to inform the system at all. The CIS then assumes that the task is currently in progress and is incomplete. The verification procedure is currently being modified to require teachers only to verify these incomplete tasks as incomplete. It is expected that this will reduce verification time by 60% to 70% and will reduce average prescription times to under .9 minutes.

On-line versus off-line facilities. When the cost of providing information services by computer is higher than other methods, the use of the computer can only be justified if it is felt that the benefits outweigh the additional cost. The CIS is an attempt to completely replace a paper and pencil information system with a comprehensive computer-based discipline. The CIS is self-contained and requires no supporting paper and pencil procedures or materials. In effect, the entire process is "on-line." Although it is recognized that the ultimate worth of the total system depends upon the extent to which it facilitates the instructional process, the benefits of computerization may be greater for some parts of the CIS than for others.

The field test experience has shown that the CIS feature which enables teachers to browse through instructional options on-line is not essential. Comparable services might be provided at lower cost by a computer printout in a ring binder located next to the terminal. Although it is necessary to store all instructional options in the computer so that they may be retrieved and printed on prescription forms, the facility to browse through these options on-line when making a prescription decision may not be necessary. Were the options conveniently available in printed form, the teacher might quickly locate the desired options and enter brief numeric codes into the computer to identify the options desired. This would be as fast or faster than the current scheme, would somewhat simplify the CIS, and would not reduce the overall effectiveness of the system.

Student use of the CIS. The students quickly learned to operate the self-scheduling component of the system and few difficulties were reported. The menu approach restricted all student input to numbers, reduced keyboard search time, made system operation self-explanatory, and allowed even the youngest students to operate the CIS without difficulty. The most persistent problem was ensuring that the students remembered to log-in on the computer terminals when they began a task and to log-out when they completed a task. Since the prescription forms were printed earlier in the day, and were available to the student, it was possible for a student to complete an assignment and begin another without informing the CIS.

Although the teachers have developed management procedures which have minimized the frequency with which this occurs, the problem will not be eliminated until a scheme is devised which makes reporting to the CIS a natural and essential step in the self-scheduling process. The preferred solution would be to eliminate the printing of prescriptions in advance and to print prescriptions on demand whenever a self-scheduling decision is made. This would require the student to use the terminal in order to obtain the prescription and also would allow the teachers to alter the prescription at any time prior to its printing. This solution involves no insurmountable technical obstacles although it does require that a reasonably fast and quiet printing unit be installed in the classroom. Were such a unit available and particularly if it operated on a fast copier-like principle, it might also be used for other potentially interesting applications such as the dynamic production of individualized tests, work book sheets, and the like.

Classroom terminal requirements. Data obtained during the field test indicated that adequate CIS services with minimal queuing delays would be possible with a terminal ratio of one terminal for every

25 students. Although the terminal would be in use only 40% of the time or less with a 25 to 1 ratio, any significant increase in the number of students per terminal beyond this level would present queuing problems.

For use primarily as a CIS terminal, the television-like display is preferable offering high speed, quiet operation, and the elimination of unnecessary paper. The terminal display speed of 120 characters per second used during the field test was ample, and it is felt that higher display rates would not significantly alter the nature or speed of the interaction. Although a classroom hardcopy printing unit was not used since most printing was performed on the high-speed printer located nearby, a printing unit would normally be required for the printing of reports and prescriptions. The need for silent operation would preclude the use of most impact printers and would require the use of printing units employing a thermal or copier-like printing method.

For prescriptions, a printer operating at 30 characters per second would be adequate and would enable over 95% of the prescriptions in the current instructional options database to be printed in 10 seconds or less. For those reports for which hardcopy is required, higher speeds would be necessary depending upon volume. A unit operating at 120 characters per second would print in 30 minutes per day or less all of the reports regularly produced during the field test.

The Contribution of the CIS to the Instructional Process

The CIS is designed to provide students and teachers with timely student progress information that can be used when planning and tailoring instruction to the learning needs of individual students. The preliminary results of the CIS field test indicate that the reports produced by the system see frequent and heavy use and have altered the instructional planning process in ways the teachers view as favorable. The teachers find the summary reports shown in Figures 6-10 particularly useful when evaluating the accuracy and effectiveness of their prescriptions. The ability to easily obtain concise, well structured data on individual students enables the teacher to review progress with students and parents at any time and to do so in detail.

The effects of providing students with immediate and task specific feedback on a regular basis have been dramatic. The computer generated reports enable the students and the teachers to visualize the individual student's learning patterns and achievements at a glance. The impact of this is probably best summarized by student comments during the weekly planning conferences with teachers: "I didn't realize that I spent 80 minutes in science last Friday!" "I guess I better spend more time on my reading assignments." "I thought I worked in reading for at least two hours each day!" "No wonder I did not finish my reading three days in a row." "I had a 137% task completion rate? Wow!" "The reason why I spent all that time in games everyday last week is because me and Michael and Jill are having a chess championship contest..." "I like to get all my assignments done first before I do my exploratory." "May I do Science everyday next week so that I can get out of the Black Unit." "I always do my spelling with Liza, and we get done faster when we work together."

Planning time with students has been reduced since teachers now have available well formatted, summary data to use as the basis for discussion. The teachers can quickly review the information with the student and begin to negotiate and plan the next set of assignments. Interestingly, these summary reports are often read by the students themselves outside of the regular planning sessions. Most important, these reports and their use in the planning sessions have provided the students with valuable experience in determining what information is relevant and should be used as the basis for planning and making instructional decisions. The CIS database also provides the teacher with a long term memory bank which maintains itself and which can be tapped at will. This is important since it has been shown that even the best and most conscientious teacher is not able to recall relevant student progress information accurately (Wang, 1973).

Only a very small portion of the total CIS instructional resources have been used during this field test. In the future, the emphasis will be upon the development of "exception" reports to pinpoint trouble spots and areas of interest and in using the database to address instructional design questions. These will include studying the effectiveness of learning tasks designed to teach particular objectives to students with certain learning characteristics, whether certain tasks are more interesting than others for students with certain characteristics, whether some tasks require more learning time for students with specified characteristics, whether rate of learning is specific to the student or to the task, and a variety of related questions that might provide some answers and guidance to those faced with the task of designing instructional programs that are adaptive to the learning characteristics of the individual student.

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Appendix A

Flow Charts Depicting Logic Flow of CIS Components

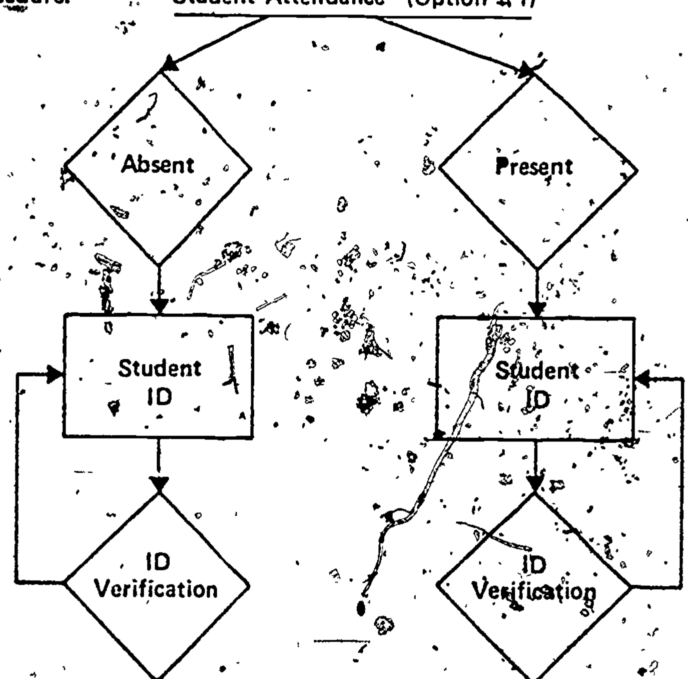
Flow Charts developed by Mary Ebert. Graphics by Donna Rottman.

Teacher Interaction Procedure Student Attendance

Purpose: to record absentees

N.B.: Only absentees need to be recorded

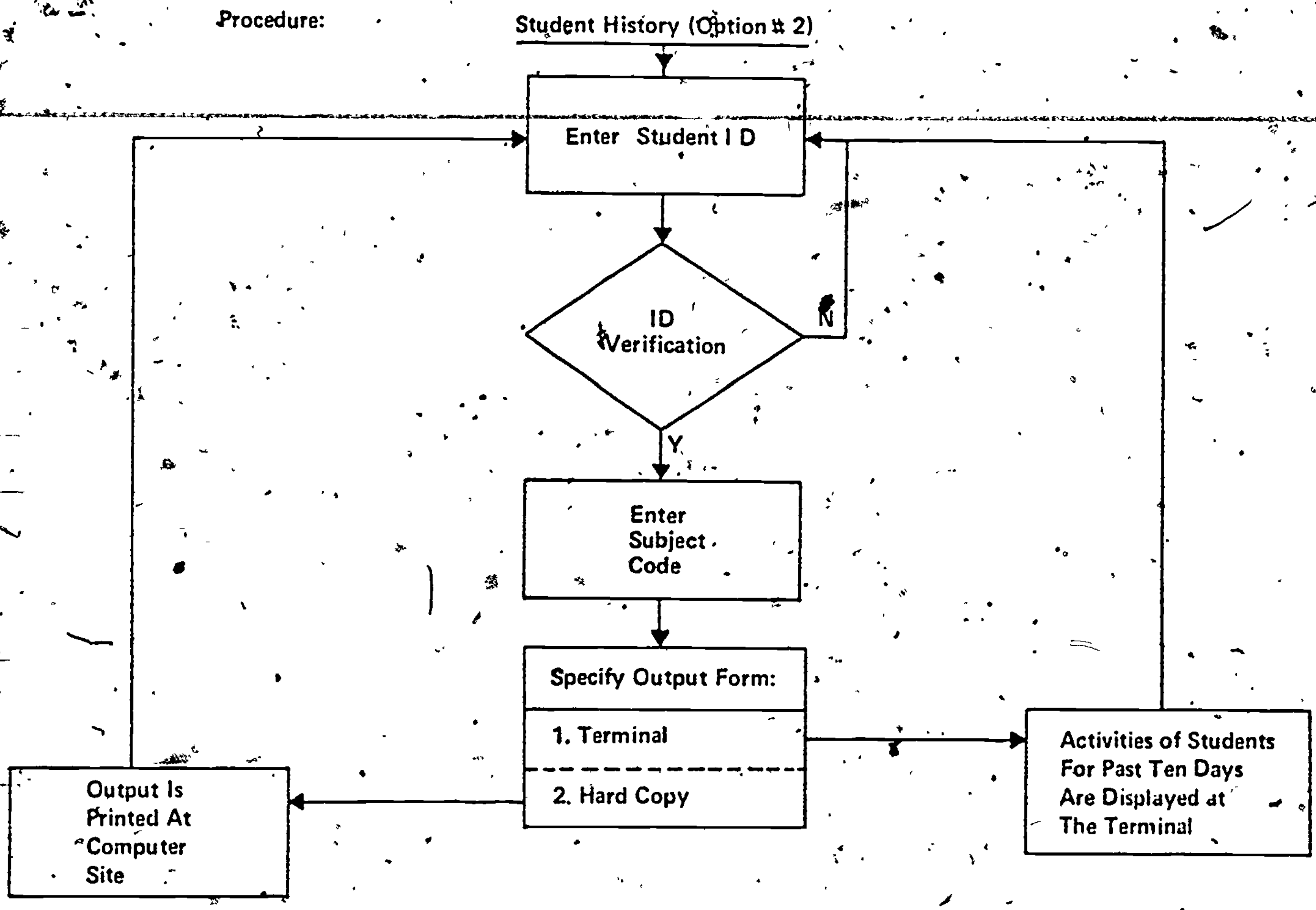
Procedure: Student Attendance (Option #1)



Teacher Interaction Procedure — Student History

Purpose: to display students' activities (date, task, area, time, score, mastery decision).

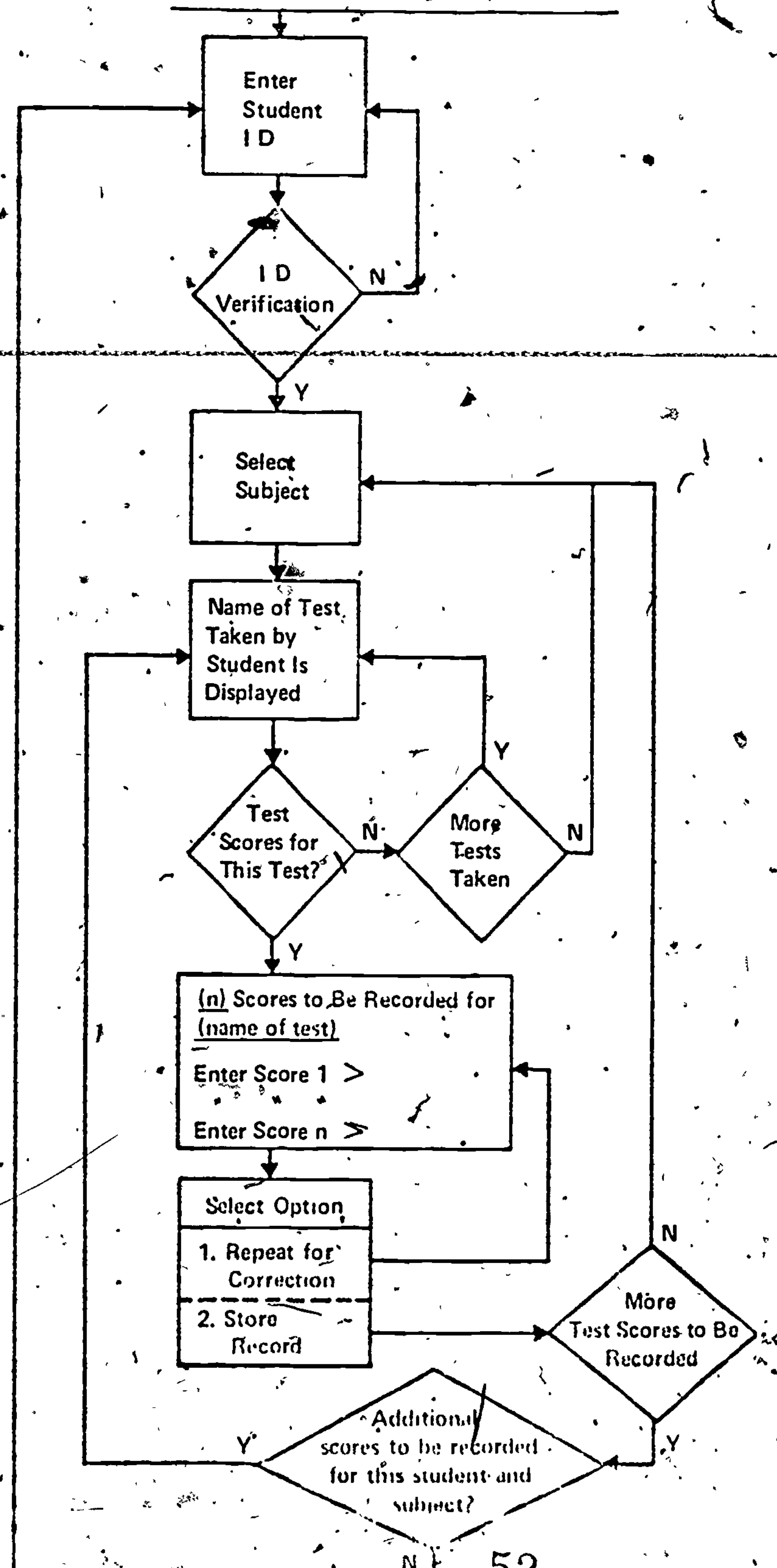
Procedure:



Teacher Interaction Procedure Test Score Recording

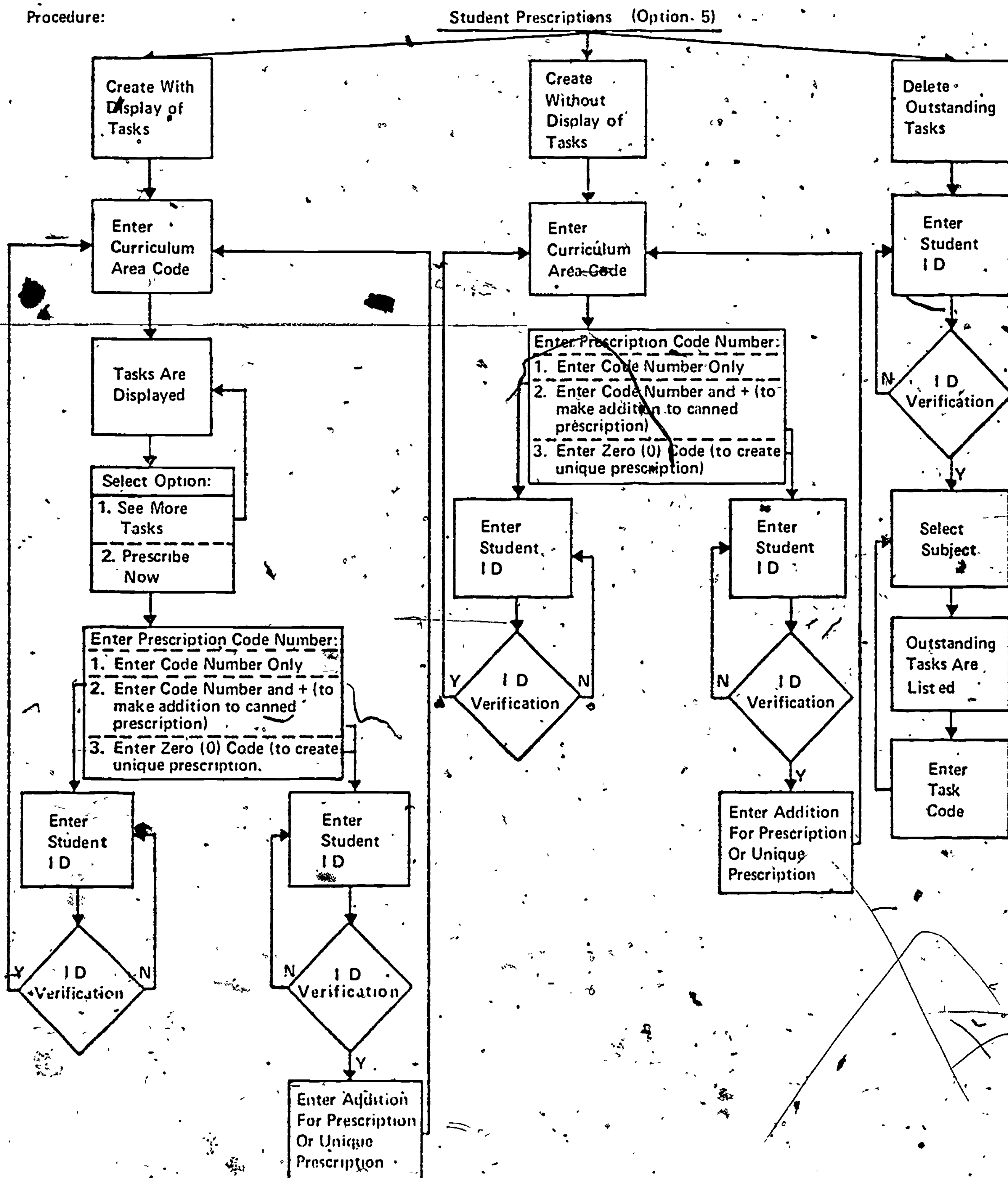
Purpose: to record students' test scores.

Procedure: Test Score Recording (Option #3)



Purpose: to create or delete prescriptions.

Procedure:



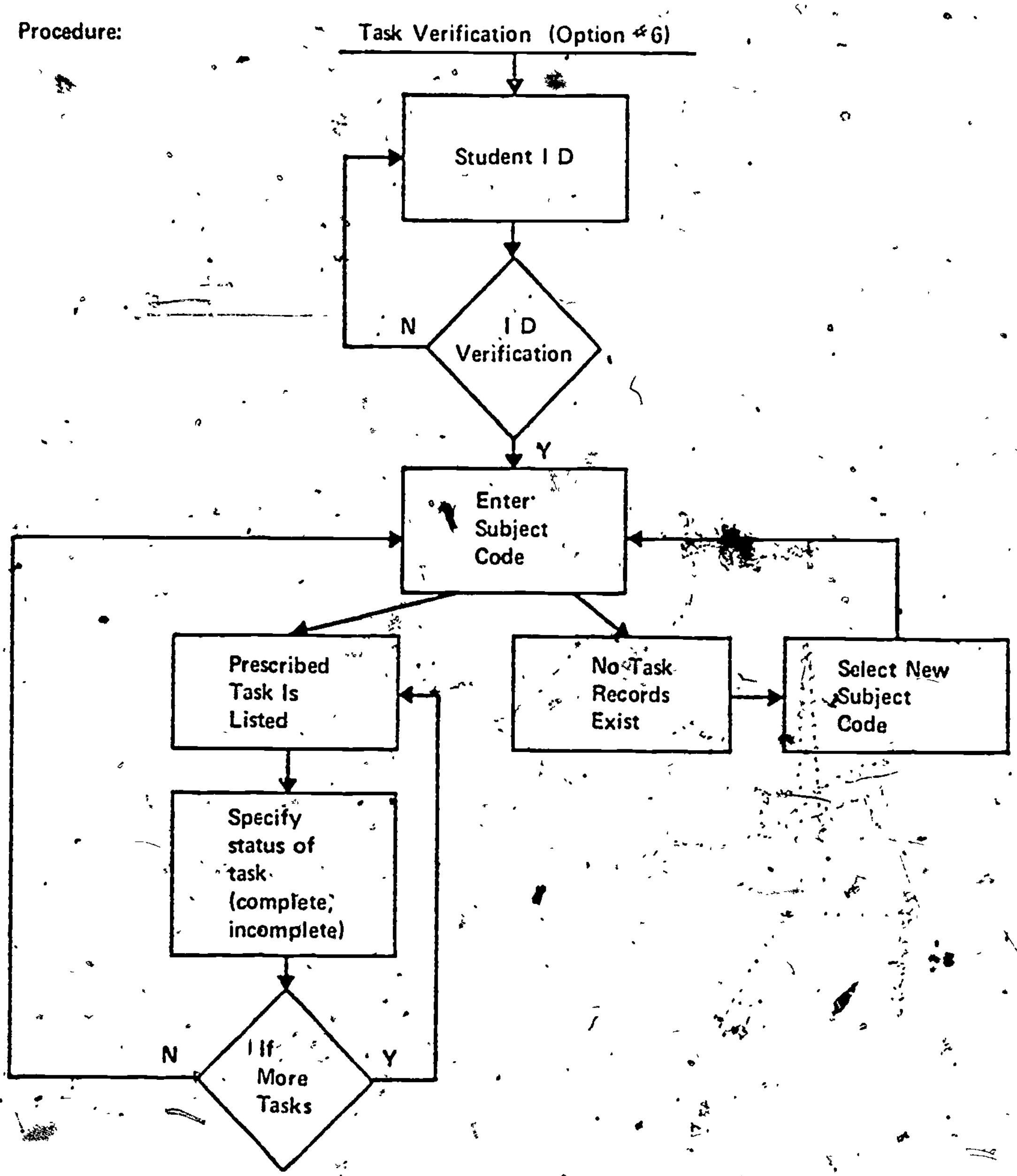
Teacher Interaction Procedure

Task Verification

Purpose: to verify if a student actually has completed tasks prescribed.

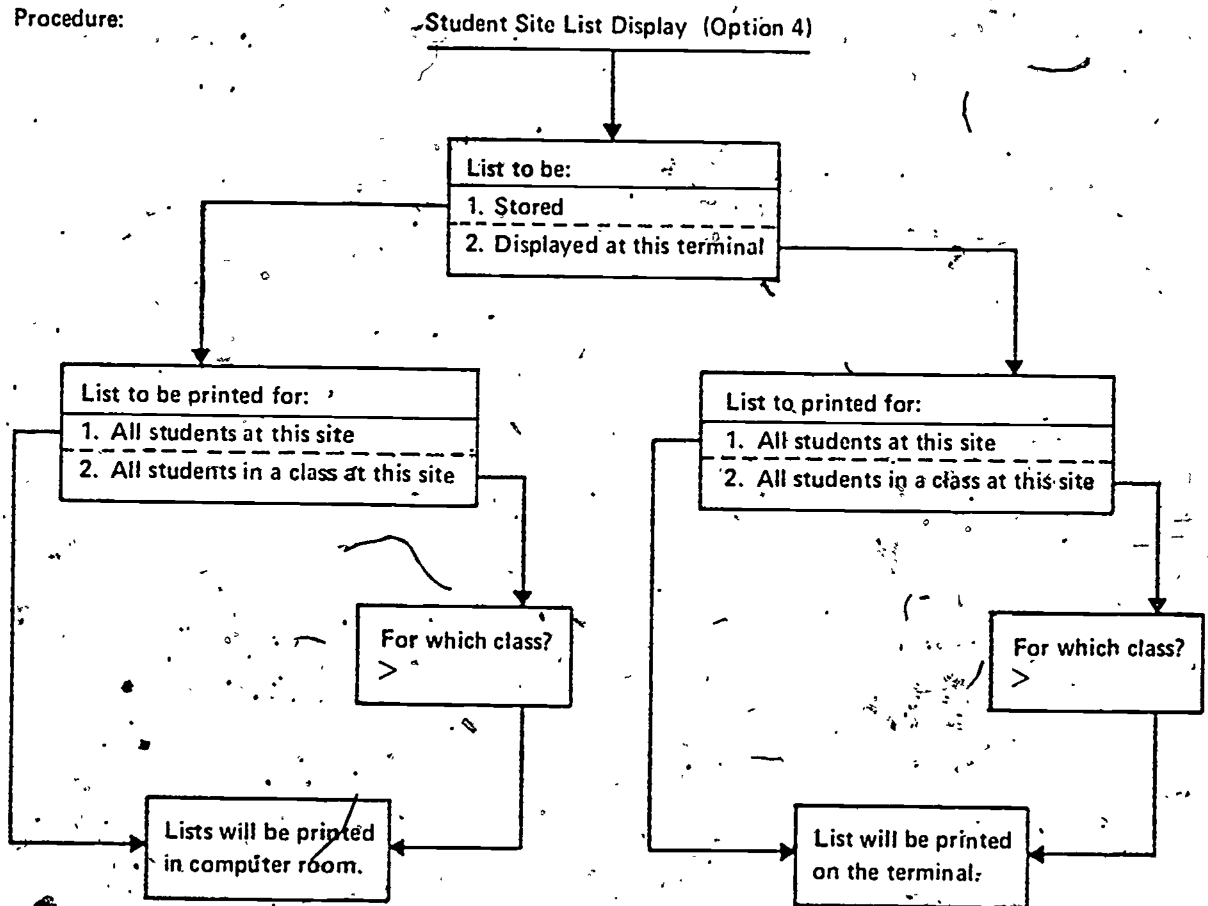
N.B.: If the teacher indicates that the student has completed a task, the task will no longer appear on the student's prescription printout.

Procedure:



Purpose: to generate listing of students' names, IDs, birthdates, ages and class.

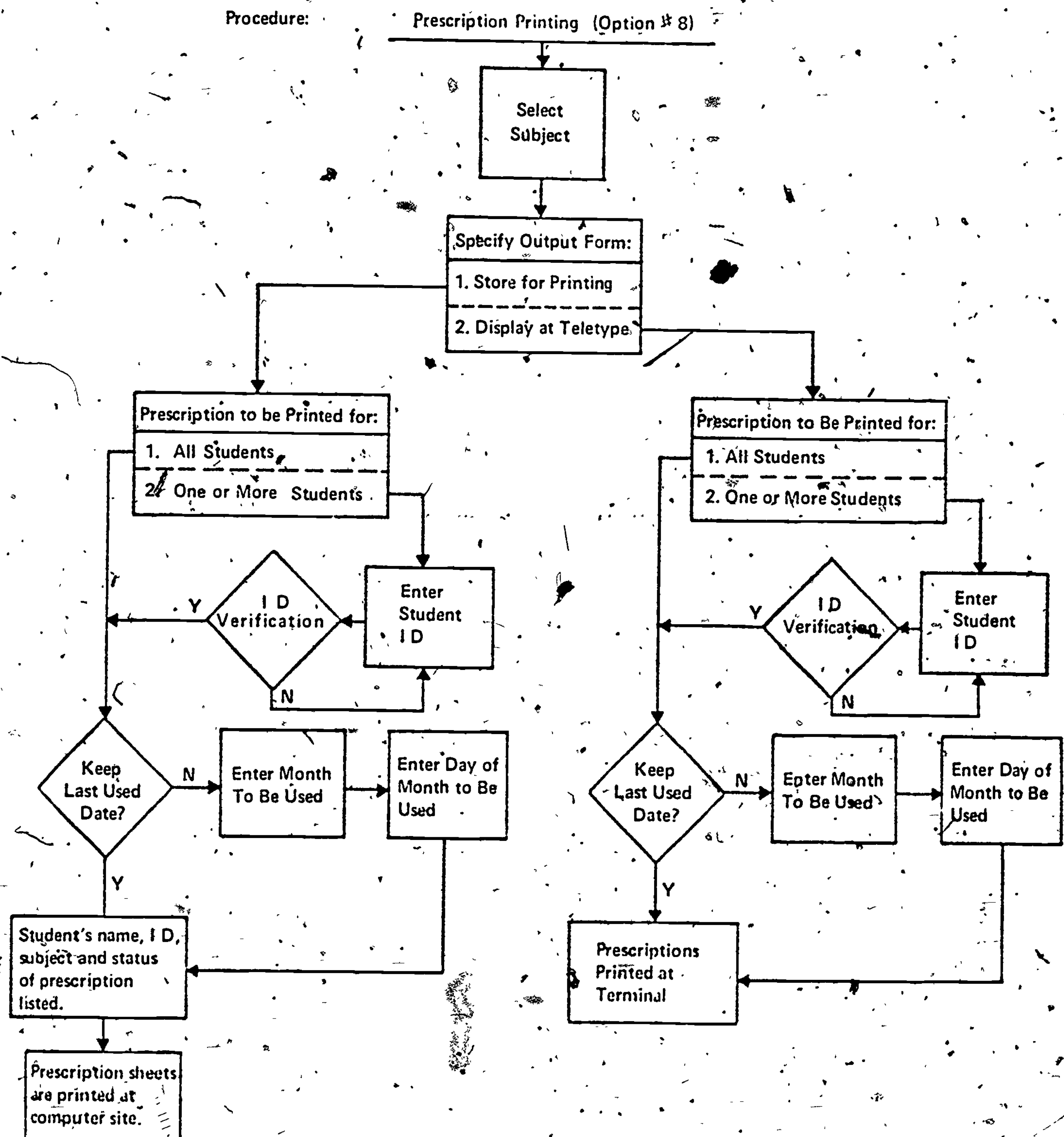
Procedure:



Teacher Interaction Procedure — Prescription Printing

Purpose: to print prescription hard copies for distribution among the students.

Procedure:

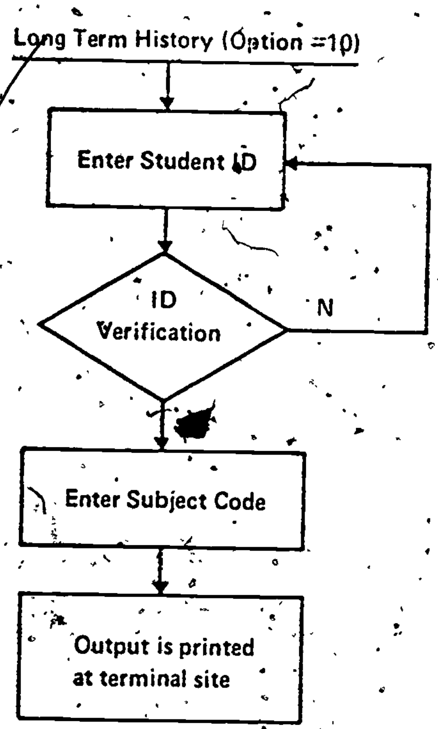


Teacher Interaction Procedure

Long Term History

Purpose: to obtain a complete listing of student's work during the entire school year.

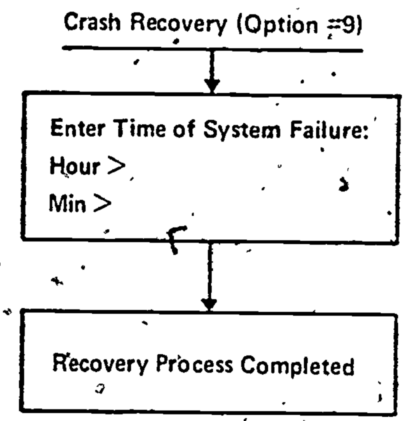
Procedure:



Teacher Interaction Procedure — Crash Recovery

Purpose: to finish CIS procedures interupted by computer crash

Procedure:

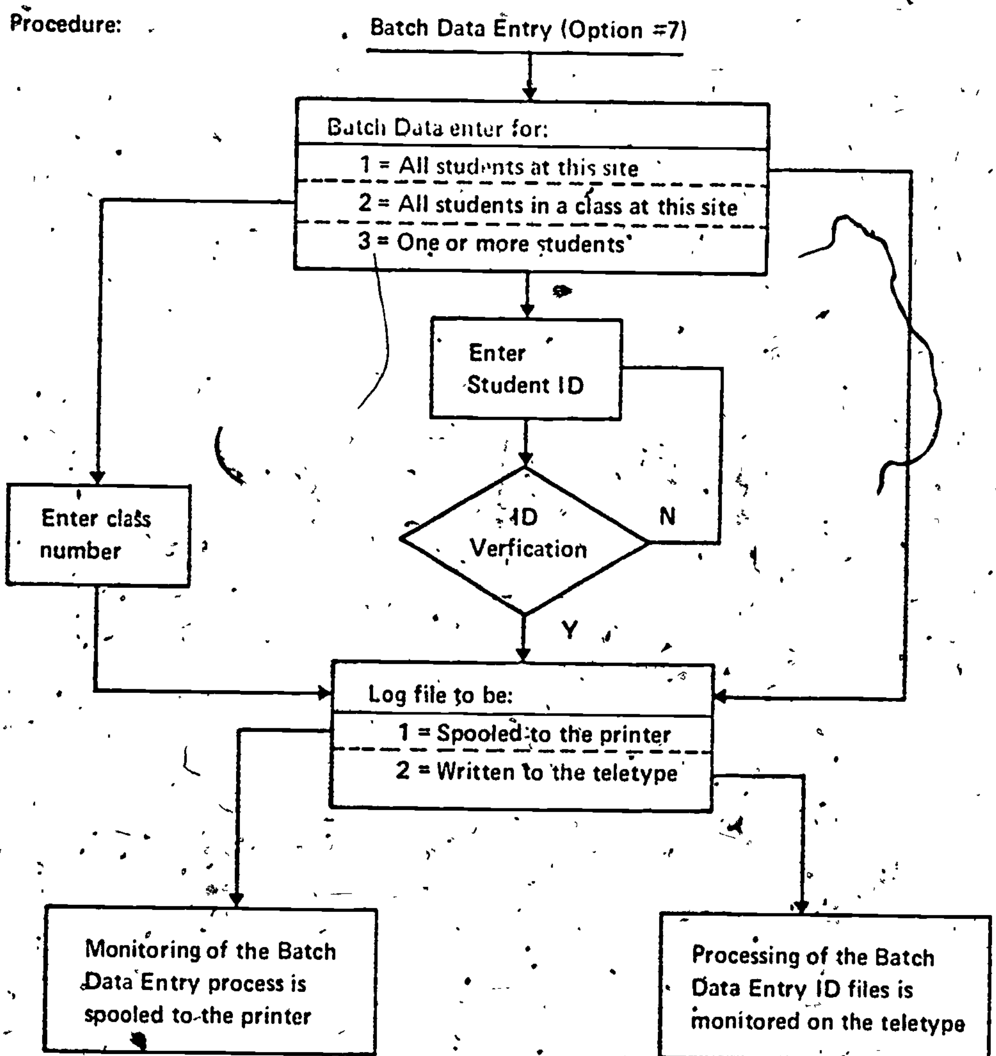


Teacher Interaction Procedure

Batch Data Entry

Purpose: to enter data accumulated during computer down period.

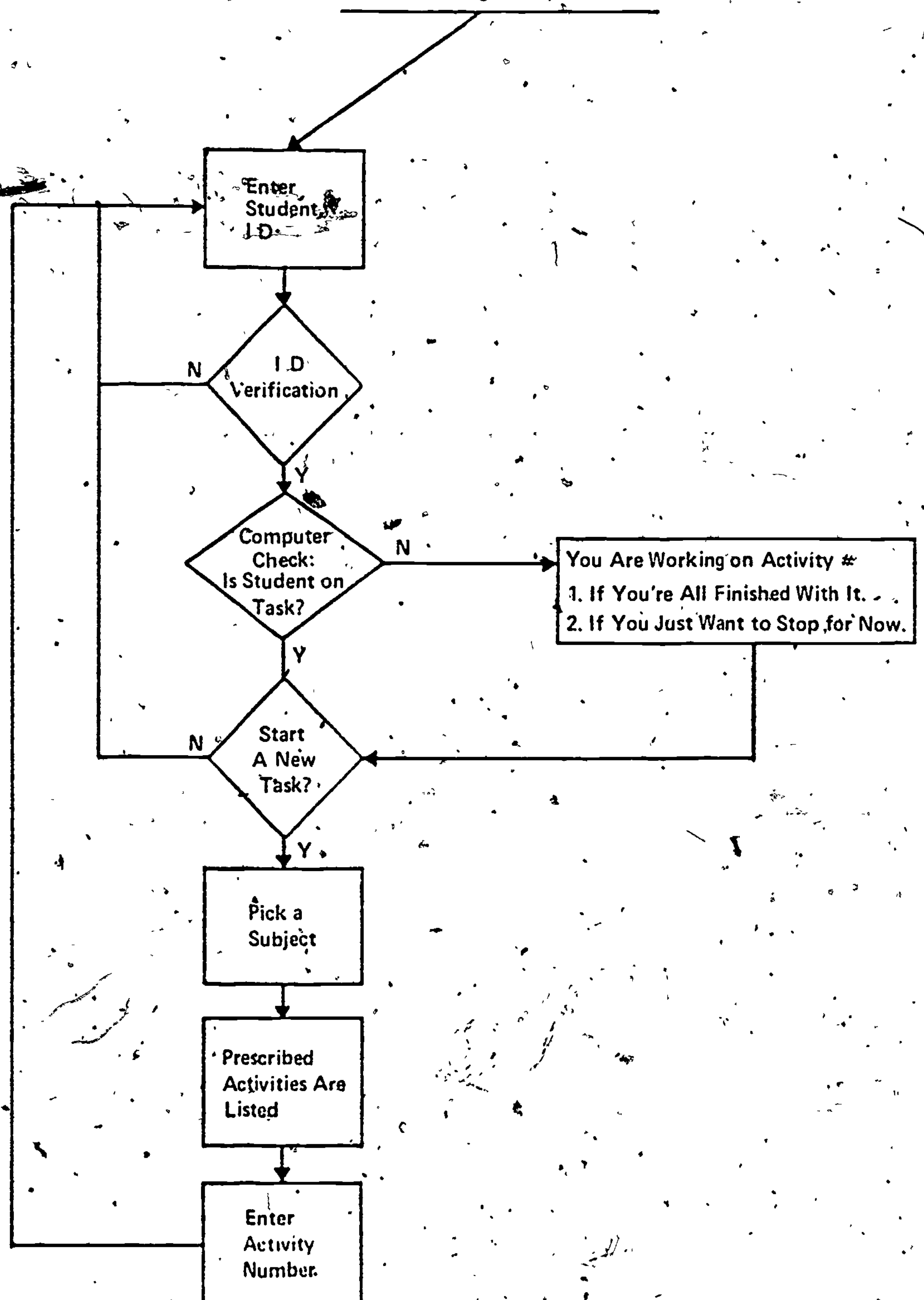
Procedure:



Student Interaction Procedure — Student Usage

Purpose: to record student activities (date, task, time, etc.).

Procedure: Student Usage (Option #1)



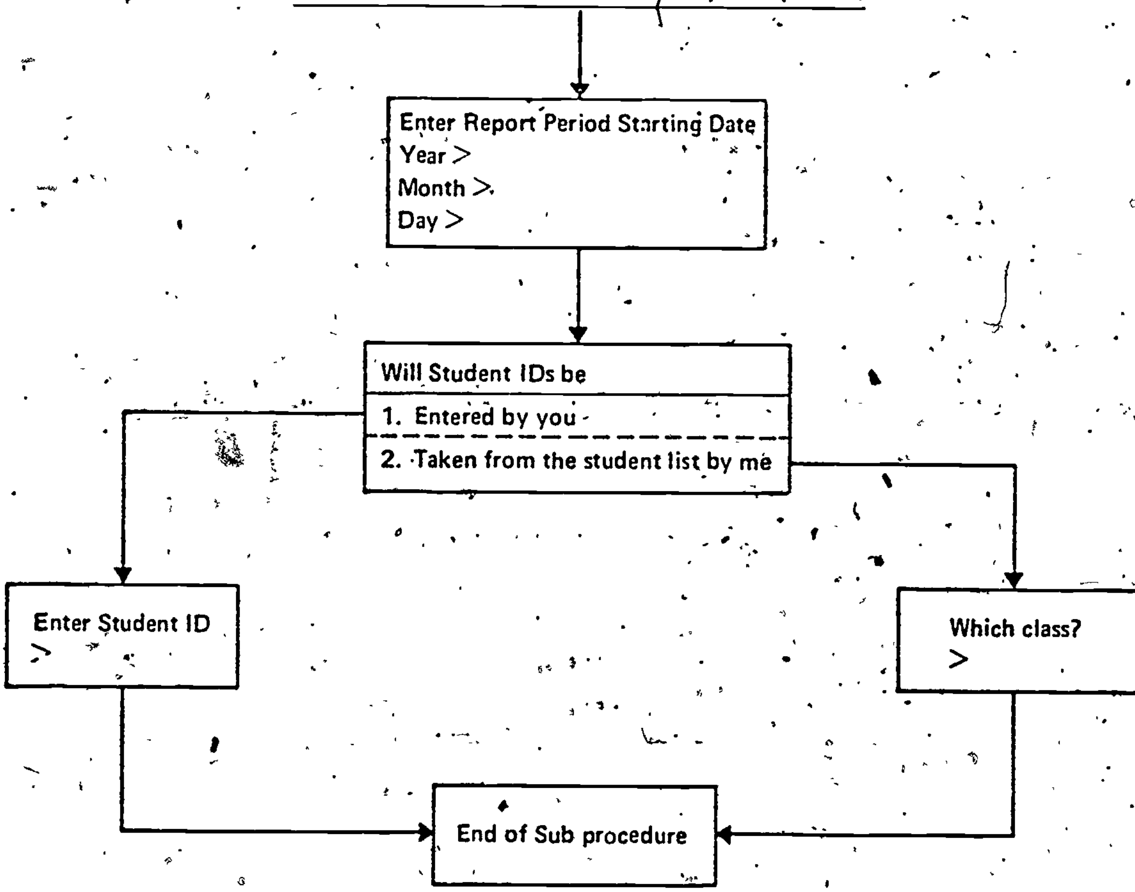
Report Specification Procedure

Minutes Spent on Each Subject

Purpose: to generate weekly reports on the time students spend on each subject.

N.B.: This report must run over night and will be available the following morning.

Procedure: Minutes Spent on Each Subject (Option 1)

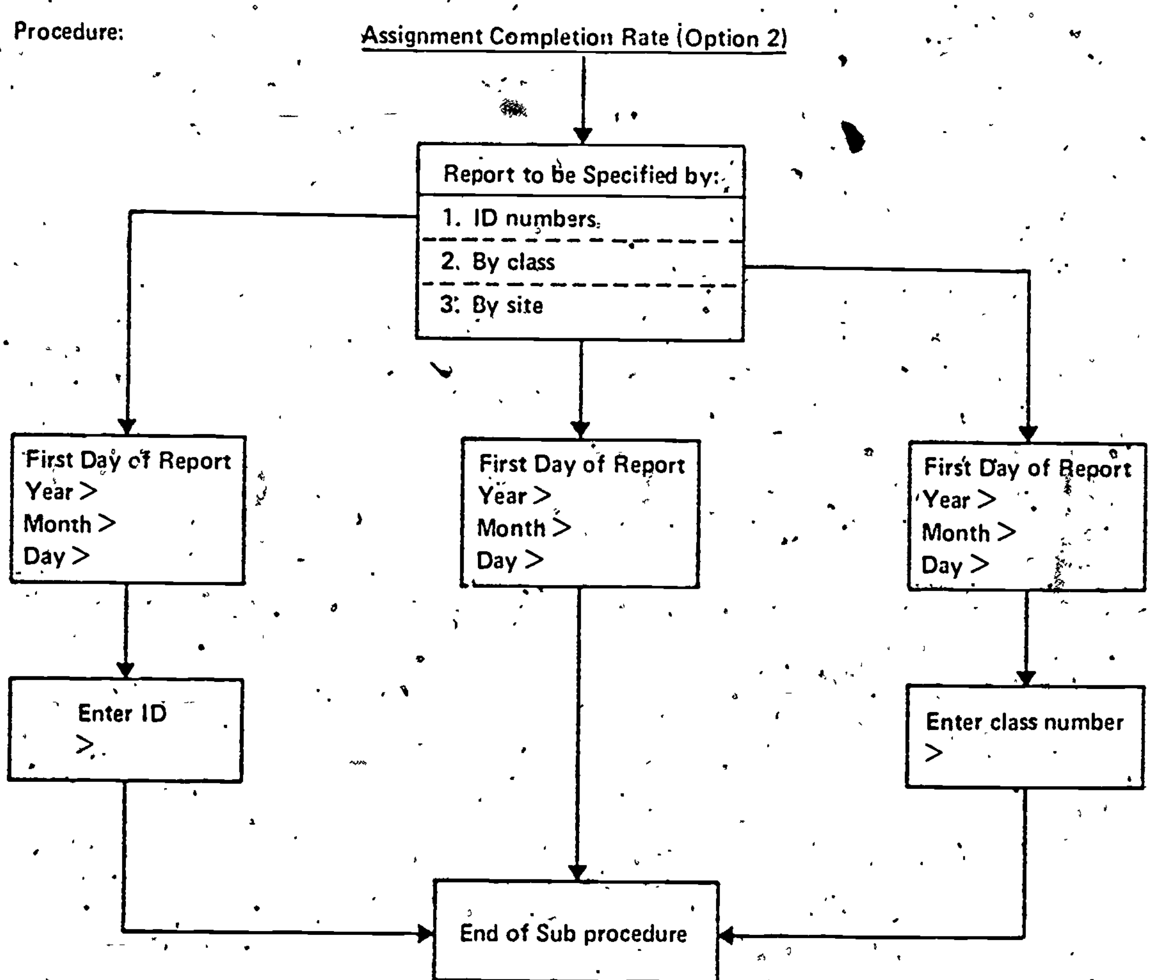


Report Specification Procedure — Assignment Completion Rate

Purpose: to generate weekly reports on the students assignment completion rates.

N.B.: This report must run over night and will be available the following morning.

Procedure:



Report Specification Procedure — Task Completed

Purpose: to generate weekly reports on the number and type of tasks that are completed by the students.

N.B.: This report must run over night and will be available the following morning.

Procedure:

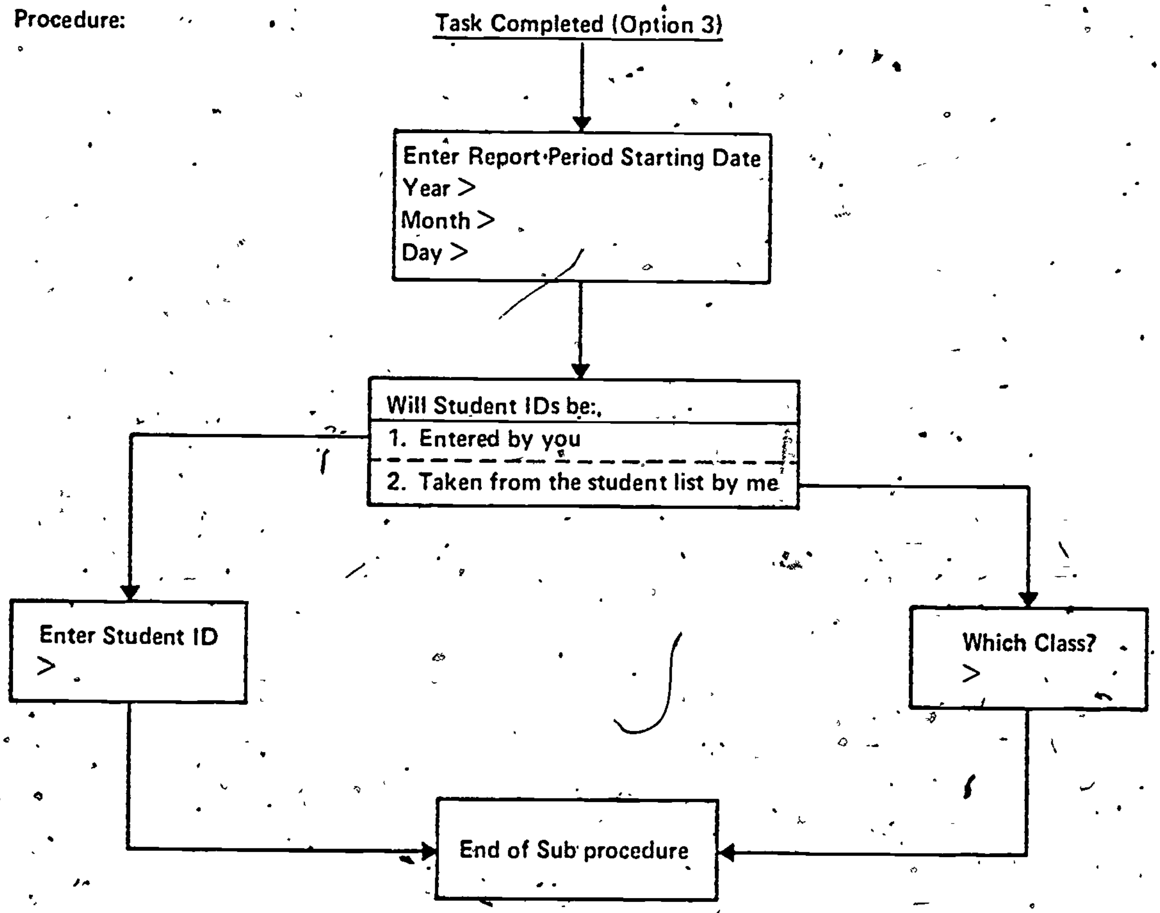


Figure Captions

Figure 1. Classroom information system structure.

Figure 2. Procedure used by child to select and initiate an activity.

Figure 3. Procedure used by child to terminate an activity.

Figure 4. Example of prescription process followed by teachers.

Figure 5. Example of student prescription sheet.

Figure 6. Weekly summary report of tasks completed.

Figure 7. Weekly summary of task completion rate in each subject.

Figure 8. Weekly summary of time spent in each subject.

Figure 9. Examples of the short term history report.

Figure 10. Examples of the short term history report.

Figure 11. Summary of minutes spent for individual CIS training sessions.

Figure 12. Comparison of average prescription time between the CIS and the pencil-paper procedures.

Figure 13. Minutes spent prescribing using CIS procedures, 1976-1977 school year.

Figure 14. Minutes spent on CIS verification procedures 1976-1977 school year.

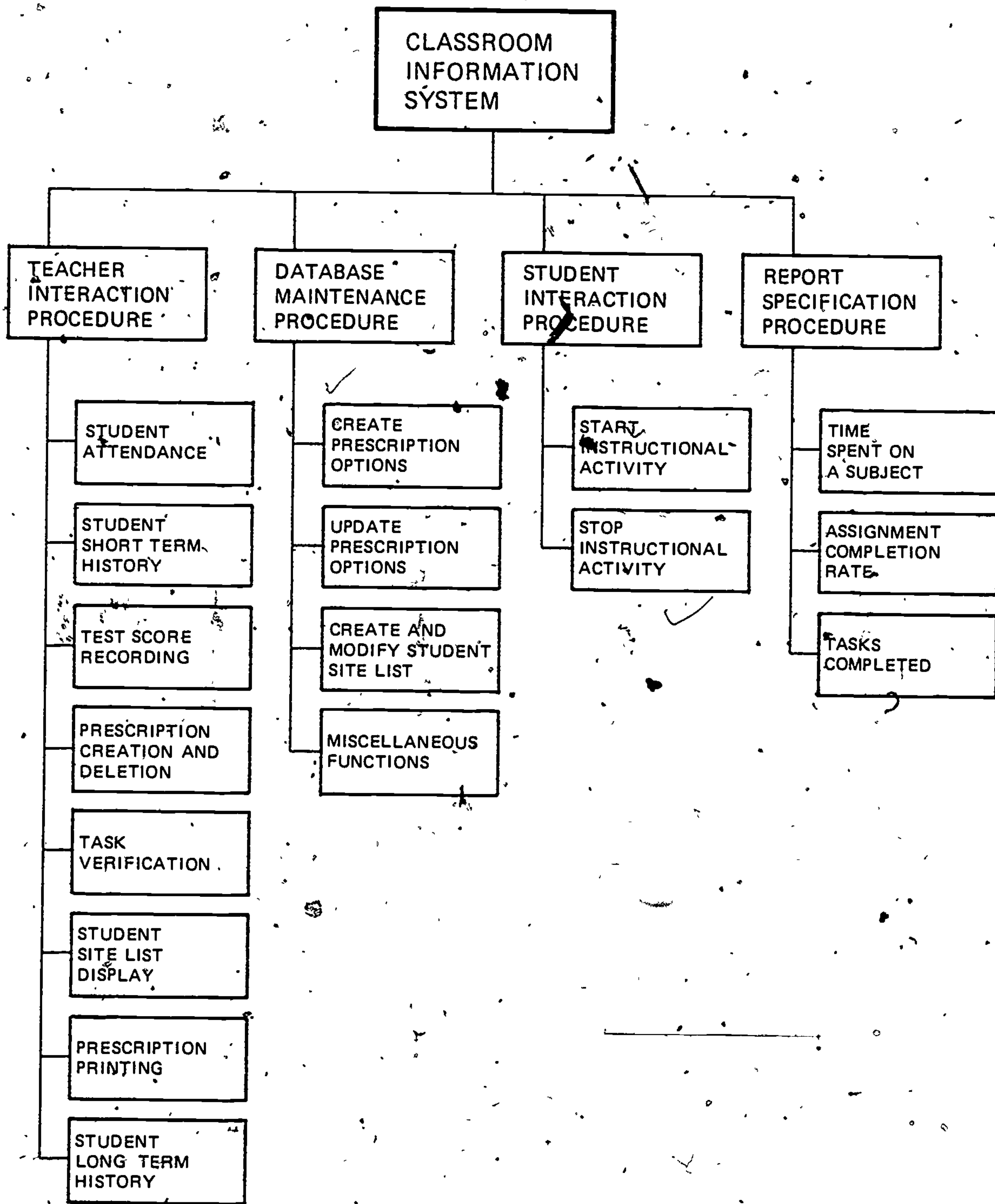


Figure 1. Classroom information system structure.

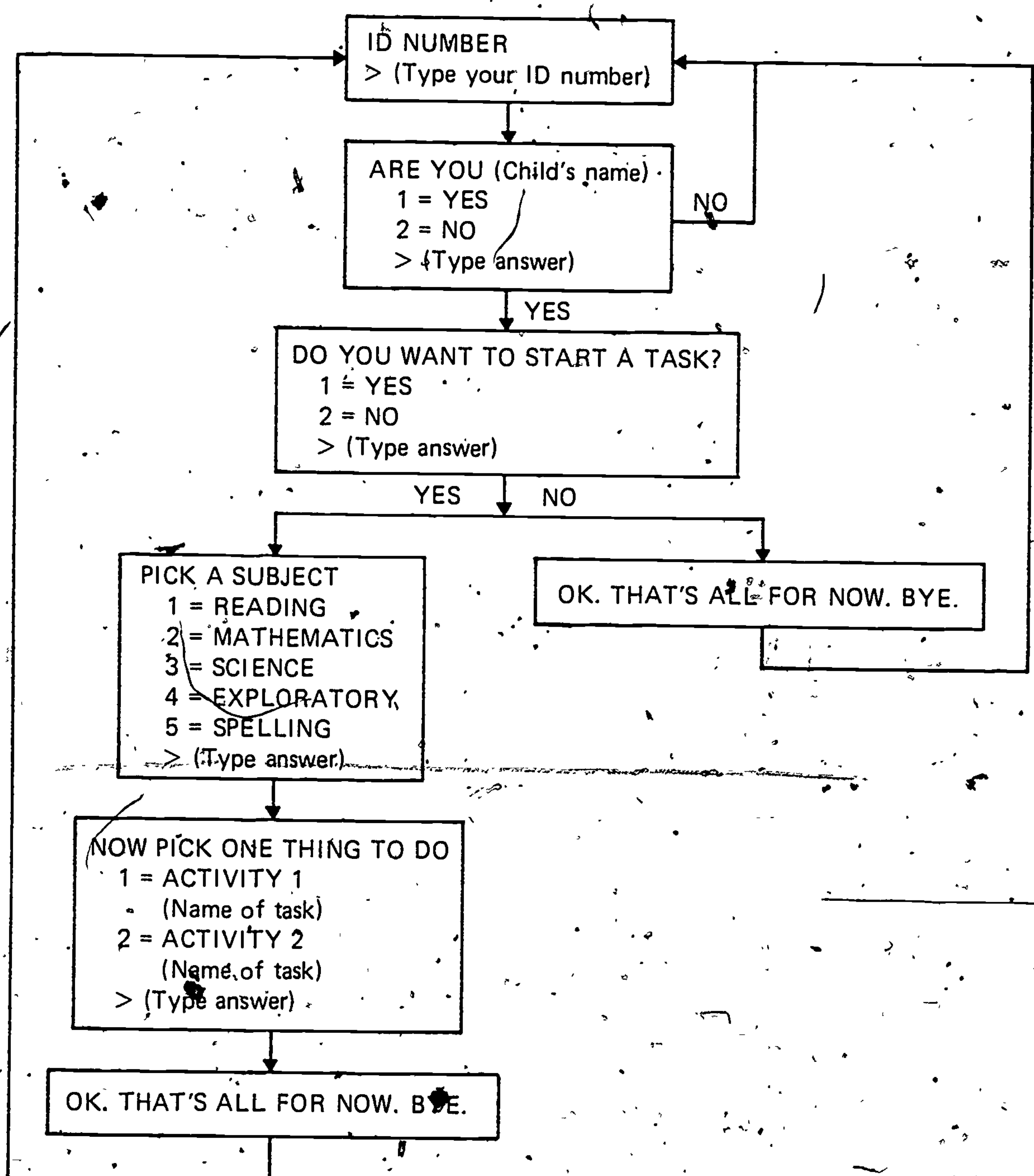


Figure 2. Procedure used by child to select and initiate an activity.

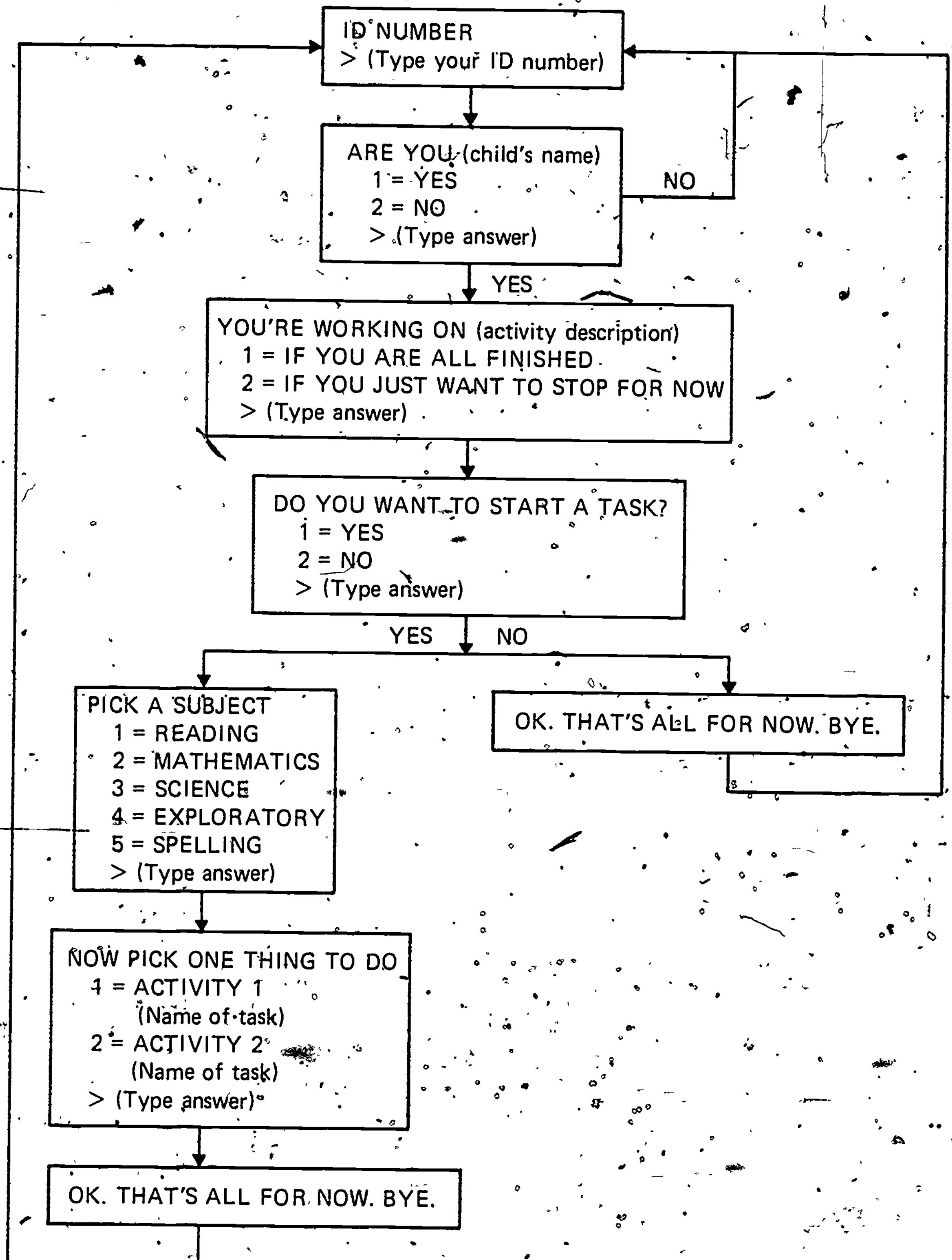


Figure 3. Procedure used by child to terminate an activity.

CLASSROOM INFORMATION SYSTEM MONDAY 21-FEB-77

SUB-PROCEDURE: STUDENT PRESCRIPTION

PRESCRIPTION OPTIONS:

1 = CREATE--WITH DISPLAYING OF AVAILABLE TASKS
2 = CREATE--WITHOUT DISPLAYING
3 = DELETE OUTSTANDING TASKS
>1

ENTER CURRICULUM AREA CODE:
> 2. 1. 13. 4
INSTRUCTIONAL OPTIONS FOR MATH, IM ,, IM13, M13C

[0] = TYPED INPUT FROM THIS TERMINAL

1] = [M13C-BOX 1]
USING THIS BOX THE CHILD MUST COLLECT SINGLE DIENES BLOCKS AND PLACE THEM IN THE SPACES AS INDICATED ON THE CARDS PROVIDED. THE CHILD MUST THEN WRITE THREE NUMERALS: THE NUMBER OF TENS GROUPED, THE NUMBER OF ONES GROUPED, AND THE TOTAL NUMBER OF BLOCKS ON THE CARD. THE CHILD ALSO MUST EXCHANGE SETS OF TEN ONES FOR A TENS BAR.

TODAY YOU ARE ASSIGNED WORK IN ♦MATH BOX M1301♦.

CHOOSE AN OPTION:
1 = SEE MORE TASKS
2 = PRESCRIBE NOW
>1
[2] = [M13C-BOX 4]
USING THIS BOX THE CHILD IS TO PLAY DOMINOES BY MATCHING WRITTEN NUMBERS (E.G., 6 TENS AND 3 ONES) TO NUMERALS (E.G., 63).

IN ♦MATH BOX M13C♦ YOU WILL FIND A DOMINOES GAME TO PLAY!!

3] = [M13C-LB 3]
ON EACH PAGE OF THIS LAMINATED BOOKLET THE CHILD MUST WRITE THE NUMBER OF TENS AND ONES GROUPS ILLUSTRATED. HE THEN MUST WRITE THE NUMERAL REPRESENTING THE TOTAL NUMBER OF SQUARES ON THE PAGE (E.G., 3 TENS 5 ONES = 35).

YOUR ASSIGNMENT FOR TODAY IS ♦MATH LAMINATED BOOKLET M13C3 (LB)♦.

CHOOSE AN OPTION:
1 = SEE MORE TASKS
2 = PRESCRIBE NOW
>2

ENTER PRESCRIPTION CODE
>2,3

STUDENT ID
>71111

Figure 4. Example of prescription process followed by teachers.

[2468] 8–MAR–77 SUBJECT: MATHEMATICS

ACTIVITY [1]

CONGRATULATIONS!! YOU ARE READY TO BEGIN A NEW MATH UNIT.

FIRST YOU MUST TAKE THE *PRETEST, UNIT 13* IN THE

YELLOW BOOKLET.

ACTIVITY [2]

IN *MATH BOX M13C* YOU WILL FIND A DOMINOES GAME TO PLAY!!

Figure 5. Example of student prescription sheet.

STUDENT ID NUMBER: 71309 WEEK OF: 76/11/ 8

TASKS COMPLETED

SUBJECT	MON	TUE	WED	THU	FRI	TOTAL
READING						
NRS: CASSETTE	1		1	1		3
NRS: WORKPAGES	1	1			1	3
NRS: READ ALONE STORY				1		1
NRS: TEST		1				1
SUBJECT TOTAL						8
MATHEMATICS						
BOOKLET	1	1	1	1	1	5
TEST			1		1	2
SUBJECT TOTAL						7
SCIENCE						
DIRECTED GROUP ACTIVITY			1			1
SUBJECT TOTAL						1
EXPLORATORY						
MATH GAME			1			1
LIBRARY	1					1
CONSTRUCTION		1	1		2	4
GAMES	1	2	1	2	1	7
SUBJECT TOTAL						13
SPELLING						
--UNDEFINED ACTIVITY--				1		1
SUBJECT TOTAL						1
TOTAL	5	6	7	6	6	30

Figure 6. Weekly summary report of tasks completed.

STUDENT ID NUMBER: 71309 WEEK OF: 76/11/ 8

ASSIGNMENT COMPLETION RATE

SUBJECT	MONDAY		TUESDAY		WEDNESDAY		THURSDAY		FRIDAY		TOTAL
	A	C	A	C	A	C	A	C	A	C	(C/A)*100
READING	2	2	1	2	2	1	1	2	2	1	100
MATHEMATICS	1	1	2	1	1	2	2	1	1	2	100
SCIENCE	0	0	1	0	0	1	0	0	0	0	100
EXPLORATORY	2	2	2	3	2	3	2	2	2	3	130
SPELLING	0	0	0	0	1	0	0	1	0	0	100

27 TOTAL NUMBER OF TASKS ASSIGNED
30 TOTAL NUMBER OF TASKS COMPLETED
111% ASSIGNMENT COMPLETION RATE FOR THE WEEK

STUDENT ID NUMBER: 71401 WEEK OF: 76/11/ 1

ASSIGNMENT COMPLETION RATE

SUBJECT	MONDAY		TUESDAY		WEDNESDAY		THURSDAY		FRIDAY		TOTAL
	A	C	A	C	A	C	A	C	A	C	(C/A)*100
READING	1	1	1	1	2	1	0	0	2	2	83
MATHEMATICS	1	0	0	0	1	1	0	0	0	0	50
SCIENCE	1	0	0	1	0	0	1	0	0	1	100
EXPLORATORY	2	2	2	2	2	2	2	0	2	1	70
SPELLING	1	0	0	0	0	1	1	0	1	1	66

23 TOTAL NUMBER OF TASKS ASSIGNED
17 TOTAL NUMBER OF TASKS COMPLETED
73% ASSIGNMENT COMPLETION RATE FOR THE WEEK

Figure 7. Weekly summary of task completion rate in each subject.

STUDENT ID NUMBER: 71309 WEEK OF: 76/11/ 8

MINUTES SPENT ON EACH SUBJECT

SUBJECT	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	TOTAL
READING	35(0)*	32(1)	15(0)	26(0)	22(0)	130(1)
MATHEMATICS	16(0)	16(0)	15(0)	6(0)	7(0)	60(0)
SCIENCE	0(0)	0(0)	20(0)	0(0)	0(0)	20(0)
EXPLORATORY	74(0)	70(0)	59(0)	14(0)	85(0)	302(0)
SPELLING	0(0)	0(0)	0(0)	21(0)	0(0)	21(0)
TOTAL	125	118	109	67	114	533

533 TOTAL NUMBER OF MINUTES SPENT ON ALL TASKS
30 NUMBER OF TASKS HAVING TIME INFORMATION RECORDED
17. AVERAGE NUMBER OF MINUTES SPENT ON A TASK

*Note: Number in the ( ) indicate the number of tasks for which no time is recorded.

Figure 8. Weekly summary of time spent in each subject.

ACTIVITIES OF 71304 IN MATHEMATICS
AS OF: 76/10/19
SITE: LRDC THIRD FLOOR CLASSROOM
CLASS: 1

DATE	TASK	AREA		TIME	SCORE	DEC
76/10/8	PRETEST 28	MATH,IM	,IM28	1:34	12	MAS
					24	MAS
					12	MAS
					10	MAS
					4	NMAS
					6	NMAS
					6	NMAS
					5	NMAS
76/10/8	PRETEST 28	MATH,IM	,IM28		CMPL	
					12	MAS
					24	MAS
					12	MAS
					10	MAS
					4	NMAS
					6	NMAS
					6	NMAS
					5	NMAS
76/10/11	M28A-BKLT 1	MATH,IM	,IM28	0:35		
76/10/11	M28A-BKLT 1	MATH,IM	,IM28		CMPL	
76/10/12	M28A-BKLT 1	MATH,IM	,IM28	0:31		
76/10/12	M28A-BKLT 1	MATH,IM	,IM28	0:27		
76/10/12	M28A-BKLT 1	MATH,IM	,IM28		CMPL	
76/10/14	M28BA-BKLT 1	MATH,IM	,IM28	1:15		
76/10/14	M28BA-BKLT 1	MATH,IM	,IM28	0:27		
76/10/14	M28BA-BKLT 1	MATH,IM	,IM28		CMPL	
76/10/15	M28BA-CET 1	MATH,IM	,IM28	1:30	CMPL	MAS
76/10/15	M28BA-CET 1	MATH,IM	,IM28		CMPL	MAS

ACTIVITIES OF 71309 IN SCIENCE
AS OF: 77/ 1/17
SITE: LRDC THIRD FLOOR CLASSROOM

76/11/4	LAGR L7	SCI	,LVLC,C-LA	0:33	
76/11/4	LAGR L7	SCI	,LVLC,C-LA		CMPL
76/11/16	LAGR L9	SCI	,LVLC,C-LA	0:38	
76/11/16	LAGR L9	SCI	,LVLC,C-LA		CMPL
76/11/19	LAGR L4	SCI	,LVLC,C-LA	0:21	
76/11/22	LAGR L4	SCI	,LVLC,C-LA		CMPL
76/12/3	LAGR L 10	SCI	,LVLC,C-LA	1:03	
76/12/6	LAGR L 10	SCI	,LVLC,C-LA		CMPL

Figure 9. Examples of the short term history report.

ACTIVITIES OF 71408 IN READING
AS OF: 77/ 1/17
SITE: LRDC THIRD FLOOR CLASSROOM
CLASS: 2

DATE	TASK	AREA	TIME	SCORE	DEC
77/ 1/11	ADD ACTIVITY	READ,GINN,GINN	0:30		
77/ 1/11	ADD ACTIVITY	READ,GINN,GINN		CMPL	
77/ 1/12	GROUP MEET	READ,GINN,GINN	0:17		
77/ 1/12	GROUP MEET	READ,GINN,GINN		CMPL	
77/ 1/13	GROUP MEET	READ,GINN,GINN	0:20		
77/ 1/13	GROUP MEET	READ,GINN,GINN		CMPL	
77/ 1/13	WKBK ASSIGN	READ,GINN,GINN	0:50		
77/ 1/13	WKBK ASSIGN	READ,GINN,GINN		CMPL	

ACTIVITIES OF 71309 IN EXPLORATORY
AS OF: 77/ 1/17
SITE: LRDC THIRD FLOOR CLASSROOM
CLASS: 2

77/ 1/ 5	GAMES	EXP ,EXPL,EXPL	0:46	
77/ 1/ 5	GAMES	EXP ,EXPL,EXPL		CMPL
77/ 1/ 6	GAMES	EXP ,EXPL,EXPL	0:53	
77/ 1/ 6	GAMES	EXP ,EXPL,EXPL		CMPL
77/ 1/ 6	CONSTRUCTION	EXP ,EXPL,EXPL	0:30	
77/ 1/ 6	CONSTRUCTION	EXP ,EXPL,EXPL		CMPL
77/ 1/ 6	LIBRARY	EXP ,EXPL,EXPL	0:15	
77/ 1/ 6	LIBRARY	EXP ,EXPL,EXPL		CMPL
77/ 1/ 7	GAMES	EXP ,EXPL,EXPL	0:46	
77/ 1/ 7	GAMES	EXP ,EXPL,EXPL		CMPL
77/ 1/ 7	CONSTRUCTION	EXP ,EXPL,EXPL	0:23	
77/ 1/ 7	CONSTRUCTION	EXP ,EXPL,EXPL		CMPL
77/ 1/ 7	CONSTRUCTION	EXP ,EXPL,EXPL	0:31	
77/ 1/ 7	CONSTRUCTION	EXP ,EXPL,EXPL		CMPL
77/ 1/10	GAMES	EXP ,EXPL,EXPL	0:15	
77/ 1/10	GAMES	EXP ,EXPL,EXPL		CMPL
77/ 1/10	CONSTRUCTION	EXP ,EXPL,EXPL	0:37	
77/ 1/10	CONSTRUCRION	EXP ,EXPL,EXPL		CMPL
77/ 1/10	GAMES	EXP ,EXPL,EXPL	0:16	
77/ 1/10	GAMES	EXP ,EXPL,EXPL		CMPL
77/ 1/11	GAMES	EXP ,EXPL,EXPL	0:32	
77/ 1/11	GAMES	EXP ,EXPL,EXPL		CMPL
77/ 1/11	EXTRA MATH	EXP ,EXPL,EXPL	0:20	
77/ 1/11	EXTRA MATH	EXP ,EXPL,EXPL		CMPL
77/ 1/12	GAMES	EXP ,EXPL,EXPL	0:36	
77/ 1/12	GAMES	EXP ,EXPL,EXPL		CMPL
77/ 1/13	GAMES	EXP ,EXPL,EXPL	0:38	
77/ 1/13	GAMES	EXP ,EXPL,EXPL		CMPL
77/ 1/17	CONSTRUCTION	EXP ,EXPL,EXPL	0:31	
77/ 1/17	CONSTRUCTION	EXP ,EXPL,EXPL		CMPL

Figure 10. Examples of the short term history report.

Class	COMPUTER EXPERIENCED STUDENTS: Average Training Time/Child (Range)	Average No. of Sessions Needed for Training	Average Time per Session (Range)	N	COMPUTER NON–EXPERIENCED STUDENTS: Average Training Time/Child (Range)	Average No. of Sessions Needed for Training	Average Time per Session (Range)	N
Kindergarten	—	—	—	—	22.50 (15 - 30)	1.50	15 (10 - 20)	2
First	—	—	—	—	19.33 (10 - 30)	1.33	14.5 (10 - 20)	9
Second	10.60 (6 - 15)	1	10.60 (6 - 15)	5	40 (25 - 55)	2	20 (10 - 27)	2
Third	7.29 (5 - 11)	1	7.20 (5 - 11)	7	22.33 (22 - 23)	1	22.33 (22 - 23)	3
Totals	8.74	1	8.74	12	26.04	1.46	17.96	16

Figure 11. Summary of minutes spent for individual CIS training sessions.

# of Students Prescribed for		Time Involved		Time/Child	
Computer	Pencil-paper	Computer	Pencil-paper	Computer	Pencil-paper
5	26	50.82	70	10.16	2.69
7	24	40.82	77.5	5.83	3.23
8	23	41	66	5.13	2.87
12	19	42.5	69.5	3.54	3.68

Figure 12. Comparison of average prescription time between the CIS and the pencil-paper procedures.

Month	N	Average minutes spent on verifying task completions per day	Average minutes spent on verifying task completions per child
November	32	30.55	.95
December	36	20.70	.57
January	38	23.70	.62

Figure 14. Minutes spent on CIS verification procedures 1976 - 1977 school year.

Month	N	Average minutes spent prescribing per day	Average minutes spent prescribing per child
November	32	61.44	1.92
December	36	48.6	1.35
January	38	48.1	1.26

Figure 13. Minutes spent prescribing using CIS procedures, 1976 - 1977 school year.