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ABSTRACT

An evaluation of the first year of operation of the elementary part of the Individualized Mathematics System (IMS) is reported in this document. The opening section describes the IMS course, where re-usable workpages guide students to work individually, often using manipulative materials, to meet carefully defined objectives at nine levels. The evaluation covered four aspects: curriculum adequacy, material effectiveness, cost effectiveness, and learning effectiveness. The means used included the following: reports by Joseph Scandura and Robert Gagne on the IMS structure and methods (reprinted in full); teacher surveys at training workshops and three times during the year; reports and meetings of evaluation coordinators (one in each of the 23 participating schools); and standardized student achievement tests. Estimates of pupil progress in IMS are extrapolated from the overall test results, and results in four selected schools are analyzed in more detail. Observations on the implementation and usage of the IMS materials are drawn from the verbal reports. The evaluation shows that IMS is meeting most of its goals, but several recommendations for specific improvements and extensions are derived. (MM)

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Chapter I - Introduction

Description of IMS

The Individualized Mathematics System (IMS) is a low-cost, brightly illustrated mathematics curriculum for grades 1-6. It is designed to provide maximum creativity and flexibility for teachers and pupils, and should not penalize pupils if they are not proficient in reading. Diagnostic tests enable the teacher to prescribe the specific topic, level and learning style appropriate for each pupil. Other tests incorporated into the curriculum give the pupil immediate feedback on his work and are usually scored by the pupil himself.

IMS has been developed over the past three years by the Center for Individualized Instructional Systems in Durham, North Carolina. The Center is an affiliate of the National Laboratory for Higher Education, formerly known as the Regional Education Laboratory for the Carolinas and Virginia. During the 1970-71 school year, IMS was used on an experimental basis by more than 10,000 pupils in 37 schools in North Carolina, South Carolina, Virginia and Florida. Previously, major sections of the curriculum were tested in eight schools in North Carolina and Virginia. A revised version of IMS will be field tested by approximately 135 schools across the nation during the 1971-72 school year.

IMS covers 10 topics: numeration, addition, subtraction, multiplication, division, fractions, mixed operations, money, time and measurement. Within each topic, there is a carefully arranged sequence of skills to be learned. The skills are organized into nine levels of difficulty, and each skill, or "behavioral objective," is incorporated into a separate skill folder. There are 376 skills in the IMS curriculum. Figure 1 shows the number of skills in each IMS topic at each of the nine levels.

IMS is not a workbook or a textbook. It is a series of about 7,500 brightly colored, deftly illustrated 8.5" x 11" pages. Each page is laminated in plastic. Pupils mark on the plastic pages with special pencils and pens and, when they have completed their work and scored it, wipe the pages clean with a paper towel and return them to a mobile storage cart. The pages can be used over and over again, and are expected to last at least five years. Mobile storage carts house the entire curriculum, the various tests and the manipulative devices. The carts eliminate the need for storage space, simplify filing techniques and enable IMS to be rolled from classroom to classroom.

The skill folder, the "atom" of the IMS molecule, contains from four to more than 20 pages. The skill folders provide for various types of learning styles, from manipulation of concrete materials such as tokens

IMS	I	II	III	IV	V	VI	VII	VIII	IX
NUMERATION	11	8	11	8	4	9	6	3	3
ADDITION	4	6	5	5	8	3	2	2	3
SUBTRACTION	5	6	4	4	5	4	2	1	3
MULTIPLICATION	3	6	3	9	6	8	5	4	4
DIVISION	1	4	4	6	5	6	3	5	4
FRACTIONS	1	2	5	5	6	6	6	6	2
MIXED OPERATIONS	3	2	5	4	4	4	4	2	4
MONEY	2	3	2	3	3	3	2	—	—
TIME	1	2	3	5	6	5	3	3	—
MEASUREMENT	2	5	5	4	4	5	3	5	5

Cell numbers indicate number of skills per unit.

Fig. 1

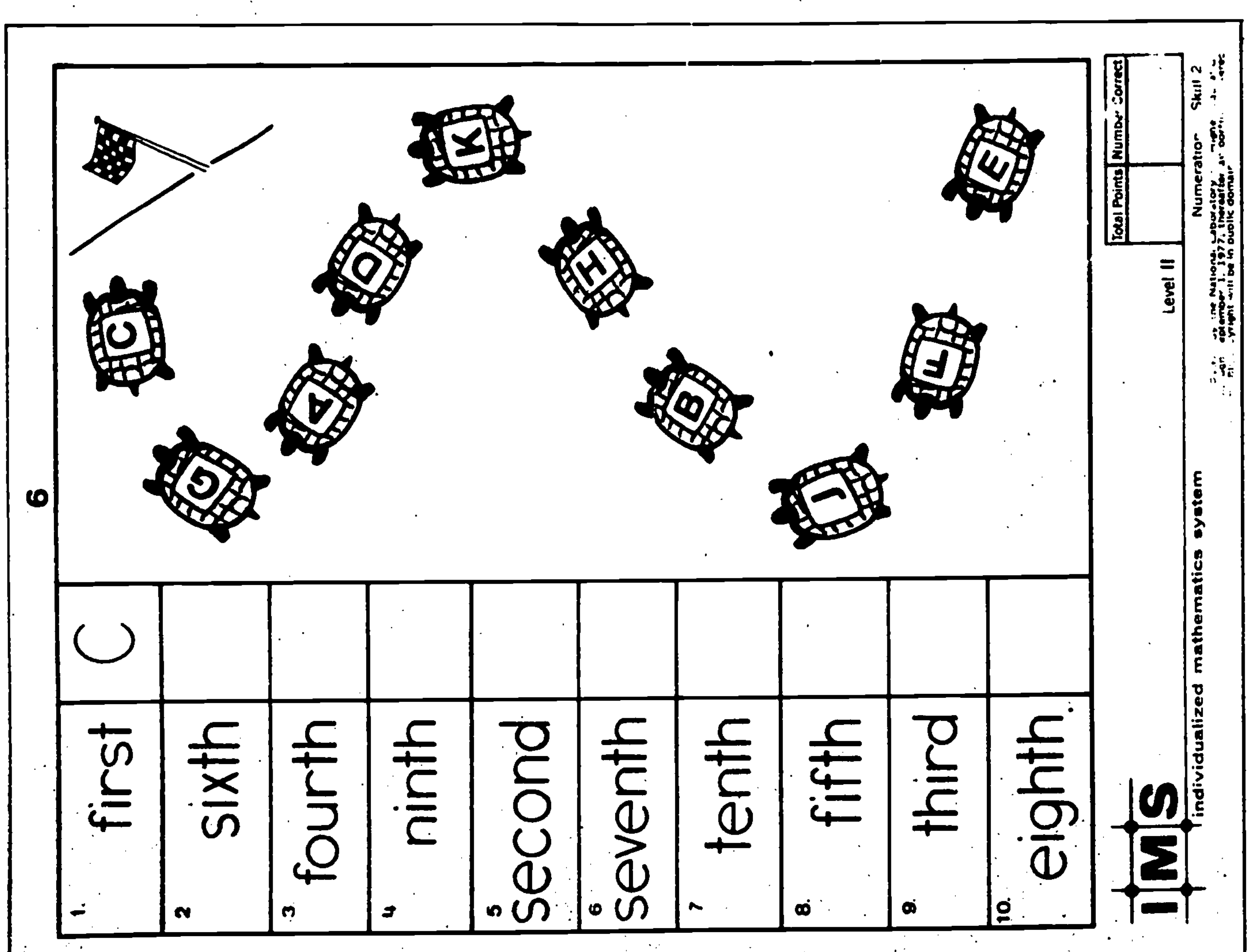


Fig. 2-II Numeration, Skill 2

and counters to increasingly difficult perceptual and abstract styles. The number of written directions especially in the lower levels, is minimal so pupils with limited reading ability can successfully use the materials. Figures 2 through 4 are pages from skill folders covering the topic, Numeration, at different levels of difficulty.

The use of a large number of manipulative devices and educational "toys," such as balance scales, centimeter rods and measuring cups, has been incorporated into the curriculum. A list of the minimum collection of such items recommended for use with IMS (Appendix I) was sent to all schools. The schools' use of this information and materials is discussed in Chapter V, pages 80-81. There are also pages of special activities for pupils to use independently, and some for teachers to use with small groups. Figures 5 and 6 are teacher and student activity pages from Addition skill folders. Each folder contains two checkup tests which the pupil uses to find out if he has mastered the skill. Figure 7 is a checkup test from a Measurement skill folder.

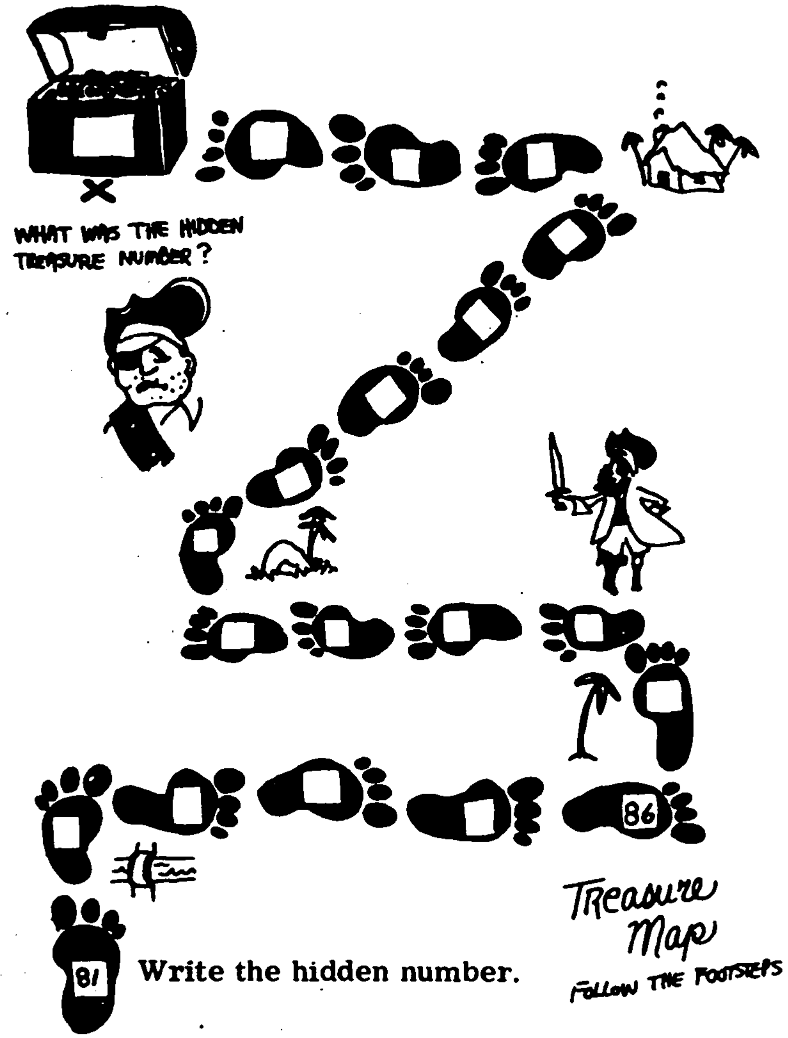
The entire system is color-coded, so pupils can easily locate the materials prescribed for them. All skill folders and pages for Numeration, for example, are pink; materials for Fractions are yellow, and so on. In addition to helping the pupil find the materials he needs, the color-coding provides an additional advantage for individualization. The color identifies only the topic the pupil is working on, not the level at which he is working.

Imaginative drawings, color and familiar frames of reference are introduced into the curriculum to make it more

2

1.

COUNT



Write the hidden number.

Total Points	Number Correct
1	

IMS individualized mathematics system

Level III

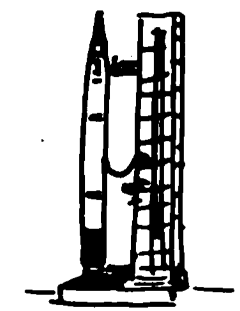
Numeration : Skill 2

Fig. 3-III Numeration, Skill 2

9

1.

Countdown to lift-off:



1000, ____, 993, ____, ____,

995, ____, ____, ____, 991, ____,

____, 988, ____, ____, ____,

____, ____, 982, ____, ____,

____, ____, ____, 976, ____,

974, ____, ____, ____, 970,

____, ____, ____, 966, ____

____, ____, 962, ____

HOLD:

Breakdown in computer system.

Total Points	Number Correct
1	

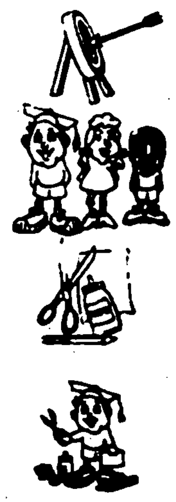
IMS individualized mathematics system

Level V

Numeration: Skill

Fig. 4-V Numeration, Skill 1

TA - 1



Reviews the meaning of the "+" and " " signs.

One to twenty students.

Per student:
1. Number cards (1-10).
2. Ten counters.
3. A "+" card and an "=" card.

Chalkboard and chalk for the leader.

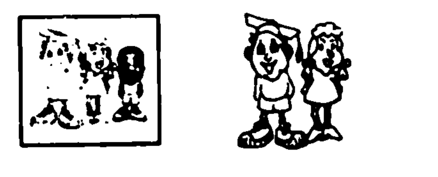
The leader:
1. Writes an addition statement on the blackboard, using a system of notation with which the students are familiar, i.e., "2, 3 ⟶ 5."
2. Directs the students to place counters on their desks to represent the addends of the given statement, i.e., "oo ooo ."
3. Reviews the meanings that can be given to the addition statement by asking the following questions:
   a. How many counters do you have on your desk? (Students answer, "Five.")
   b. How can you show me a group of five counters? (Students may push the two sets of counters into one group.)
   c. How does the statement, "2, 3 ⟶ 5" illustrate what you just did? (Students may suggest that the statement means, "Two and three are five," or "Two brought together with three is another name for five," etc.)
4. Writes "+" on the chalkboard. Explains that the symbol "+" means "and" or "brought together with."
5. Asks a student to identify the position that the "+" sign should occupy in the addition statement.
6. Writes "=" on the chalkboard and discusses its meaning in a manner similiar to that used with the "+" sign.
7. Asks the students to use their number cards and sign cards to represent the given addition statement, i.e., "2 + 3 = 5."
8. Continues with other examples until the students are familiar with the meanings given to the signs.

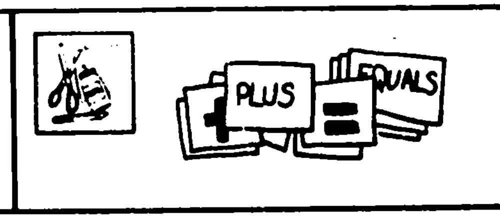
IMS individualized mathematics system — Level II — Activity — Addition: Skill 3 — Product of RELCV

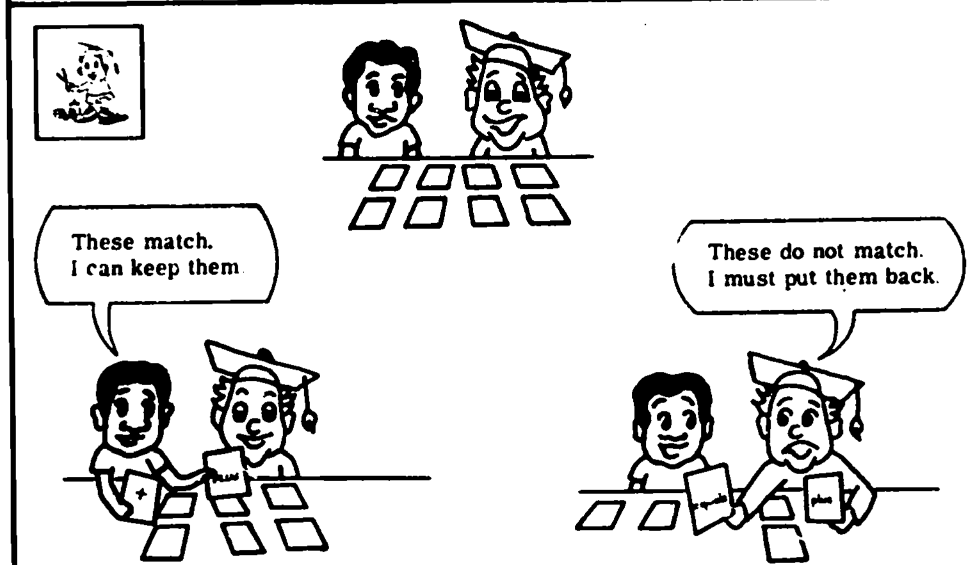
Fig. 5-Teacher Activity Page from II Addition, Skill 3

A

Matches " + " and " = " with corresponding words.







1. Shuffle all of the cards and place them face down on the table.
2. Turn over two cards. If they match, i.e., " + " and "plus," keep them. If they do not match, put them back in their original places.
3. Your partner follows the same procedure.
4. Continue the process until all the cards have been matched.
5. Shuffle the cards and begin another round.

IMS individualized mathematics system — Level II — Activity — Addition: Skill 3 — Product of RELCV

Fig. 6-Student Activity Page from II Addition, Skill 3

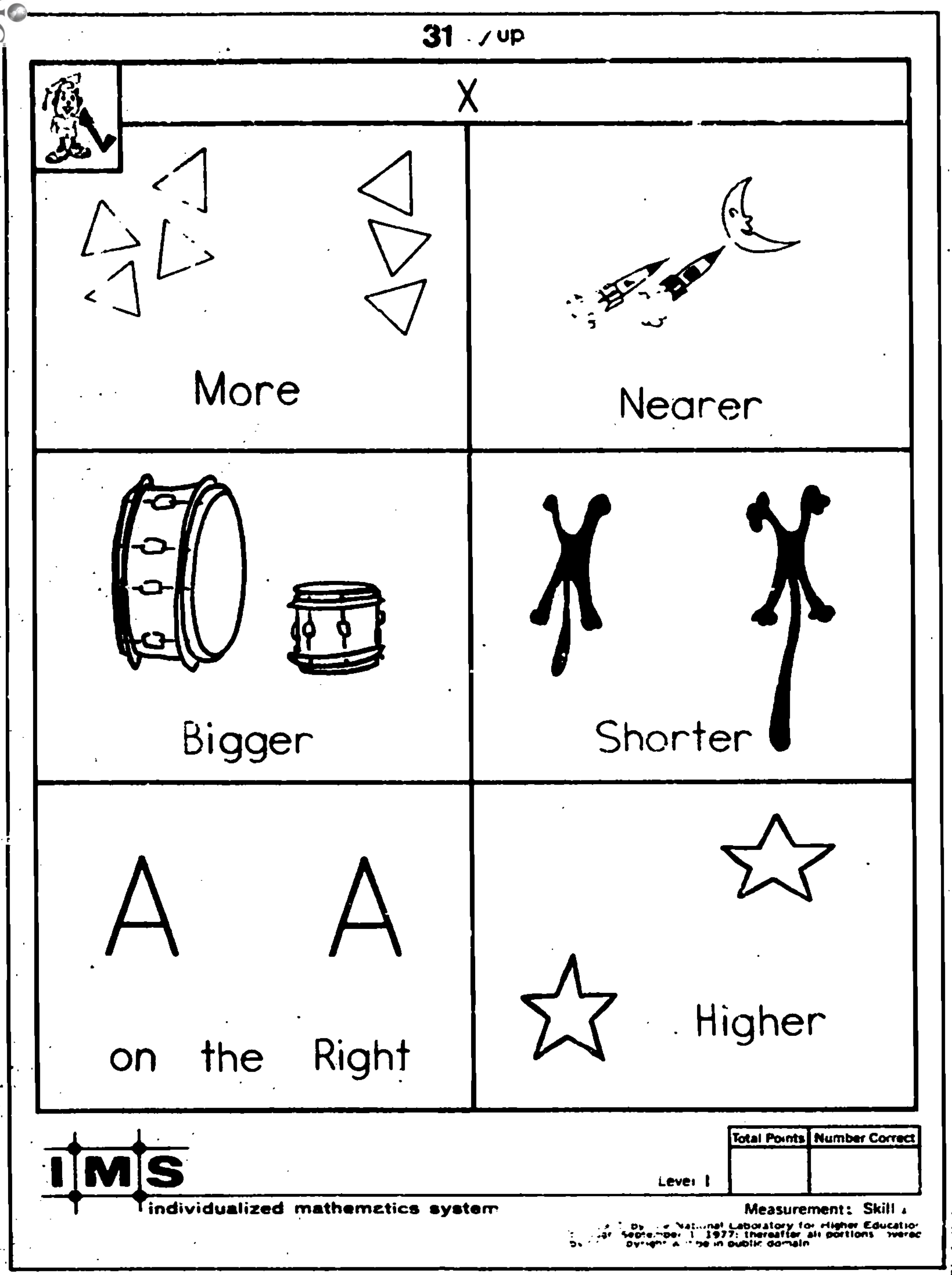


Fig. 7-Checkup test from I Measurement, Skill 1

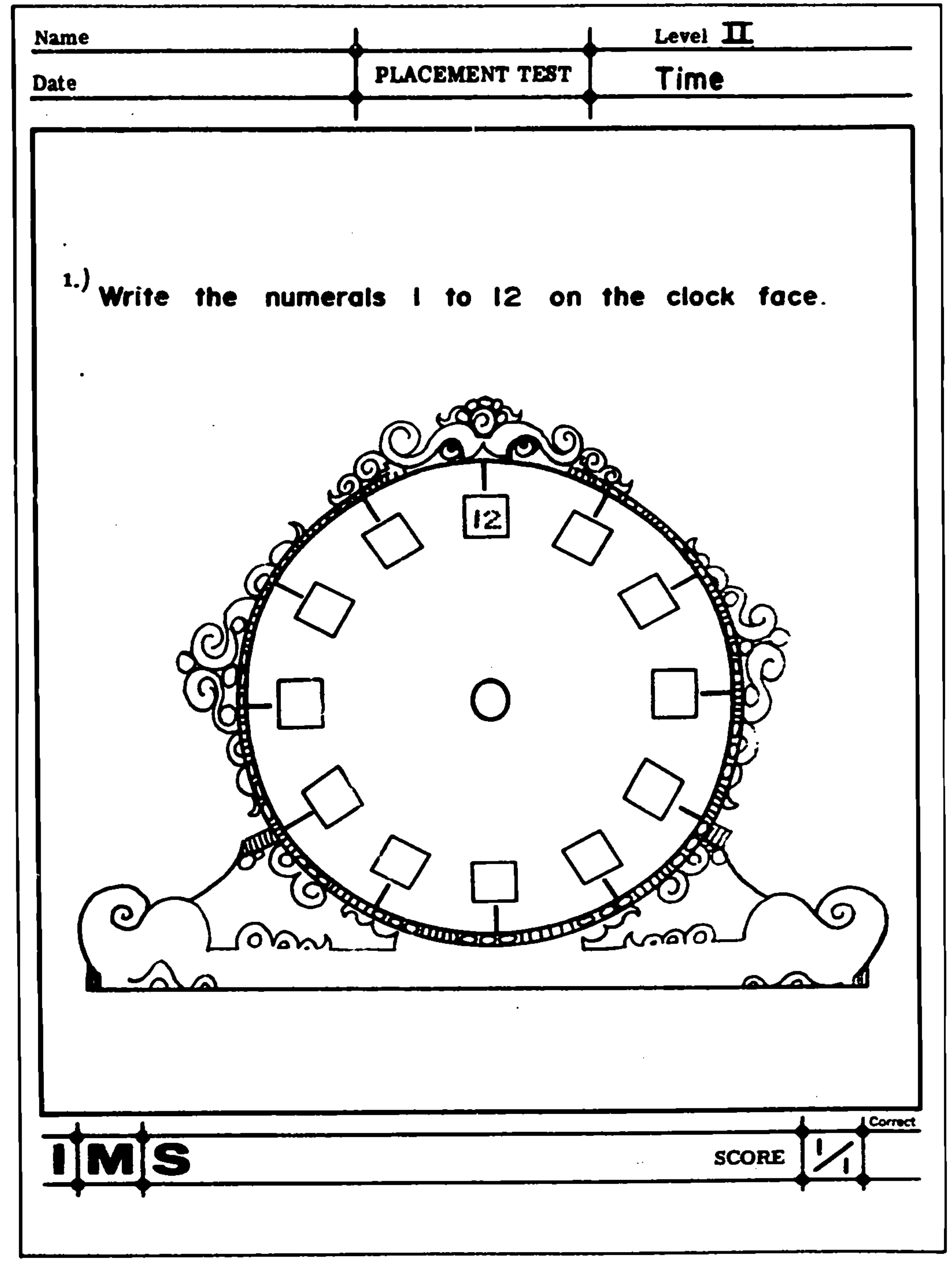


Fig. 8-Placement test for II Time

attractive and relevant to pupils. The illustrations include a variety of benign monsters, "grape man," and a whimsical but improbable being simply known as "the blob." As one fifth grader at Thomas Jefferson Elementary School in Falls Church, Virginia, wrote: "I like your cartoons. They are very tasteful. There are a lot of tasteless cartoons around, but yours are very nice." Another classmate added: "We all like the cartoons in the math folders. They help you understand the directions better. They also help you like to work in math more, even though we didn't like math that much."

The IMS curriculum moves the pupil through a series of small steps toward the accomplishment of specific, measurable objectives. It represents an uninterrupted sequence into which the child can enter at any point. Testing in IMS is used to aid the pupil, not to categorize him. The placement test determines his starting point (topic and level of difficulty), and a pretest, taken before he begins work, determines the particular skills in which he needs instruction within that topic. Figures 8 and 9 show the placement test and corresponding pretest for Level II Time.

For example, the placement test might indicate that the pupil should begin work in Measurement, Level IV. There are four skills in Measurement, Level IV, and the pretest might indicate that he has already mastered Skill 1 and 2. Therefore, his prescription (teachers write prescriptions

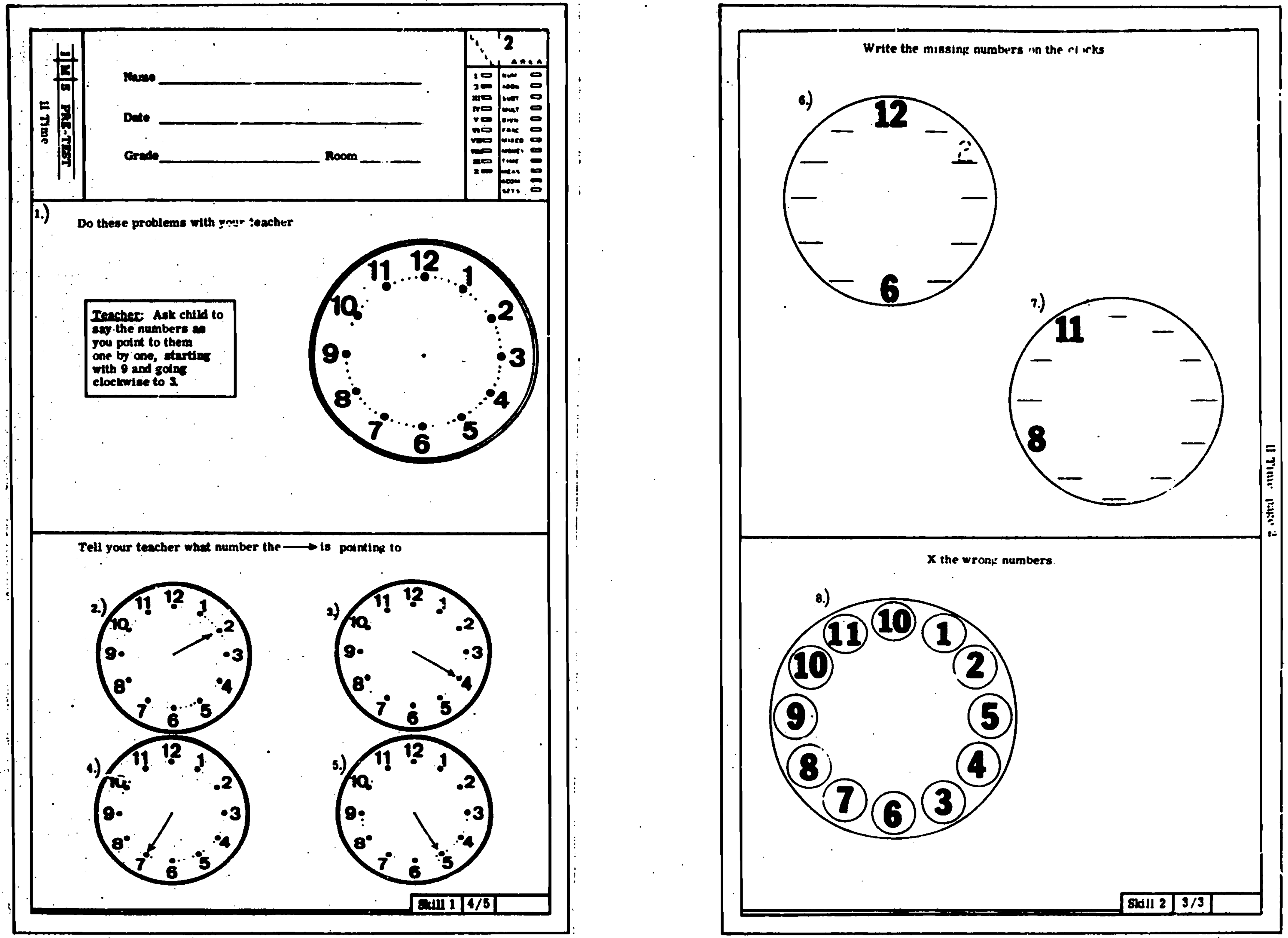


Fig. 9-Pretest for Li Time

for lower levels of the curriculum; pupils often write their own prescriptions for advanced levels) will direct him to the folders for skills 3 and 4.

The checkup tests, generally scored by the pupil, tell him whether or not he has mastered the skill in the folder. If he does not attain mastery score on the first checkup test, he can take the second after he does further work in the folder or has some help from his teacher. When all skill folders in a unit have been mastered, the pupil takes a unit posttest. The posttest indicates whether the pupil is ready to go on to the next prescription, or whether additional work is needed. It is essentially an alternate form of the pretest.

Frequent testing is an integral part of IMS. Since it occurs at each small step along the way, it becomes a means of proving success rather than a psychological roadblock. The pupil soon learns that the tests are not there to punish him but to help him. As one fourth grader wrote, "I like IMS because the teacher trusts us to score our own test. It makes me feel like a teacher myself."

How Does IMS Work?

At the beginning of the school year, several hours of class time are devoted to pupil orientation. The students learn how to find the materials they need, how to score themselves (in the lower grades, teachers and teacher aides help pupils with scoring) and how to record their scores.

They also practice wiping pages clean and returning them to the storage cart. Each student makes a simple construction-paper flag (often inscribed "Help!" or "Not Together!") which he props up on his desk when he needs help.

Then the class takes a placement test, which determines for each student "where he is" in the system regarding the ten topics and nine levels of difficulty. From the placement test, the teacher makes up a "pupil profile chart" for each child. Figure 10 shows the profile chart for a student who has mastered at least Levels I through III in all topics from Numeration through Time. He has mastered Levels I and II in Measurement. The profile chart indicates he should tackle Measurement, Level III, which has five skills of "behavioral objectives" in it.

This student then takes the pretest for Measurement, Level III, and the results might indicate he has mastered everything but Skill 2. Skill 2's objective calls for the pupil to use a ruler with one-inch divisions to measure real objects or pictures to the nearest inch. The student reads his prescription, then finds skill folder 2 in the pigeonhole on the cart marked Measurement, Level III. There are seven pages in the folder, and the prescription might call for work on pages one through four. The student gets a ruler from the storage cart with the manipulative devices and begins work.

IMS STUDENT PROFILE

IMS	I	II	III	IV	V	VI	VII	VIII	IX
NUMERATION	X	X	X						
ADDITION	X	X	X						
SUBTRACTION	X	X	X						
MULTIPLICATION	X	X	X						
DIVISION	X	X	X						
FRACTIONS	X	X	X						
MIXED OPERATIONS	X	X	X						
MONEY	X	X	X						
TIME	X	X	X						
SYSTEMS OF MEASUREMENT	X	X							

NAME ______________________ GRADE ________ ROOM ________

Fig. 10

After completing the four pages, the student takes the checkup test. He is asked to measure drawings of a pencil, a nail, a wrench and a paintbrush. He writes in his answers, checks them against the scoring key and records his score. He should get four right, which is the mastery level for this skill folder. He then erases the pages, returns the skill folder to the cart and takes the unit posttest. He should achieve mastery level on all five skills of Measurement III, all of which are covered on the posttest.

The whole process begins again. The student goes back to the pupil profile to see what he is to do next and takes the pretest for the new unit. Then he receives a prescription (or writes his own) for pages to teach the first of the skills identified by the pretest as needing work. There are always stumbling blocks, of course, but the possibilities for solutions are many. If the student does not show mastery of a particular skill on the posttest, or in any checkup test along the way, he may simply require further practice. Thus, more work pages might be prescribed or a group activity might be used to clarify a concept or an advanced pupil might be asked to help the student.

Often the teacher may decide to work with a child individually or in a small group until a given skill is acquired. Thus, the classroom may be organized to make use of IMS materials in many ways. But the fact remains: each child is being taught individually because he is moving at his own pace in a program tailored for him. Dennis Nichols, principal of Morehead School in Durham, points out that achievement in IMS represents mastery of the material and all the requisite skills preceding it. "Under the textbook method," he said, "pupils were often going too fast, being exposed to material but not really understanding it. Using IMS, they stay with the material until they really master it. The curriculum gives us a way to discover and remedy deficiencies on an individual basis."

Because IMS is individualized, pupils do not receive standard letter grades measuring their progress against that of others in the class. Instead, the IMS report card is a variation of the pupil profile chart. Parents receive this form, called a "pupil progress report," four times during the semester. The color-coded chart tells parents where their son or daughter entered the system on the placement test, and what progress he has made.

The role of the teacher in IMS is clearly different from that in the traditional math classroom, but certainly no less important. "IMS provides an opportunity to make maximum use of the creativity and flexibility that master teachers always have brought to the classroom," says J. W. Knight, director of the Center for Individualized Instructional Systems. "IMS allows teachers to abandon the lockstep pace of the lecture method and become prescribers or managers of learning. They spend most of their time working individually with pupils or with small groups--which is what they do best."

Plan for Evaluation

The funding for the evaluation reported herein was not for the purpose of determining the effectiveness of IMS as compared to some other approach to teaching mathematics. The IMS stage of development for 1970-71 was not sufficiently advanced to warrant comparative evaluation. Instead, the evaluation had as its goal bringing about changes in IMS in order to make it more effective for subsequent use. Some results reported in subsequent chapters are the revision of about 20% of the tests in the system and the revision of over 250 teaching pages, which includes complete reorganization of four skill folders. In addition, teacher training procedures have been revised. Therefore, any comparative results with respect to usage of IMS in 1970-71 would be essentially invalid, since the system should be improved for future use.

In addition to effecting changes in IMS the evaluation was conducted to determine whether IMS has achieved certain goals, either as initially introduced or as a result of changes made during the year. Specific goal areas are:

> Curriculum Adequacy. The provision of a comprehensive set of mathematics objectives suitable for a wide spectrum of pupil aptitudes.
>
> Materials Effectiveness. The provision of attractive and effective learning materials and teaching aids which incorporate various alternative means

of achieving curriculum goals.

Cost-Effectiveness. Achievement of a low cost per pupil compared with other available mathematics systems with similar structure. Specific areas to be considered in this repsect are:

Actual production costs and adequacy of reusable materials.

The extent to which students can and do assume responsibility for operation of the system (thus reducing or eliminating the need for paraprofessional personnel in the classroom).

The cost and effectiveness of teacher training required to implement the system.

Learning Effectiveness. Pupil achievement and progress within the system comparable with or superior to that obtainable under conventional teaching conditions.

Schools

To investigate effectiveness of IMS with respect to these goal areas 23 elementary schools in the Carolinas and Virginia were selected for field testing of IMS. These schools cover a wide range of educational situations including urban deprived, rural, middle-class-urban and upper-middle-class-suburban. Over 5000 students were involved.

Four of the 23 schools were chosen for collection of detailed data on pupil progress. Each of these is quite different from the other three, and combining their student populations yields a diverse yet reasonably representative sample. At various times, however, it will be necessary to relate results to the specific school of origin. For this reason, these four schools are now described in terms of their more outstanding characteristics.

Enterprise Elementary School. This school fills a very difficult role and does so very well considering the circumstances. Virtually the entire student population comes from homes where poverty, if not present, is always lurking in the background. Parents are mostly mill employees and are subject to seasonal and other layoffs. A recent survey revealed that parents of only three students had ever even attended college. Social conditions are often unstable for these families. The restrictions of an urban environment under much less than affluent circumstances weigh heavily on these families of predominantly southern rural extraction. Enterprise is about 40% black due to recent desegregation, and the changing position of black people with respect to poor whites probably heightens social tensions. However, there have been no racial disturbances in the area. Only a small proportion of the students achieve grade-level or higher than grade equivalent scores on standardized tests. Teachers report frequent minor (sometimes major) behavior problems which they associate with unfortunate home conditions for many of the students.

Academia Elementary School. Only about 10% of the fathers of students at this school have eighth grade or lower educations. In contrast about 53% of fathers have at least some college training and 11% hold doctorates. The school is considered "experimental" and has excellent facilities and equipment. A nearby university frequently provides teaching assistants and trainees and conducts special programs. Approximately two-thirds of the teachers hold masters degrees. Although a small proportion of the students come from "deprived" backgrounds and show some school achievement deficiencies, the average student scores well above grade level on standardized tests. Less than 2% of the students are black.

Countryside Elementary School. The families of Countryside are probably at about the same socio-economic level (on the average) as those of students at Enterprise. The school's facilities and equipment are not as good as those of Enterprise. Nevertheless, Countryside seems to take greater advantage of those facilities and materials which are available to them. The school serves a rural clientele near an urban center. Most of the families live on small farms that have been in their families for many years. However, this kind of farming has become largely uneconomical, and most of the fathers hold blue collar jobs in the nearby urban center. Many of the mothers work also. While their work is not more stable than that of the parents at Enterprise, they have their farms to "tide them over." Most raise vegetables and many keep some dairy cattle. About 10% of Countryside's students are black, the same ratio for the community as a whole. Social and economic relationships between blacks and whites have matured over many years and there is no sign of tension. The average student is approximately at grade level on most standardized tests. Teachers report very few discipline problems.

Urbania Elementary School. This school is near the edge of a large southern metropolitan complex, yet it cannot be called "suburban." It is in a neighborhood of modest homes, but about 40% of its students are bussed from a nearby black neighborhood. Almost three-fourths of the black children are from families receiving welfare payments. In total, 30% of Urbania's students represent severe poverty conditions. Only about 5% of Urbania's students have fathers whose occupations might be described as "professional," loosely defined here as requiring a college degree. About 20% are white collar nonprofessional. Employment for approximately 50% of the fathers classifiable as blue collar workers is probably more stable than that for fathers in Enterprise. Students at Urbania represent a wide range of academic achievement, but on the average they score approximately at grade level on most standardized tests. The school facilities are excellent and it is in a district which provides extensive support in terms of teacher aides, instructional materials and supervisory assistance.

In further discussion, these schools will be referred to as the intensive evaluation schools or individually by name.

Teacher Training

During the summer of 1970, four workshops were held to introduce school personnel to IMS practices and materials. One was for principals and supervisory personnel, and three were for teachers. Approximately 50 attended each workshop.

These workshops are considered an integral part of the IMS program, and their evaluation influences many outcomes reported herein.

Data Collection

This aspect of evaluation is extremely diverse, and many sets of data will be used for multiple purposes. To organize this process for presentation in this section, each major area of evaluation is discussed in terms of data collection involved.

Curriculum Adequacy. A specialist in mathematics education, Dr. Joseph Scandura, of the University of Pennsylvania, was asked to evaluate IMS structure (Behavioral Objectives) and materials with respect to suitability for enabling students to achieve the stated objectives. In addition, he was asked to evaluate the materials with respect to mathematical consistency and correctness and completeness of subject matter coverage with respect to preparation for topics to be met in later mathematics courses.

A specialist in learning theory, Dr. Robert Gagné, of Florida State University, was asked to evaluate IMS order and method of presentation and Behavioral Objectives from the standpoint of appropriate learning theories and child development research.

Teacher Training. At the end of each workshop, all participants responded anonymously to the questionnaire, IMS WORKSHOP

EVALUATION FORM (Appendix III). However, the main sources of evaluating the effectiveness of teacher training came from other sources. Monitor Reports (Appendix IV) were prepared by IMS personnel visiting schools at various times during the school year and provided data regarding training. Three Teacher Surveys (Appendix V) contained questions regarding teachers' later opinions of workshop effectiveness.

Installation and Operation Procedures. A teacher was selected from each school to act as an Evaluation Coordinator (EC). EC's were responsible for coordinating the collection of pertinent data within their schools and participated in modification planning. They arranged to have other teachers in their schools furnish information concerning the operation of the system. Much of this information was forwarded on Incident Report forms (Appendix VI) to the Laboratory on a weekly basis. Monthly EC workshops were held to discuss the information collected and to aid in analyzing the practicality of teacher recommendations.

The EC's participated in several other phases of data collection in addition to that just described. All these activities were coordinated through the monthly workshops.

Based on school visits, IMS personnel reported many data regarding installation and operating procedures. These observations were usually reported through use of the IMS Monitor Report (Appendix IV).

System Effectiveness. Teacher evaluation of system effectiveness was obtained through use of the three IMS Teacher Surveys (Appendix V). Some of the topics covered are:

- Student assumption of responsibility for operation of the system
- Adequacy of materials to permit selection of appropriate learning task to fit needs of individual pupil
- Reaction of pupils to materials
- Availability of time to spend with individual pupils

The Teacher Surveys were administered in December, March and May by the EC's.

To be effective, the system depends heavily on the validity of the tests used to govern progress between levels. To investigate this question, all posttests completed by students at the four intensive evaluation schools were forwarded to the Laboratory. Item responses were recorded for later analysis, and tests were returned to the students.

Pupil Achievement and Progress. The Metropolitan Achievement Test (MAT) - Arithmetic (grades 1 and 2) and the Iowa Test of Basic Skills (ITBS) - Mathematics (grades 3 through 6) were used to provide normative data concerning the students in the intensive evaluation schools. These tests were given in mid-October and again in mid-May.

EC's obtained from all schools monthly teacher reports listing the number of students at each level for each topic of the system. These data bear both on system effectiveness, and pupil achievement, since progress from level to level is an essential feature of the system and is also evidence of what skills the students have mastered.

Costs. Actual production costs were recorded along with costs to schools for auxiliary equipment and materials.

Basis for Effecting Curriculum Changes

The evaluation procedures just described are formative in that all were conducted in order to determine changes needed in various parts of the system. When a broad goal of this kind must be accomplished, there are basically two ways to proceed. Every element of the system may be tested individually--each teaching page, each activity, etc. Another approach is to seek only data which indicate malfunctioning features of the system. When resources are limited the second approach is the only feasible one. It is not as thorough and may not uncover every deficiency. However, due to limited resources, it was necessary for this evaluation to adopt the policy of accepting as satisfactory elements of the system for which no adverse data were noted. Incident Reports (Appendix VI) were especially useful in identifying problems with respect to which other data collection procedures were not specifically directed.

Chapter II

The Evaluation Coordinator Program

No small amount of emphasis should be placed on the function of the EC program in this evaluation. While their function "on paper" was largely one of data collection and reporting, a great deal of information passed through them to the schools. In most cases, the EC's became the leaders and problem solvers for IMS in their schools. They often transmitted questions or problems to the IMS staff or the evaluation staff and worked with teachers in their schools to effect solutions and further explain IMS procedures. In many schools, they conducted weekly seminars for teachers and aided in presenting IMS to parents and the community. It is a firm recommendation of this report that a person be appointed in every new IMS school to assist in the manner of the EC's. (The Laboratory paid EC's a small monthly honorarium for their services, but this payment did not take into account all phases of their work as described above.)

Eight EC meetings were scheduled for the months November through June. Two of these were attended by principals rather than the EC's because of a need to discuss administrative problems connected with installation and operation of IMS and for presentation of approaches to informing parents about the program. The remainder of this chapter describes the content and conclusions of these meetings to the extent that they do not appear elsewhere in the report.

November - Orientation

This meeting was devoted to orientation of the EC and was held twice, each time for half the EC's. The basic plan for evaluation was presented, and data collection procedures were explained. The EC's also spent a half day with IMS personnel becoming familiar with stocking procedures and methods of ordering additional materials.

December - IMS Practices, Content and Procedures

Classroom practices and procedures dominated this meeting, the first attended by the entire group of EC's. A substantial amount of time was spent sharing problems and solutions to everyday classroom problems. It was the case that a number of teachers using IMS had not attended the summer workshops. This point will be discussed in detail in connection with teacher training evaluation results.

Many of the EC's requested assistance with regard to the mathematics underlying certain behavioral objectives. It was the concensus that a large proportion of teachers in their schools were having difficulty in dealing with the following:

- Explaining why division by zero is undefined.
- The emphasis (in IMS) to the effect that zero is a number.
- Prime factorization.
- Use of least common multiple and greatest common factor concepts in finding common denominators.

- Emphasis (in IMS) on arbitrariness of the convention that $a \times b + c$ means $(a \times b) + c$. (Apparently some teachers were unaware that this choice is arbitrary.)

Of all these, dealing with zero seemed to caused the most problems. Apparently many elementary mathematics programs simply avoid consideration of zero. This outcome resulted in a recommendation for revision of teacher training procedures (see pages 76-78).

The afternoon period of this meeting was devoted to touring the recently opened IMS production facility and ironing out materials supply problems.

January - Materials and Logistics Problems

Difficulties arising from specific skill folders were discussed at length. EC's brought lists of these problems, and group concensuses were reached regarding their extent, severity and the best solutions. Structure for this discussion was provided by tabulation of teachers' responses to an item on the first Teacher survey, which asked teachers to list the pages they felt required revision most urgently. The result of this and other efforts to determine revision needs is discussed in Chapter VI.

A second segment of this meeting was devoted to logistics problems. EC's presented floor plans of their schools and explained the use of IMS materials in these settings. IMS personnel collected this information for use in determining stocking strategies for 1971-72.

February - IMS Activities

Student and teacher activities beyond Level IV had not been written as of this time, and the February meeting was devoted to a compilation of the activities teachers had developed for their own use at these levels. Small presentation groups were formed, each led by an IMS representative who recorded the proceedings for transmission to writers. (Two activity writers were available to lead groups.)

Another segment of this meeting was devoted to a review of evaluation findings to date.

March - Principals' Meeting

Principals of all participating schools attended this meeting in place of the EC's. After a review of evaluation findings to date, the meeting was conducted by IMS personnel, who received principals' recommendations and comments regarding administrative measures necessary to provide for successful introduction of IMS. These recommendations were later passed on to principals of schools which began using IMS in September, 1971

A second phase of the meeting concerned methods of presenting the IMS program to parents and the community. A major outcome of this discussion was the consensus that the majority of parents had little basis for distinguishing between the mastery achieved using IMS and whatever learning short of mastery may be achieved through the usual textbook presentation. Concern was expressed to the effect that parents might feel a student was "short-changed" if in using IMS he had mastered only fourth grade topics by the end of the sixth grade. Such a student might be of the sort who would otherwise get a low "C" in mathematics after a somewhat ineffective exposure to the usual sixth grade textbook presentation. In response to this area of concern a recommendation is made to emphasize, in teacher training, the importance of communicating to parents the mastery aspect of IMS achievement (see pages 72-74).

The afternoon period was devoted to tours of the IMS production facility and individual conferences with IMS personnel regarding materials orders and other school matters.

<u>April - Manipulative Materials, Presenting IMS to Parents and Student Involvement</u>

To prepare to discuss manipulative materials for student use in connection with IMS, EC's brought inventories of such materials on hand in their schools and indicated the extent to which they were useful for various purposes. It was interesting to note that items considered of little value in some schools were highly used in others, sometimes for different purposes. Some EC's reported that their schools had not obtained certain items considered necessary for IMS; pan balance scales were most often reported missing. A summarization of actual usage reported is in Chapter V, pages 80-81.

The second topic was parent understanding of IMS. Comments by principals at the March meeting and questionnaire results had led to the conclusion that parents were generally unaware of the fact that progress in IMS is based on mastery of specific behavioral objectives. It was explained to EC's that careful presentation of this feature is important, since otherwise some parents of slower children may not understand why they appear to be working on "below-grade level" topics. It was suggested that understanding the difference between mastery and simple exposure to a topic (often followed by a low report card grade) is the key to parent acceptance, both of their children's achievement level and continued use of IMS.

Several EC's reported on the success of IMS presentations before PTA meetings and other adult groups. The most enthusiastic reports came from schools in which students had participated in demonstrations of IMS. In some cases a demonstration class was run, and in others students explained their own work in IMS to their parents after orientation sessions by teachers.

Questionnaire results had shown a wide variation in the extent to which students were given responsibility for performing various tasks within the system. Several EC's explained the bases for decisions relating to student involvement in their schools. Consensus was reached regarding several points; these outcomes are reported in Chapter III.

May - First Grade Practices

Census reports had shown that IMS usage in the first grade was less than had been anticipated. Therefore, EC's were requested to investigate IMS first grade usage or the lack of it in their schools. In response, many were able to bring first grade teachers or aides to the May meeting. The substance of their findings is reported in Chapter V, page 82, where other results bearing on the first grade are also reported.

June - New Principals' Orientation

While EC's completed data collection in their schools, the principals were invited to a workshop for principals whose schools were to enter IMS.in September, 1971. The experienced principals participated in discussions and made presentations relating their experiences and recommendations for introduction of IMS.

Chapter III

Evaluation of Learning Effectiveness and Student Progress

Student Progress Within IMS

The nine levels of IMS cover approximately the subject matter introduced in a typical six-year series of elementary school mathematics texts. Therefore, it is of substantial interest to users to know the extent to which students may be expected to cover this material under individualization. Two important factors bear upon this outcome:

i) Progress in IMS represents mastery. In a typical elementary school classroom, the teacher presents a topic to the class or groups within the class and gives a test. Let us assume that no student "fails" the test. Nevertheless, some students do well on tests and others do somewhat poorly. The poor performers get lower grades, but the entire group or class then moves on to the next topic. In IMS each student stays with a topic until he has mastered it to the extent required by the system, usually by performing in the 85-100% range on an IMS posttest. Thus it would be reasonable to expect that many low ability students will not complete the entire IMS curriculum in six years. The IMS-2 junior high school program, currently under development, calls for completion of the first nine levels of IMS in the junior high school classroom for students who have not mastered the skills therein.

ii) Only six of the nine levels of IMS were available to schools during 1970-71. Therefore, estimates of materials coverage for six years of elementary school are based on the assumption that progress (mastery of skills) in the upper levels of IMS will occur at the same rate as in the lower. This assumption seems justified in view of the fact that, throughout the 23 schools using IMS to date, differences in rate from grade to grade and from lower to higher levels of IMS have been slight.

This latter result does not mean that IMS progress has been uniform in every aspect. Table 1 shows average IMS levels for students in the 23 schools participating in the evaluation. The basic datum, for which the Table reports averages, is each student's average position in IMS. For example, suppose a student's placement test locates him at Level V in three of the ten areas of IMS and at Level VI in the remaining seven. Then his average starting point in IMS is Level 5.7. If at the end of the school year he is ready to start Level VII in five areas and Level VIII in five areas, his ending point in IMS is Level 7.5. These average levels are the data for which Table 1 reports means by school, and in some cases groups within schools. The time covered by the data obtained from schools is only two-thirds of a school year and less for some schools or groups within schools. Therefore, to estimate gain within IMS for an entire school year each mean in column five of the table was multiplied by the inverse of the proportion of the school year covered by the data. These results are

TABLE 1

AVERAGE STUDENT IMS LEVELS - MEANS BY SCHOOLS

SCHOOL	(1) # OF STUDENTS IN IMS	(2) AVERAGE GRADE LEVEL 9 - 70	(3) INITIAL IMS LEVEL AND DATE REPORTED	(4) FINAL IMS LEVEL AS OF 6 - 1 - 71	(5) AVERAGE CHANGE	(6) ESTIMATED CHANGE FOR 9 MONTHS	(7) ESTIMATED AVERAGE FINAL IMS LEVEL, GRADE 6
Appalachian	188	3.50	3.92 (11-30-70)	5.07	1.15	1.73	9.38
	128	3.40	3.80 (3-1-71)	4.31	.51	1.53	8.29
Belvoir	274	3.60	3.22 (3-1-71)	3.88	.66	1.98	8.63
Boonville	342	4.00	3.85 (11-30-70)	4.51	.66	.99	6.49
Bruns Avenue	639	5.50	4.40 (11-30-70)	5.75	1.35	2.03	6.76
Central	167	2.50	2.24 (1-15-71)	2.83	.59	1.18	6.96
Chapin	119	5.50	4.71 (11-30-70)	6.53	1.82	2.73	7.90
	63	4.00	3.62 (3-1-71)	4.46	.84	2.52	9.50
Clays Mill	123	3.20	3.15 (11-30-70)	4.06	.91	1.37	7.88
Clear Creek	274	4.00	3.53 (11-30-70)	4.46	.93	1.40	7.25
Deep Creek	418	3.00	2.93 (11-30-70)	3.79	.86	1.29	7.66
	125	3.00	3.08 (1-15-71)	4.00	.92	1.84	9.52
Dunbar	257	3.90	3.05 (11-30-70)	3.75	.70	1.05	5.96
T. Jefferson	190	4.50	3.93 (11-30-70)	4.82	.89	1.34	6.82
Lawsonville	308	3.60	3.06 (11-30-70)	3.58	.52	.78	5.45
	22	2.00	1.70 (1-15-71)	2.34	.64	1.28	7.46
Lemon Road	368	3.60	2.76 (11-30-70)	3.98	1.22	1.83	8.37
Lewisville	77	2.00	1.93 (1-15-71)	3.08	1.15	2.30	12.28
Lylburn, Downing	49	6.00	5.22 (1-15-71)	5.92	.70	1.40	5.92
	54	5.00	4.40 (3-1-71)	5.06	.66	1.98	7.04
Mebane	139	5.40	3.61 (11-30-70)	4.57	.96	1.44	5.43
Morehead	169	3.80	2.45 (11-30-70)	3.19	.74	1.11	5.63
	42	4.00	2.07 (1-15-71)	3.33	1.26	2.52	8.37
North End	59	2.00	2.15 (11-30-70)	2.56	.41	.62	5.02
Pineview	201	3.90	3.81 (1-15-71)	4.53	.72	1.44	7.55
Taylor	82	3.00	3.10 (11-30-70)	3.92	.82	1.23	7.61
	36	3.00	2.74 (1-15-71)	3.52	.78	1.56	8.20
Waddell	158	3.00	4.28 (1-15-71)	4.98	.70	1.40	9.18
Willow Drive	91	4.70	4.11 (11-30-70)	4.78	.67	1.01	6.09
Rena B. Wright	134	2.80	2.92 (11-30-70)	3.42	.50	.75	5.82
	55	3.00	2.92 (1-15-71)	3.38	.46	.92	6.14

shown in column six. An estimate of the average final position in IMS at the end of grade six was obtained by multiplying the result in column six by the average number of years remaining in elementary school for the students of the subsample and adding this product to the mean in column four. The result is shown in column seven.

Three groups are omitted from Table 1, specifically, 40 second grade students at Lawsonville Avenue, 74 third grade students at Chapin and 154 fourth grade students at Taylor and Willow Drive. Data for these groups were inconsistent, and the sources of error could not be determined.

Column 7 of Table 1 requires substantial interpretation. What does it mean to say that the average student's estimated IMS level at the end of sixth grade is 9.38? Of course, it means that the average student will complete about four Level IX topics and leave six for junior high school. (See explanation on page 31.) Half the students will accomplish more than this and half less. However, the spread of these final average IMS levels attained by students is also of interest.

Data from the intensive evaluation schools suggest that the standard deviation of the final average IMS level scores is about 1.0 for groups of students scoring for the most part no more than a half year below grade level on standardized mathematics tests. For students more than a half year below grade level, the standard deviation is greater, approximately 1.5. The distributions involved are essentially symmetrical except for those containing substantial numbers of students whose progress in IMS was curtailed due to absence of Levels VII, VIII and IX. (In total, there were relatively few such students; most fifth and sixth grade classes in the evaluation contained students whose progress in mathematics had been somewhat retarded.)

The smaller estimated standard deviation (1.0) should be applied to schools with higher estimated final average IMS levels. With a few possible exceptions, the schools with final estimated average IMS levels above 7.0 may be characterized as representing the kinds of educational situations in which most students are at least near-grade level on standardized test. The higher (1.5) standard deviation may be applied to the remaining schools.

Application of these standard deviations may be illustrated for Dunbar and Lemon Road (see Table 1). Since at least 90% of cases may be expected to occur within two standard deviations on either side of the mean, Dunbar's students may be expected to have final IMS averages ranging from 2.96 to 8.96 (mean=5.96, standard deviation=1.5). Therefore, only a small scattering of Dunbar students may be expected to reach Level IX, with even fewer finishing it.

For Lemon Road two standard deviations (1.0) on either side of the mean yields a range of 6.37 to 10.37. Of course, IMS covers only through Level IX (up to 10.0). Therefore, a small percentage of Lemon Road students should complete all nine levels of IMS. If the distribution of final average IMS levels is approximately normal, this proportion would be about 5%. By the same process, about 30% of students at Waddell might be expected to complete IMS before the end of sixth grade.

It must be emphasized strongly at this point that the above results are estimates only and probably very rough ones at that. Several sources of error intrude in addition to the absence of Levels VII, VIII and IX. For example, classes starting later in the school year usually made faster progress than those starting earlier, probably due to profiting from the experience of others. Also, for a few schools, progress seems somewhat slower than might have been expected when compared with that for similar schools. Schools with most IMS students in lower grades appear to have systematically higher estimated average final IMS levels. This situation seems not to be due to younger groups covering more material. Instead, older groups seem to have had surprisingly low initial placement in IMS, not all of which may be overcome by the end of sixth grade. (This outcome is discussed in great detail in Chapter IV.)

All these things considered, it would appear that the estimates for the final average IMS level may be low. Nevertheless, one outcome appears quite definite. A large proportion of students cannot complete the first nine levels of IMS during the six years of elementary school. For some subpopulations, it appears that virtually none will finish. For others, as many as half may finish, but a more conservative estimate is 5% to 30% for fairly ordinary elementary schools.

This outcome illuminates one of the greatest strengths of IMS. It gives clear information as to exactly what kind of achievement is going on. To say that the average graduating sixth grader in school X has a grade equivalent score of 6.9 on a standardized test suggests that such a student is performing adequately. Yet it is widely acknowledged that the mathematical acumen of the average student leaving sixth grade is very meager. IMS gives a much more accurate picture of what a student at any grade level can actually do in mathematics.

A hypothetical average sixth grader leaving school X needs to get only slightly more than half the problems right on a standardized test in order to be "at grade-level" at the end of the sixth grade. This is not the kind of performance built into IMS. Further, it raises anew the question of the advisability of exposing a large proportion of elementary school children to mathematics topics they evidently cannot master at the time. The extent of this problem becomes more apparent when we stop to consider the fact that the half of the students who score "below-grade-level" for the most part get <u>less</u> than half the problems right on a standardized test. In IMS there is reasonable assurance that every student has a genuine grasp of all areas he has covered.

One further note regarding the results of Table 1 should be considered. With a few exceptions, results reported there cover several grades within a school. This kind of reporting was necessary in order to keep data collection and reporting activities within the resource limits of the evaluation. In contrast, at the four intensive evaluation schools, records were maintained on individual students. It is largely these data that led to the earlier conclusion that progress rates within IMS are reasonably uniform from level to level and from grade to grade within schools. The real interest with respect to these data, however, lies in their relations to standardized test scores. These results are covered in Chapter IV.

System Test Results

A substantial analysis procedure was undertaken with respect to the posttests within IMS. Results obtained bear on several aspects of evaluation. The psychometric properties of the tests themselves are important, since reliable and valid scores are a prerequisite for using test results to evaluate other features of the system. If reliable and valid, test results may be used to infer the degree of success of the materials of the system in fostering the achievement of behavioral objectives. In addition, the posttests regulate progress through the system. Therefore, the meaningfulness of the results presented earlier in this chapter is dependent on evaluation of system posttest results.

It is not possible to summarize precisely the outcomes of this phase of evaluation in a few words. In general the results are quite favorable, but certain specific and general weaknesses within IMS become apparent upon examination of test analyses. The remainder of this section explains the methods for analysis and lists major findings.

Method of Analysis

From the four intensive evaluation schools, all posttests taken by students were collected. From these a sample was drawn consisting of approximately 100 students' responses to each of the 60 posttests in use during the year (Level VII-IX not available). For some posttests fewer than 100 students responded. Results are reported hereafter only for a sample of 20 or more.

Each posttest item was assigned a score of 1 if correct and 0 if incorrect. The means for these item scores (across students) are, therefore, an estimate of the proportion answering each item correctly in the larger population of all students using IMS. If the proportion of subtest items a student must answer correctly to master a skill is, for example, 85%, and only 60% of students answering a given item in the subtest get it right, something is probably wrong. The item may be inappropriate or misleading. On the other hand, the students may not have learned what the item legitimately tests. Often inspection of the offending item and the related learning materials yields an obvious conclusion.

The identification of these test items of obvious poor quality or obviously inadequate teaching materials based on inspection of difficulty levels of items is a major contribution of the formative evaluation of IMS. Probably no other method could have accomplished as much with the same expenditure of resources.

For some items the proportion of correct responses may be "borderline" or there may be no obvious explanation for a very low proportion correct. To investigate these cases further, the item scores for each student were matched with three other scores, his grade-equivalent score (GE) on the ITBS or MAT, his age in months at the time of the standardized test and the quotient, GE divided by age. Then for each item three correlation coefficients (biserial) were computed--item scores successively with GE, age and GE/age. This last measure may be considered a measure of ability, since younger students with higher GE scores will have high GE/age ratios. Older children with low GE scores will have proportionally much lower GE/age ratios.

In a successful situation, all three of these coefficients should be near zero, within the range of sampling error. That is, a student's score on an external measure should not influence the success he has after completing an IMS skill folder (assuming proper placement). A student's age should not be a handicap or an advantage, since individualization arranges for some students to complete units while much younger than others. Finally, ability as represented by GE/age should not be a factor in IMS success on a given posttest.

The following section is a summary of findings based on the above statistics. This summary includes some findings regarding "extension items." These are posttest items that were judged to be more difficult or involved than items which might be used to test a specific skill. In some cases, they are simple problems but require more than one skill for solution. They appear at the end of most posttests and are not required for skill mastery. They are included for several purposes: to add interest for bright students, to give practice with fairly conventional problems not otherwise covered and to provide research clues for further curriculum development.

In addition to item analysis outcomes, a table has been included which summarizes the results of the biserial correlations of item scores with GE, age, and GE/age. (See Table 2) Items whose scores were found to correlate significantly with one or more of these variables were reconsidered and appropriate revisions were made whenever possible.

Level I - Only Multiplication I and Division I posttests were available in sufficient quantity to warrant analysis. Other data indicated serious need for revision of Skill 2 of Multiplication I and test results confirmed this need. (See Chapter VI.) Performance on all other areas of the Multiplication I and Division I posttests indicated excellent achievement, with good difficulty levels and low correlations with criteria. High achievement on items 16 through 18 of the Multiplication I posttest indicates that children taking the tests were able to cope with commutativity of

TABLE 2

Biserial Correlations of Test Item Scores With Three Variables

	Significant Correlation/Total Correlations (Percentage of Significant Correlations)*			
	GE/age	GE	Age	Total of all three variables
Level I	5/18 (27%)	5/18 (27%)	0/18 (0%)	10/18 (19%)
Level II	42/258 (16%)	43/258 (17%)	20/258 (8%)	105/774 (14%)
Level III	31/315 (10%)	24/315 (8%)	21/315 (7%)	76/945 (8%)
Level IV	17/417 (4%)	15/417 (4%)	40/417 (10%)	72/1251 (6%)
Level V	30/385 (8%)	18/385 (5%)	52/385 (14%)	100/1155 (9%)
Level VI	20/321 (6%)	15/321 (5%)	29/321 (9%)	64/963 (7%)

*The number of responses on each posttest ranged from 39 to 159, and averaged 83 responses per item. Significant correlations presented in this table were tallied in terms of an average significant coefficient of = .25 (at the .01 level of significance) for 83 cases (df = n - 2 = 81). Any correlation coefficient computed on items with difficulty level greater than .90 were not included with significant correlations due to instability of the index at extremes of item difficulty.

multiplication when presented with visual representations. However, it should be noted that the average age of those represented was somewhat high, about 8 years on the average. This result occurred because most second grade and many third grade students began in Level I for Multiplication and Division. Very few first grade children were represented, and use of all Level I tests should be validated on a sample of these students.

Levels II through VI - At this point results become too numerous to record in narrative and are presented in tabular form (Appendix XI) for cases in which negative or otherwise exceptional results occur.

Pretest Data

The approach just described for analysis of posttest responses would not be appropriate for pretests. These are administered for the purpose of writing prescriptions and a wide range of performance is expected. Some students may get a substantial number of items right, thereby indicating the need for only a rather short prescription to clear up a relatively minor area of misunderstanding. In other cases, students may miss almost all the items related to a behavioral objective. Therefore, measures of pretest item difficulty or discrimination have little meaning.

If a student attains the mastery level on part of a pretest, he must later pass the corresponding part of the posttest. Should the pretest be too easy or too difficult with respect to the learning materials or the posttest, various difficulties might arise. Only one source of data was available to detect this problem. Teachers were requested to report difficulties related to testing on Incident Reports.

Of the 300 or more Incident Reports received, about 40 concerned circumstances involving pretests. Some of these reported errors or problems were due to the students' difficulty in interpreting the questions. All of these were corrected prior to reprinting of the tests for usage during the 1971-72 school year. However, a more frequently reported trouble was attaining mastery on the pretest and failing the posttest. Most of these cases were explainable in terms of posttest inadequacies just listed. Those not in this category were probably due to the fact that pretests usually contain more worked examples and hints to help students interpret notation. The fact that, in some cases, this help was insufficient to insure attaining posttest mastery after some time interval, is not reason for changing the pretests in the opinion of the test developers.

All that this circumstance requires is a short prescription to permit the student to make up the deficiency. Based on Incident Reports received, it was not possible to identify the pretest areas definitely requiring revision due to being too easy.

Student Involvement in IMS Operation

The original formative evaluation plan submitted for funding by the Division of Educational Laboratories (of the U. S. Office of Education) called for systematic observation in classrooms to determine certain operating characteristics of IMS. It was thought that various procedures, such as prescription writing, checking work, and arranging for individual help might be improved upon as a result of these findings. However, part of the funding for the evaluation was withheld and the decision was made to delete the classroom observation phase. This decision was made because of the relatively large expense involved and the unavailability of trained personnel within the Laboratory for this work. Recruiting and training observers would have made this phase of the evaluation even more costly.

To obtain some information in areas which might have been covered by observation, teachers were asked to respond to questionnaire items regarding the extent to which students could and did take responsibility for operation of the system. These questions appeared in Teacher Survey #2 (Appendix V b) after it was found that a related question on Teacher Survey #1 (Appendix V a) was too general in its application.

Results for question 8 of Teacher Survey #2 (193 responders) are as follows:

Task	% encouraging student involvement *		% of students successful **	
	Grades 1 - 3	Grades 4 - 6	Grades 1 - 3	Grades 4 - 6
Score Skill pages	36%	91%	44%	70%
Score Check-up tests	13%	43%	51%	70%
Score pretests	9%	21%	36%	78%
Write prescriptions	20%	68%	33%	63%
Obtain and return materials	86%	99%	71%	85%

When asked what proportion of their students could score accurately their own check-up tests without regard to whether the practice was encouraged or not, responses were as follows (question 7):

Percent of students able to score check-ups	No. of teachers responding*** Grades 1 - 3	Grades 4 - 6
0 - 25%	73	24
25 - 50%	7	21
50 - 75%	5	16
75 - 100%	6	25

The general tone of these results may be characterized by the following observation. In grades 4 - 6, 72% of teachers estimate that 25% or more of their classes can score checkup tests accurately. Yet only 48% of these teachers encourage the practice.

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* Not counting small numbers of omissions.

** Average of estimates by teachers encouraging student involvement in task.

***There were 16 omissions.

Therefore, it is strongly recommended that teachers be encouraged to have students experiment and try to manage their own progress through IMS. As noted on page 63, in the absence of any aides whatsoever, students at Countryside Elementary School were able to make progress through the system at somewhat greater rates than those of Urbania Elementary School where student involvement was less.

Teacher Survey #3 also had questions regarding student involvement. See Appendix V c, items 13-17. The percentages reported there are the proportion of "true" responses according to grade taught, grades 1 - 3 as compared with grade 4 - 6. As seen from these results, even in the lower grade a substantial proportion of responsibility may be assigned to students. students.

Aide Usage

Of the 23 schools in the evaluation, fourteen used paid aides. They averaged about one full-time aide for every four or five teachers, but ran from a high of one full-time aide for each two teachers to a low of one aide for 13 teachers. Two schools with paid aides also used volunteer aides, but these were not the schools with the fewest aides per teacher. EC's estimates of time saved per teacher per day by paid aides ranged from 30 minutes to 150 minutes and is somewhat related to the number of paid aides per teachers. All but one school reported that time saved per teacher by paid aides closely approximates or exceeded aide time available.

Volunteer aides spent from 30 to 60 minutes per day with each teacher and reportedly saved those teachers from 20 to 120 (!) minutes of work per day. These aides served in eight schools, two of which also had paid aides.

Three schools used no aides at all. The rates of progress within IMS for students in these schools (one was Countryside) were as high as or higher than those reported by similar schools with aides.

The above results regarding aide usage are summarized from a questionnaire sent to all EC's (see Appendix VII).

Classes Not in IMS

The EC questionnaire (Appendix VII) also sought information regarding the reasons for classes not entering IMS after being scheduled to do so originally. Of the 23 evaluation schools five reported classes not entering IMS due to materials shortages. In four of these schools, 13 classes have not entered IMS for this reason. Specific difficulties were the following:

School layout requires additional materials	(1 school)
Manipulative materials needed	(1 school)
Not enough carts available	(1 school)

Level VII and higher materials needed (2 schools)*

Heavy concentration of students at lower levels requires more materials (2 schools)

Accordingly, some schools had multiple problems, but apparently these were not widespread. The fifth school was originally scheduled for 17 classes in IMS but reported only five at the time of the survey. In this case, serious multiple difficulties prevented full usage, but these were only partly due to materials shortages.

In total, 264 classes were originally scheduled for IMS in the 23 evaluation schools. At the time of the survey, March 1, 1971, 207 classes were participating, and very few were added before June. In addition to materials problems, reasons for classes not participating are as follows:

Decisions not to use IMS in first grade.

School organization changes.

Teacher preference.

While all of the above reasons and some of the materials problems (carts and manipulative materials availability) were beyond the control of the Laboratory, every effort was made to assure users of adequate availability of materials and assistance in other areas.

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*A number of schools expressed the need for these materials, but only two actually kept classes out of IMS for this reason.

Chapter IV

Results from Intensive Evaluation Schools

The purpose of this chapter is to relate results of system operation as reported in Chapter III with standardized test scores as collected in the four intensive evaluation schools (see pages 17-18). Data reported here cover only the 1070 students at these schools who were present on both days of standardized testing. By grade level they are distributed as follows:

Grade	No. of Cases
1	70
2	153
3	293
4	342
5	152
6	60
	1070

Census reports for the four intensive evaluation schools show a total of approximately 1500 students using IMS in these schools. The bulk of the deficiency must be accounted for in terms of absences due to illness and turnover in the sample. One third grade class of about 25 could not complete the second half of the ITBS. While attrition is rather high, in the opinion of the author it represents no readily classifiable source of bias insofar as results of this study are concerned. Specifically, there was no exodus of white students as a result of recent changes in racial composition of the schools.

With respect to standardized test results, it is important to keep in mind the differences between materials covered and level of mastery expected in IMS as compared with the conventional curricula on which test standardization is based. For example, consider two low ability students, one in IMS and the other in a conventional classroom: it is possible that the two may not be taught any topics in common during the school year! The conventional classroom student will be exposed to but will not master grade-level topics, while the IMS student will achieve mastery of topics which are below grade-level. Therefore, comparing the achievement of these two students with a standardized test covering mostly grade-level topics is meaningless.

This rather obvious discrepancy led the developers of IMS to set no goals with respect to below-grade-level students as determined by standardized test results. The developers did set a goal of one year's growth in standardized test reaults for students at and above grade-level on these same tests.

In order to present results relating to this goal, it is necessary to draw a correspondence between the levels of IMS and those represented by grade equivalent (GE) scores from standardized tests. While the levels of IMS are not directly comparable to work at any given grade, there is a rough correspondence in terms of new topics introduced so that 1.5 levels of IMS corresponds to approximately one year of a conventional curriculum. Figure 11 shows the grade level and

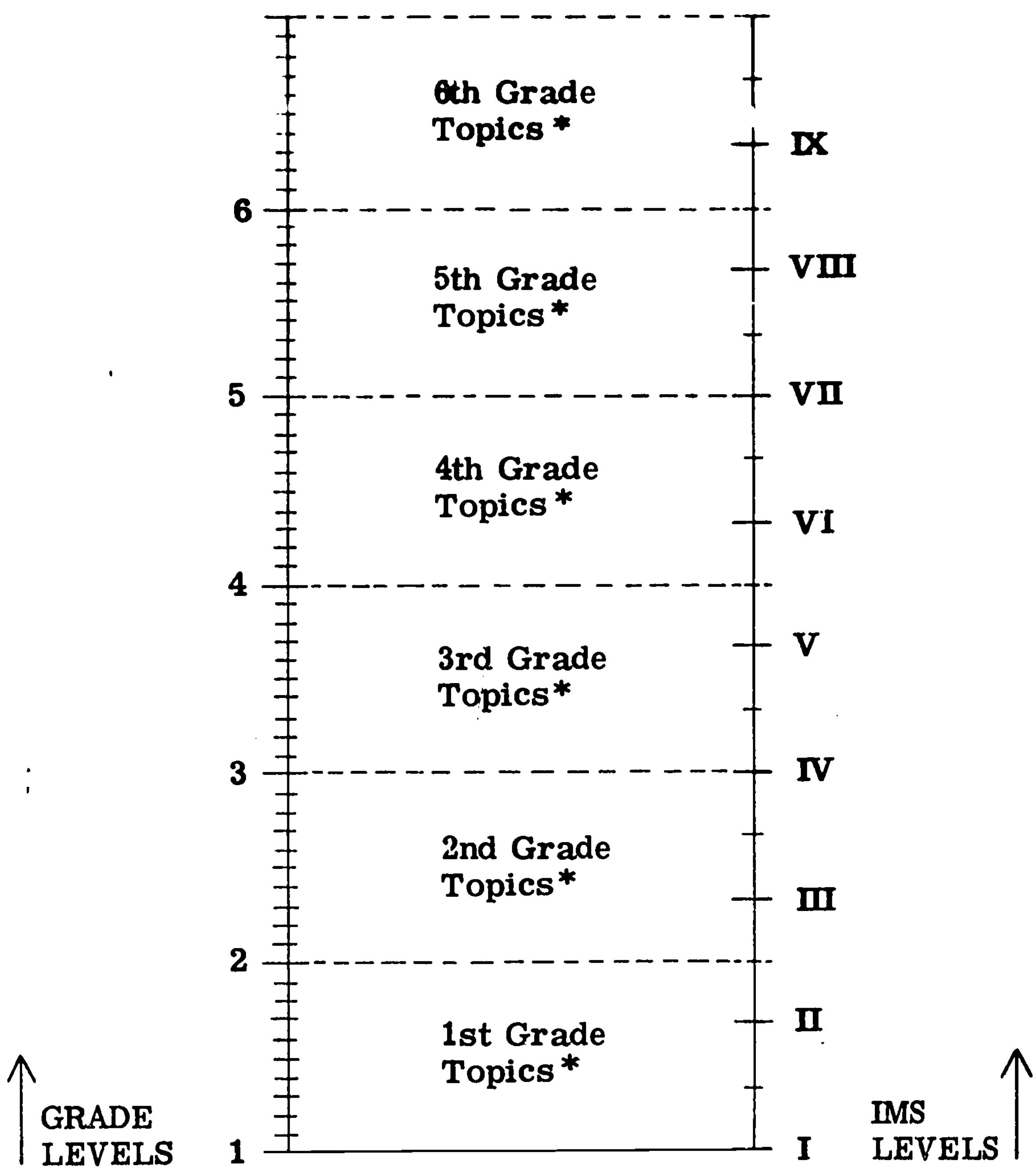

Fig. 11 Comparison Between IMS-1 Levels and Elementary School Grade Levels.

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* Topic coverage as represented here is only approximate and varies according to curricula.

IMS level scales for purposes of comparison. Note that each scale has the number, one (Roman or Arabic), as its base or zero point. Therefore numbers above six on the grade-level scale represent work taught during the course of sixth grade. Similarly, numbers above IX on the IMS scale represent work within Level IX of IMS.

After the initial administration of the standardized test, it immediately became apparent that growth in GE scores for above grade-level students would provide as little basis for evaluating IMS as is obviously the case for below-grade-level students. The reason for this difficulty is the lowness of IMS placement achieved by above grade-level students. Thus almost all students in IMS, even those above grade-level on standardized tests, were placed in IMS so that the bulk of their work for the year was on below grade-level topics. The developers of IMS interpret this outcome as the consequence of the non-mastery approach in the conventional programs to which these students had previously been exposed.

Grades Three Through Six

Figure 12 illustrates the situation for 796 third through sixth grade students at four achievement levels:

A - those whose ITBS GE score exceeds their grade by more than .5;

B - those whose ITBS GE scores lie between their grade and .5 above;

C - those whose ITBS GE scores lie between their grade and .5 below;

D - those whose ITBS GE scores are more than .5 below their grade.

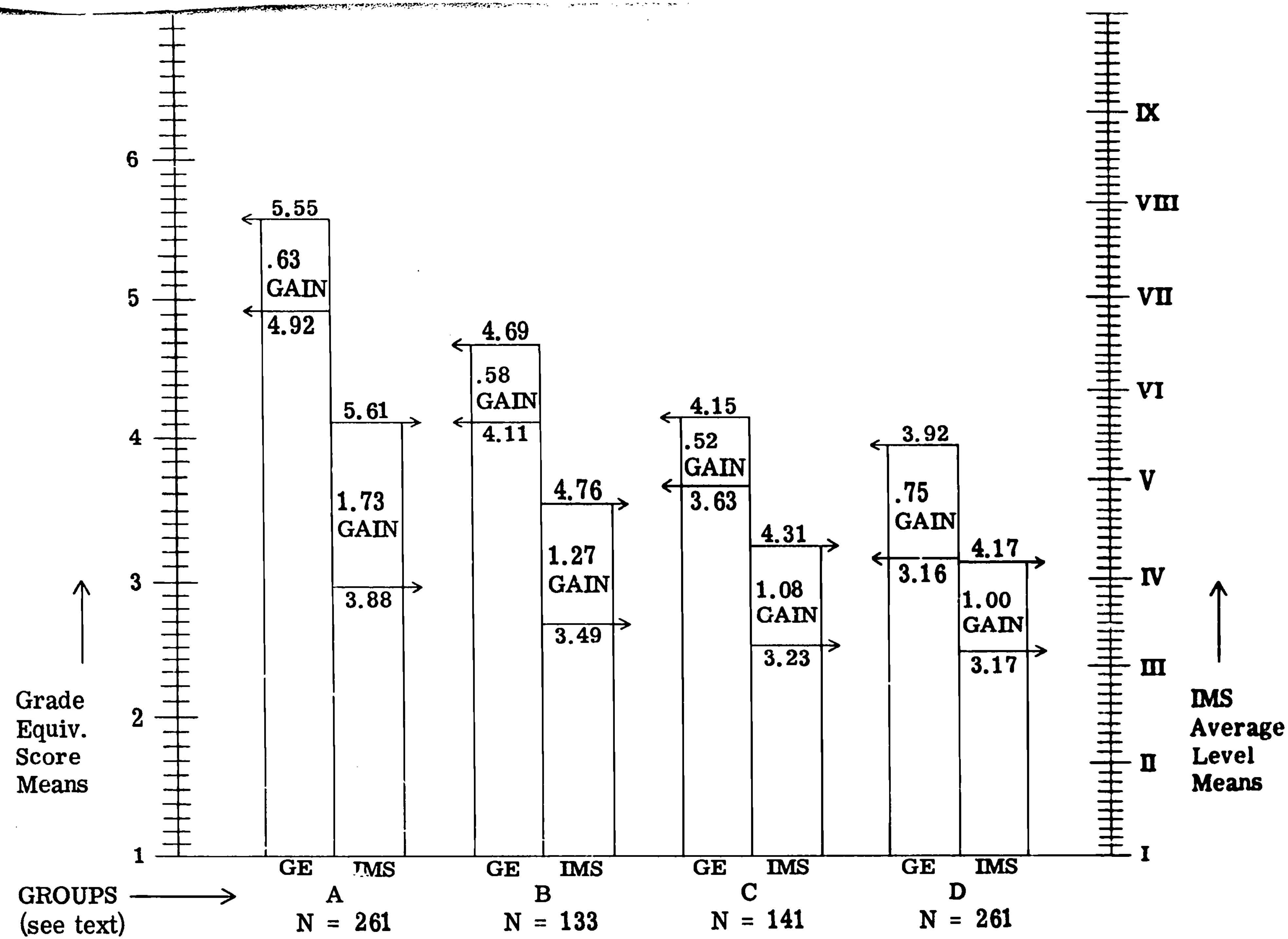


Fig. 12 Initial and Final Mean Grade Equivalent Scores and Average IMS Level Scores for Four Achievement Groups - October-May, 1970-71, Grades 3-6.

The left bar for each group represents the October and May mean ITBS GE scores. The right bar represents average IMS level for the group at the time of entry into IMS and at the end of the school year. There is little difference from grade to grade in terms of group membership or achievement characteristics At the beginning of the year, the average grade assignment of students in Group A was 3.8, those in B 3.8, in C 3.9 and in D 4.2. Therefore, Figure 12 strongly and uniformly across grade levels illustrates that grade placement scores are much more highly discrepant with respect to level of mastery for the higher achieving students.

Consider Group A: the average student in this group was approximately a beginning fourth grader but began IMS only at about Level IV. This same average Group A student covered 1.72 levels of IMS during the year, thus barely working his way into topics normally introduced in the fourth grade. Thus it is not surprising that his GE score on subsequent testing did not increase markedly. Much the same analysis follows for students in Groups B and C, in which many students never even worked their way up to grade level topics.

Group D, however, deserves special attention. The average gain in GE scores here is substantial for such a group. While there is probably some gain due to regression and readministration of the same test, such an outcome shows the extreme effectiveness of IMS in motivating low-achievers. Often a group of this type has all its score gains attributable to extraneous effects, such as maturation and regression. But a GE score gain of .75 on the average in only seven months is far too substantial for such explanations. A further consideration with respect to Group D is the fact that their IMS placement did not represent nearly as much of a discrepancy with respect to initial GE scores as was the case for the other groups. (In viewing the other groups' GE scores it should be remembered that the measurement period was seven months, not a full school year.)

Looking at Figure 12 again, it appears that GE gain is much lower for those with greater discrepancy between IMS placement and initial GE score. At the same time it appears that larger IMS gains and higher ability may modify this outcome. (Note that Group A had higher GE gain than Groups B or C and also had higher IMS gain.) To investigate this conjecture, five predictor variables were entered into a stepwise multiple regression program to predict gains in GE scores for students in grades three through six. The five predictor variables are:

1) Difference between initial GE score and IMS placement (scores expressed on a common scale).
2) Average IMS gain score.
3) Ability defined as the quotient, initial GE score/age.
4) Difference between grade and initial GE score.
5) Difference between grade and intital IMS placement (both converted to a common scale).

Only the first three variables entered the prediction equation still accounting for a statistically significant proportion of the variance of the GE gain scores. Of these three determiners, 1) is by far the most powerful, followed by 2). Ability (3) accounted for a small but statistically significant proportion of the variance of the GE gain scores. The actual regression equation is as follows:

$$-.47X + .30Y + .32Z - .35 = G,$$

in which

X = difference between initial GE score and IMS placement measured in IMS level units.

Y = gain in average IMS level over three fourths of school year.

Z = initial GE x 100/age in months.

G = gain in GE over seven months.

This result confirms the conjecture that gain in GE scores is largely a function of how far back a student is placed in IMS compared to his position as measured by a standardized test. The further back he is placed the less he is likely to gain. Further, the more he gains in IMS, the more he should gain on the standardized test. Ability has something to do with this gain but plays a relatively minor role. (Its addition to the prediction equation raised the multiple R from .45 to .51.)

Now, of course, the question that standardized test results were expected to answer has changed. We know that being put back in IMS reduces gains in GE scores and that covering more ground in IMS increases them. What we need to estimate now is how well those who were put back will catch up.

To make this estimate, it is first necessary to note that, on the average, the students for whom scores are reported here did not work on IMS the full school year. A fairly close estimate is that the average student used the IMS materials three-fourths of the school year. Thus, the IMS gain means should be multiplied by four-thirds to estimate average progress in a full school year. In Group A, the observed average IMS gain of 1.72 becomes 2.29 for a full school year. At the end of the school year, the average student in Group A was in grade 4.8, thus having 2.2 additional years of elementary school. Therefore, he should cover 2.2 x 2.29 or 5.04 more levels of IMS in elementary school. Adding 5.04 to 5.61, the point at which he finished the 1970-71 school year, yields an estimate of 10.65 for a final IMS level. This means that the average student in Group A (and all those above average in Group A) should more than finish nine levels of IMS. For Group B, the estimate of final IMS level is 8.48, in which case about 7% of students in this group might be expected to finish nine levels of IMS, assuming a reasonably normal distribution of final average IMS levels with a standard deviation of about 1.0 (see page 33). Virtually no students in Groups C or D may be expected to finish nine levels of IMS by the end of the sixth grade.

Multiple regression yields another approach to predicting progress within IMS for students in grades three through six. The following variables were selected for predicting average IMS levels at the end of the school year:

1) Difference between initial GE score and IMS placement (both scores expressed on a common scale).
2) Ability defined as the quotient, initial GE score/age.
3) Difference between grade and initial GE score
4) Difference between grade and initial IMS placement (scores expressed on a common scale).

Only the first two of these predictors entered the prediction equation accounting for a statistically significant proportion of the variance of the IMS gain scores, and the second (ability) accounted for only a very small proportion of this variance (multiple R increased from .49 to .51 with inclusion of 2) as a predictor). The resultant regression equation is:

$$.19X + .21Z + .41 = I,$$

in which

X = difference between initial GE score and IMS placement measured in IMS level units.

Z = initial GE x 100/age in months

I = gain in average IMS level over three-fourths of school year.

Application of this equation to the existing sample groups A, B, C and D, would no more than duplicate the information of Figure 12, but this result further confirms the conjecture that discrepancy between mastery level and GE is the major factor in predicting progress within IMS when the system is first introduced in grades three through six.

First Grade

Complete data were available for only 70 first grade students. Of these, 58 had very high GE scores, averaging 2.28. Like their older counterparts in Group A above, they had very low IMS initial placement, which averaged 1.69. Their average GE gain was .45. Other circumstances should be mentioned with respect to this group. Many of them entered IMS somewhat late in the year after the normal socialization processes has been completed in first grade, and, in some cases, use of the materials was sporadic at best.

The developers of IMS were disappointed with this usage for two reasons. They had hoped that bright first grade students might be introduced to IMS much earlier in the school year and that nearly all average or below first grade students would enter the system at least by mid-year. This mode of usage was followed by some schools, who reported it very successful. However, in the four schools in which standardized test data were collected, only more limited usage was reported.

As a result of this outcome a special EC meeting was devoted to collecting impressions regarding IMS usage in the first grade. These results are reported in Chapter V.

Second Grade

In second grade, three schools, Enterprise, Academia and Urbania used IMS for the major portion of the school year in classes in which standardized test data had been collected. In these cases, experience paralleled almost exactly what was observed in the higher grades. Placement was much lower than GE scores. Progress in IMS was greater for those with initially higher GE scores, and GE score gains were modest for the seven month period between test administrations.

Inter-School Differences

While the results presented above are probably somewhat representative of educational settings in general, it is of interest to review results from specific schools. The characteristics of the four intensive evaluation schools are quite distinct and deserve individual consideration.

Figure 13 shows the mean gain in average IMS level for each of the four achievement groups described earlier (see page 52) and for the four intensive evaluation schools, Academia, Countryside, Urbania and Enterprise (see pages 17-18). As was the case for the total sample, three schools show a substantial reduction in amount of IMS material covered as relative GE scores decrease. This phenomenon is most pronounced for Adademia but is essentially reversed for Countryside. Further, there are substantial differences in coverage of IMS ~~for~~ students of the same relative achievement levels.

Application of statistical tests of the significance of these differences would be inappropriate and would only belabor the point. Figure 13 shows that achievement within IMS was quite different from school to school, even for groups initially comparable in terms of standardized test scores. The causes of these differences cannot be established from available data, and it is possible only to offer conjectures as to their origins.

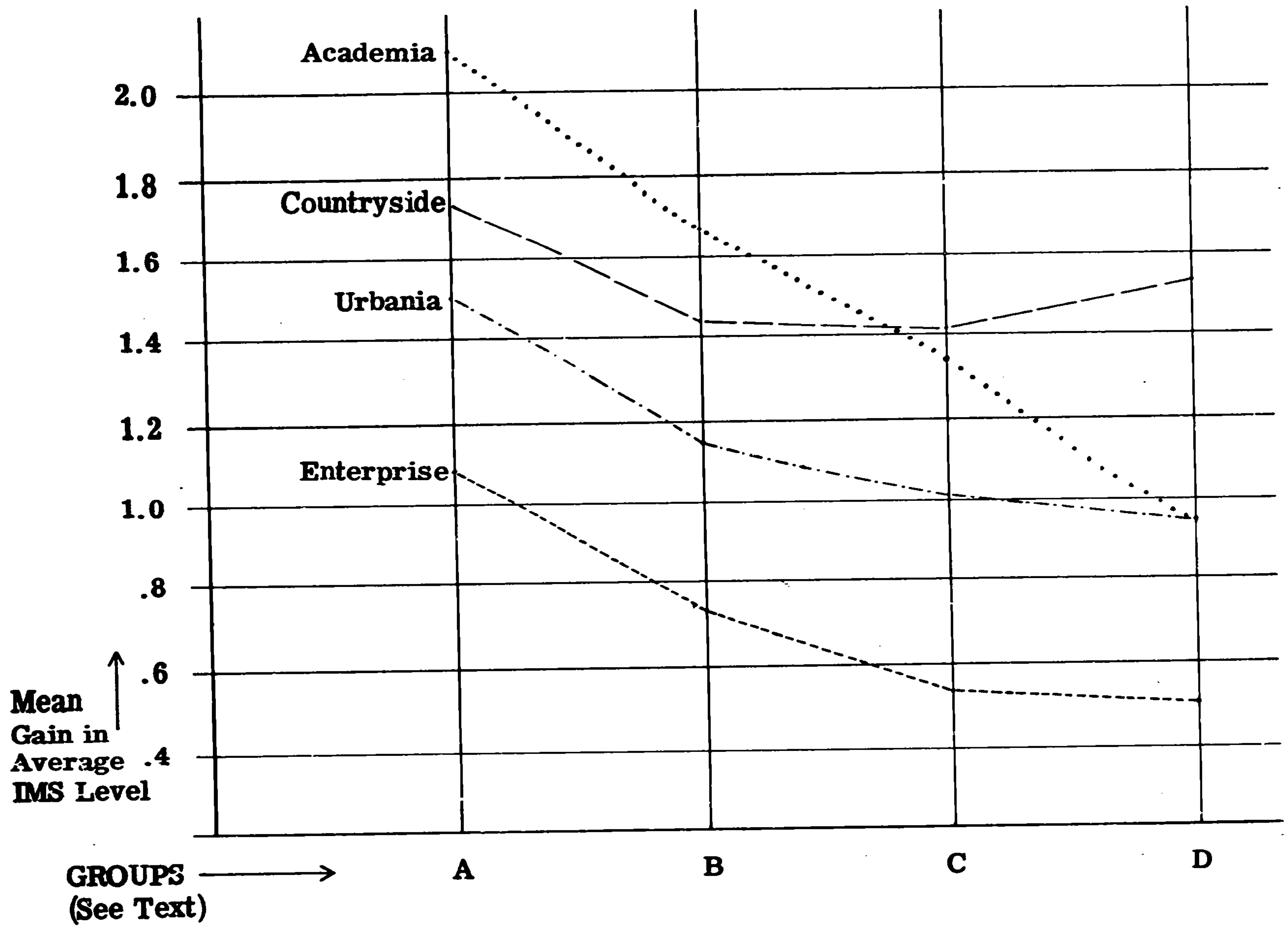


Fig. 13 Mean Gains in Average IMS Level by Schools and by Achievement Groups, October-June, 1970-71, Grades 3-6.

The students at Enterprise gave the appearance (to the author) of being tense and seemed easily agitated. Some teachers there expressed discouragement regarding the achievement of a substantial proportion of their students. They attributed this lack of success and behavioral problems as well to inadequate home environments and social or racial tension in the community. Therefore, it would appear that the mean gain in average IMS level for Enterprise (Figure 13) may have been depressed by factors external to the school. At any rate, the author observed nothing which would suggest any inadequacy on the part of the Enterprise staff. That IMS did permit a noticeable degree of achievement at Enterprise is a tribute both to the school and to IMS.

Countryside gave the impression of being a very calm school. IMS was introduced at each grade level only after careful preparation of teachers, parents and students. Students seemed eager to learn. The fact that the lowest achievement group at Countryside had such high IMS achievement may be an artifact. The Countryside sample was heavily loaded with fifth and sixth grade students, some of whom had to begin IMS at rather low levels. Good management of the system by teachers and students permitted many such students to catch up quickly in areas of deficiency. It may be noted at this point that Countryside had no aides; the other intensive evaluation schools did. In the absence of aides Countryside teachers encouraged students to take as much responsibility for system operation as they believed feasible. This approach may have motivated the students strongly. In any case a high degree of achievement was demonstrated (see Figure 13).

Urbania's initial standardized test score means are much like those for Countryside. However, IMS progress was much less on the average, even with the help of aides. Yet Urbania's general atmosphere seemed quite cheerful and supportive of educational activities in general. The lower IMS achievement at Urbania may have been due to a more exacting application of IMS procedural "rules" than at either Academia or Countryside. The aides at Urbania were strongly organized in terms of checking and returning students' work, and formalities regarding passing posttests and writing prescriptions were carefully observed. It is possible that strict adherence to schedules and regulations served to depress motivation and, in turn, achievement in IMS. On the other hand, it is possible that a combination of variables, possibly masked by the excellent facilities of the school, led to a slight depression of achievement and that performance at this particular school is nearer the average than any of the others.

Though not shown above, achievement within IMS for second grade students at Urbania was somewhat depressed also. The average second grade student at Urbania covered only .42 level of IMS in approximately six months. In comparison, at Enterprise the average second grade student covered .65 level. At Academia, the average second grade student covered 1.02

levels of IMS. Countryside completed the introduction of IMS in only grade three through six during 1970-71.

Figure 14 shows mean GE gain scores by school and ability groups in the same format as Figure 13. These results are not as dramatic as those of Figure 13 but are offered because the reader may wonder the extent to which accelerated IMS coverage was accompanied by higher standardized test scores. Countryside's record appears best in this respect. This result parallels the finding that IMS gain is a significant predictor of grade point gain in a multiple regression equation.

The surprisingly low gains for Groups B and C at Academia are not readily explained in view of generally high rates of IMS achievement. The number of cases involved is relatively small and did not adversely affect establishment of regression equations reported earlier. This outcome may be due to inappropriateness of the older, dated ITBS form used with respect to Academia's somewhat advanced curriculum

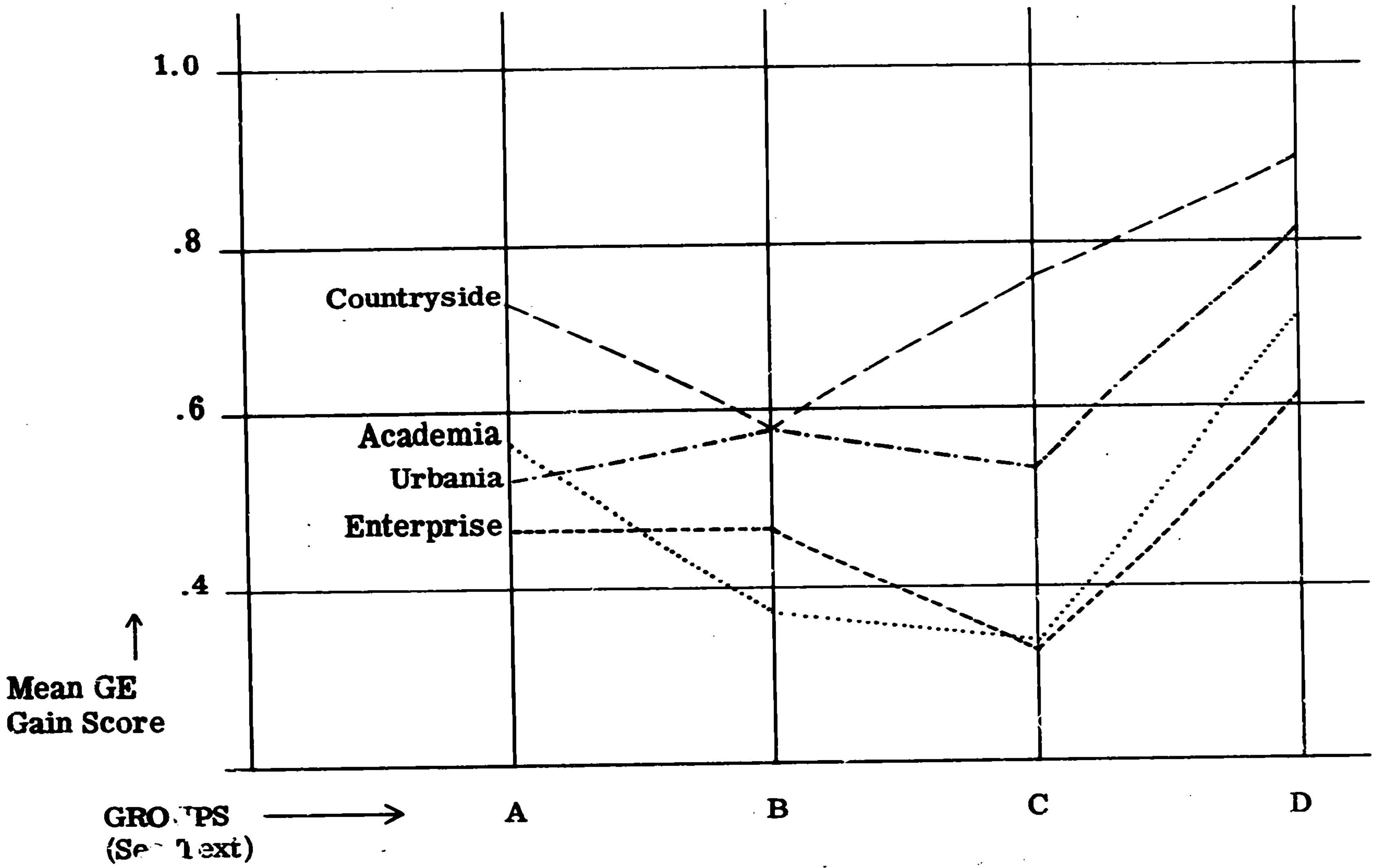


Fig. 14 Mean GE Gain Scores by Achievement Groups within Intensive Evaluation Schools, ITBS Arithmetic, October-May, 1970-71, Grades 3-6.

Chapter V

Other Evaluation Results

Evaluation by Consultants

Structure and content are the two aspects of IMS regarding which the Laboratory sought evaluation by acknowledged experts. Dr. Robert M. Gagné of the Florida State University was engaged to review IMS materials and procedures from the standpoint of the learning theories with which IMS is compatible. Appendix VIII is Dr. Gagné's report.

With respect to this report, the reactions of the IMS staff should be reported here insofar as they relate to changes which may be made as a result thereof. All agreed that a number of the behavioral objectives should be restated to sharpen the precision with which they specify criterion behaviors. Also, it was agreed that empirical studies on interdependency of skills might well make possible new approaches to prescribing learning which would be much more efficient. However, it was felt that such an undertaking was not feasible with currently available levels of funding. Similarly, redesigning the pretesting phase of IMS to provide more precise diagnostic information was believed desirable but also very costly. This development subsumes a more precise characterization of teaching pages and activities to permit maximum usage of more information from pretesting. Dr. Gagné's recommendation for developing and characterizing activities of the system in terms of application, transfer of learning and problem solving is certainly feasible if given modest support and good direction.

Testing is one phase of IMS which it was felt may have been misinterpreted by Dr. Gagné. If IMS is properly managed, students should feel no pressure from testing. Placement tests are to be used only when a student enters IMS, and pretests are used only for prescribing work in skill folders. If all has gone well, the posttest should not be a challenge but, instead, an opportunity for the student to display what he has learned and at the same time obtain more practice.

Dr. Joseph Scandura of the University of Pennsylvania reviewed IMS from the standpoint of mathematical content and suitability for fostering attainment of the behavioral objectives. He made a substantial number of specific suggestions regarding format, notation, terminology and the extent to which materials conformed to their related objectives. These comments, along with his suggestions for further development of IMS comprise Appendices IX a and b. Dr. Scandura's specific recommendations for revisions were presented to the IMS staff for their consideration and are discussed further in Chapter VI (page 88).

Another area of Dr. Scandura's report consists of proposals for enhancement of the IMS program in three related areas: arithmetic skills, critical reading, and logical thinking. The importance of training in these areas and the benefit to students using IMS cannot be denied. Not only should development of critical reading and logical thinking skills help students in IMS, the benefits should extend to other curriculum areas. While arithmetic skills are taught in IMS, development of additional activities in this area is certainly appropriate.

It is strongly recommended that the proposed development work outlined by Dr. Scandura be given highest priority when program resources become available for such activity.

Teacher Characteristics

Teacher Survey #1 (Appendix V) covered the 175 teachers using IMS in December. These included four first grade teachers, 33 second, 35 third, 40 fourth, 35 fifth and 24 sixth. Four respondents did not indicate grade taught. Only 6% of respondents had used IMS the preceding year, but 13% had had experience with other individualized mathematics systems. Average experience of the 175 teachers was 10.8 years, and 17% held masters degrees. Over 95% felt their background in mathematics adequate for teaching with IMS. Later surveys covered approximately 200 teachers, as more classrooms began using IMS, but the distribution across grades remained approximately the same.

Questionnaire Results

Three questionnaires were administered in December, March and May (see Appendix V). The first two requested responders' names and the third was anonymous. On the first two, responders were encouraged to omit items if in doubt but on the third were requested to respond to all items (see cover letters and instructions in Appendix X).

As may be seen from the questionnaires themselves, a wide range of topics was covered. Many of these are discussed elsewhere in appropriate sections of this report. For example, responses regarding materials revision are covered in Chapter VI, and those regarding effectiveness of summer workshops are covered in this chapter (page 76). Responses concerning student involvement with system operation are discussed in Chapter III. What remains to be summarized here are for the most part questions of opinion or judgement on the part of responders. Responses to a few procedural questions were simply tabulated and reported to the IMS staff (e.g., "Should keys to skill pages be laminated?").

Teacher Survey #1

This survey showed almost unanimous agreement that the materials are attractive and generally effective with students (see Appendix Va for responses to IMS Goals, items 1-5,9,10,15).

The questions regarding activities, materials supply, students taking responsibility for operation of the system, and parent opinion and understanding of the system suggested the need for more detailed questions on the second questionnaire.

Question 17 concerned overall effectiveness of IMS compared with the system used previously. About 42% of responders chose not to answer the question. Of those who answered, 69% chose IMS as the more effective system.

A large proportion of responders cited the need for some kind of test to precede entrance into Level I. The IMS staff responded with publication of the IMS Initial Screening Device. Its introduction was reported extremely helpful by all users (see IMS Problems, items 1-2).

Very few responders claimed that older students reacted badly to lower level materials (IMS Problems, item 13).

When asked if some mathematics system other than IMS might be more suitable for some students in their classes, 47% of responders replied positively. Almost all of these went on to specify low achievers as not profiting from IMS compared with a teacher-centered, drill-oriented curriculum. This outcome is in direct conflict with the facts as reviewed on pages 54-55 regarding Group D, those six or more months below grade level according to standardized test results.

Teacher Survey #2

There were 193 responders to this survey administered in March. The increase over Teacher Survey #1 was due to additional teachers using IMS. Grade taught were as follows:

	1st	2nd	3rd	4th	5th	6th	Total
No. of respondants	9	44	40	40	34	26	193

Question 5 pursued the problem of availability of materials. Responses were as follows:

Shortage of	Percent Responding Now	Percent Responding Previously
Special Pens or Pencils	27%	22%
Skill Folders	23%	13%
Manipulative Materials	24%	15%

Apparently shortages of one kind or another affected many classrooms using IMS. Apart from the simple need for larger quantities there is apparently some need for better usage arrangements within schools, since responses to question 6 were as follows:

	Percent Responding
Lack of carts or storage space has caused supply problems	14%
School layout has prevented efficient use of materials	14%

These responses and related data were reported to the IMS staff. Along with other results, these outcomes led to the establishment of a stocking model responsive to school layout and achievement levels of students. This model was used for stocking schools for the 1971-72 school year.

Question 9 regarding prevailing student opinion of IMS had the following responses:

162 Favorable 1 Unfavorable

27 Mixed 3 Omitted item

Question 11 had responses as follows regarding parent understanding of certain features of IMS:

IMS Feature	Parent Understanding→ Almost all Understand	Many Do not Understand	Item Omitted
	Percent of Teacher Responses		
Each student works at his own level	61%	25%	14%
Each student works at his own speed	56%	29%	15%
Completion of a level represents mastery, not exposure as in the textbook approach.	25%	54%	21%

The large proportion indicating parental non-understanding or omitting the question suggested a substantial problem area for IMS. It was the case that many schools did not make use of available resources in explaining IMS to parents, while others showed an IMS film at PTA meetings or had IMS representatives speak to parent groups. Still others scheduled demonstrations of IMS or used other local resources to present this facet of their school programs.

The apparent lack of parent knowledge regarding the "mastery" aspect of IMS was especially disturbing. It was pointed out to the EC's that one way or another many parents would come to know that by reaching, for example, only Level VI or VII of IMS in elementary school, their children would not have been exposed to certain topics typically in sixth grade textbooks. Only if they understand that such exposure is no substitute for really being able to perform in lower areas will they appreciate IMS fully.

Of the responses to question 10 regarding prevailing parent opinion of IMS, responses were as follows:

70	Favorable	10	Unfavorable
74	Mixed	29	Omitted item

An interesting subset of these data is the responses of those teachers who indicated that they thought almost all parents understood at least two of the three features of IMS discussed earlier in this section. Of the 193 teachers responding 105 are in this category. Their responses as to prevailing parent opinion were as follows:

56	Favorable	5	Unfavorable
40	Mixed	4	Omitted item

The proportion favorable in this group is 53% as compared with 16% for the remaining group when these are removed from the total. In other words, 56 of the 70 favorable responses regarding parent opinion came from teachers who also thought that almost all parents understood at least two main features of IMS. Of course, teacher judgement of parent opinion is only a substitute for the actual expressions of opinion but this result is certainly strong evidence in favor of making every effort to keep parents well informed. Teacher training procedures were modified as a result of these findings to emphasize the need for informing parents about IMS.

Four questions concerning teacher opinion of IMS had responses as follows:

	% of Teacher Responses		
	Yes	No	Omit
Do you find IMS, and materials generally effective for helping students achieve IMS objectives?*	82%	5%	13%

*In answering this question, teachers were asked to delete from consideration seven skill folders undergoing substantial revisions.

	% of Teacher Responses		
	Yes	No	Omit
Does provision of activity pages in addition to work pages assist in achievement of IMS Behavioral Objectives?	61%	11%	28%
Does IMS enable the teacher to spend more time giving individual assistance to students?	69%	23%	8%
Does IMS seem more effective than the mathematics system you used previously?	70%	13%	17%

These statistics speak for themselves, but two points are noteworthy. On the negative side, the proportion of omissions to the activities question was disappointing. Although activity pages through Level IV had been distributed some time prior to the survey, apparently many teachers had not used them extensively enough to answer this question. On the positive side the proportion reacting positively to the last question is much higher than to a similar question on the first survey, when 42% of responders omitted a similar question.

Teacher Survey #3

Essentially the same teachers responded to this survey as to the preceding one. Since Survey #3 was anonymous and responders were requested to answer all questions, omissions were few, never exceeding 5% of responders. Appendix V c shows actual proportion of responses.

Almost all responses to this questionnaire were highly positive. One exception was the continuing number of teachers claiming not to use IMS activity pages (item 6).

Because of this finding teacher training procedures were revised to give greater emphasis to activities.

Item 19 shows that a large majority of teachers believed IMS more effective than the textbook approach across a wide variety of situations. When taking all aspects of effectiveness into consideration (item 20) over 91% preferred IMS over the textbook approach.

Evaluation of Workshops

Three workshops for teachers and one for principals were held during the summer of 1970. At the conclusion of each workshop, the anonymous questionnaire, IMS Workshop Evaluation Form, was administered. A total of 131 responders filled out this instrument.

Of the 39 items, the first 27 lent themselves to an ordinal scale, 1 for the least positive response through 5 for the most positive. The average response over these 27 items and the 131 responders was 4.15. Accordingly, almost all participants chose very complimentary responses to these items. There was little difference from one workshop to another. The latter items, while not readily scalable, were also answered in a highly complimentary fashion. For example, only one responder said he would not recommend the workshop to others (item 38). The open ended questions were answered by most responders with no negative remarks.

While these results were reassuring, the matter of teacher training was pursued further through Teacher Surveys. Teacher Survey #1 asked if the respondent had attended an IMS workshop but failed to clarify whether it was one of the "official" workshops given by the IMS staff in the summer of 1970. Questions 2, 3, and 4 of the Teachers Survey #2 were included to clarify this situation with results as follows:

Quest. #2, 3-Type of Training	Question #4 Preparation Adequate? Yes	No	Omit
IMS Summer '70 Training	45	18	5
Other training for IMS	38	20	4
No Formal Training	20	30	13

As seen from the table the porportion of teachers who felt unprepared was much higher among those with no formal training. Discounting omissions, 60% of those with no formal training felt inadequately prepared, versus only 29% of those with IMS training and 34% of those with other formal training or experience. However, the fact that 29% of those with IMS training felt inadequately prepared was considered an indication that training procedures could be improved.

To investigate this matter further, each of the 23 teachers who answered negatively or omitted the question on adequacy of training by IMS was contacted by letter. A copy of the original IMS Workshop Evaluation Form was enclosed, and the respondent was asked to fill it out again in light of the year's experience.

Thirteen teachers responded, and the replies were highly consistent, though from a number of different schools. All 13 claimed that the main weakness of the workshops was insufficient attention to the IMS materials themselves. They found themselves unable to recognize and use the materials effectively when confronted with the actual classroom situation. Most recommended having the teachers go through the same steps as the students during the workshop or establishing demonstration classes with which workshop participants could interact. This outcome was reported to the IMS staff, and workshop plans for the summer of 1971 were changed to include more opportunities for participants to work directly with IMS materials.

Cost Data

Records were maintained by the IMS staff covering all aspects of production, teacher training and monitoring. Two outcomes may be noted as a result of analyzing these data. A proposal was submitted to the National Science Foundation for training of 500 teachers to use IMS during the 1971-72 school year. The budget for this proposal, which was subsequently funded, was based on cost data for earlier workshops. Monitoring services were included in this budget.

The cost of the materials themselves was established at approximately $10 per student for the first year's stocking. Revisions and replacements during the subsequent four years were estimated to cost $1.50 per student per year. Thus the total five-year cost was estimated to be $16 or $3.20

per student per year. This cost might be expected to vary according to circumstances - the need to stock buildings or floors of the same school separately, or large quantities of lost or damaged materials.

The estimated cost of $3.20 per student per year did not cover items provided locally, such as carts, supplies and manipulative materials (counters, games, scales, measuring devices, etc.).

Monitoring Activities

The IMS staff made about 30 monitoring visits during the course of the year. Many of these visits were for the purpose of dealing with specific problems, such as training new teachers, alleviating supply difficulties, etc. However, for all visits, detailed records of what transpired and of the monitor's impression were maintained.

Without question, these visits served to make IMS more effective during the course of the year. For subsequent years, two observations came through quite clearly in the various monitor reports:

1) Teacher training is vital to the success of the program. Almost every teacher problem encountered was the result of lack of training. (It should be noted that about one-third of the teachers using IMS in 1970-71 had no formal training.)
2) Strong administrative support of the program is a big factor in its success. Teachers can carry

a large share of the burden, but supply shortages and scheduling inconsistencies can scuttle their best efforts. Also, principals may have a large effect on parents' acceptance of the program.

Manipulative Materials Usage

The greater part of an EC meeting was devoted to discussing manipulative materials usage. Before the meeting EC's had collected data on this phase of IMS and filled out the Supplies and Materials Questionnaire (see Appendix II). This questionnaire was based on the Suggested Materials List for IMS (Appendix I), which had been provided to schools. The purpose of the meeting and data collection was to determine the need for revision of this list.

The results are somewhat inconclusive. Every item in the "supplies" category was reported in use in at least some schools, though some much more frequently than others. Apparently supplies usage is highly idiosyncratic from school to school. What effect this may have on progress within IMS remains undetermined.

In the "purchased materials" category there was similar lack of uniformity. A number of EC's expressed the need for items they had requested but never obtained. Pan balance scales was the most frequently mentioned item in this respect. Clocks with articulated hands were also mentioned as needed but unavailable. Only eight schools reported the presence of an abacus, but six of these reported it not well used.

One of the two remaining starred this item as the single most valuable manipulative. All schools agreed that centimeter rods were absolutely essential to IMS.

A number of suggestions were received for home made manipulative materials. These were turned over to IMS personnel for transmission to new schools.

First Grade Usage

Almost an entire EC meeting was devoted to the subject of IMS in the first grade. Some of the EC's brought first grade teachers experienced in IMS at their schools. Out of this discussion came several suggestions for the use of IMS in first grade.

All present teachers agreed that a school has to plan for aides, volunteer or paid, if IMS is to be successful in first grade. It is a necessity to have at least one aide in each room during the math period. More aides are desirable in order to have a smoothly running program. Morehead Elementary School, in Durham, North Carolina, had five aides in the first grade classroom when it started on IMS. By the end of the year they had reduced the number to three. If it is impossible to get the aides needed, some teachers suggested having the good readers help slow readers or getting fifth and sixth grade students to come in during the math period to help.

EC's and first grade teachers also agreed that the math period should be longer than 30 minutes. Otherwise, by the time the students are organized and have their materials, there is little time left for actual work. The suggestion was made to have three 50 minute periods a week rather than five 30 minute periods.

Screening must be done, and the brightest students should be started in IMS first. At Deep Creek Elementary in Chesapeake, Virginia, the students were to be screened at the end of the kindergarten year, so that those ready could start IMS at the beginning of first grade.

A preparation program should precede actual work in IMS. It is necessary to get the students acquainted with the materials, vocabulary, and the operation of IMS. The students should be allowed to look at and handle all the materials. They should be instructed in the sequence of activities in IMS. The knowledge of the vocabulary of IMS is essential to the system's success. Many teachers suggested that the parents who are able should help the students at home with the new vocabulary. This would take some of the burden from the teacher and also would involve the parents and acquaint them with the system.

A total of fifteen first grade classes used IMS materials during the course of the year. However, a number began somewhat late and in several only a minority of students participated. At Urbania approximately 30 first grade students participated. Their initial placement resulted in a mean average IMS level of 1.61. By the year's end, this mean had risen to 1.96 for a rather small gain of .35.

At Academia Elementary, 46 first grade students began at about the same point in IMS (mean of 1.64) but covered, on the average, 1.24 levels of IMS. Both groups were considered somewhat above average in ability and both spent about the same amount of time with IMS during the year. This set of results, while not extensive, does illustrate that substantial differences in progress can arise, apparently due to the way the system is managed.

Chapter VI

Revision of Materials

Skill Folder Revision

Revision data arise from several sources:

Incident Reports

Reports by Consultants

Questionnaire Responses

Posttest Outcomes

To some extent all of the above have been reported earlier. It is the purpose of this chapter to lend some unity to these diverse results. In addition, the progress made toward revision will be cataloged, and recommendations for further revision will be made.

Mid-year Revision

Teacher Survey #1 asked responders to list the skill pages or tests they felt needed immediate revision. The following skill folders had pages mentioned substantially more often than any others:

Multiplication I, Skill 2

Multiplication II, Skill 6

Measurement II, Skill 1

Division II, Skills 2, 3

Time III, Skills 2, 3

Based on teachers' descriptions of the difficulties encountered, revised versions of these skill folders were written and tried with students at Morehead Elementary School in Durham. Further revisions were made following this testing.

Though resources were limited, 12 revised sheets (24 pages) were laminated and sent to schools. These pages were in Measurement II and Division II and, it is believed, cleared up the worst difficulties in these folders. The difficulties in Multiplication I and II and in Time III were more pervasive. It was recommended to all schools that students be helped through these skills without the usual requirements for posttesting.

End of Year Revision

In addition to revisions already made in Multiplication I and II and Time III but not distributed, a large number of changes were recommended through Incident Reports. Many of these were simply corrections of errors due to oversight. By way of more than 300 incident reports and the inspection of all pages not already revised, approximately 250 pages were corrected or revised.

In addition to revision just described, all folders of Fractions II and VI were modified insofar as terminology and format were concerned. These changes were made by the writing staff for IMS-2, the CIIS junior high school program. This group was also completing Levels VII - IX of IMS and made the changes in Fractions V and VI to accomodate the approach they had adopted for presenting Fractions VII - IX.

Revision described thus far completed the process insofar as preparation of materials for the 1971-72 school year is concerned. Schedules were established to arrange for replacement of part of these revised pages in the 1970-71 schools. In some cases, however, the revision was too trivial to warrant the replacement. In addition to the five folders listed earlier, approximately 80 sheets (160 pages) were recommended for replacement in the present schools.

Revision to be Completed

Revision work yet to be complete falls into two categories. The first covers the materials of Levels VII - IX. As mentioned earlier, these materials were not completed in time for use by students during the 1970-71 school year. Further, the developing and editing of these materials was done by the IMS-2 junior high school writing staff and represents a substantial departure in style and approach from the earlier materials. Story lines have been introduced in many folders so that prescription of isolated pages is no longer possible. (The student must go through the folder from front to back to preserve continuity and understand the context.) Also, substantially more reading material has been introduced (sometimes unavoidably). The new materials are more "discovery" oriented and less didactic.

In view of the foregoing, no assumptions should be made regarding the materials of Levels VII - IX based on experience from the first six levels. A full scale review and revision process is recommended based on the model established for evaluating the first six levels.

The second incomplete area with respect to revision is the parts of Levels I - VI not covered above. Analysis of posttests came too late in the school year to permit acting on many changes indicated thereby. Chapter III lists all posttest items which indicate a need for revision. In many of these cases, it is the test itself which should be revised rather than the related materials. Most materials problems covered by test analysis are the results of insufficient provision of practice for certain kinds of problems.

The critique of the materials by Dr. Joseph Scandura (Appendix IXa) also calls for a number of revisions in Levels I - VI. Many of these suggestions overlap changes already made and changes indicated by posttest analyses. Further, whether some changes should be made is a matter of choice to be resolved by the IMS staff. Other changes listed in Appendix IXa are hardly debatable.

Chapter VII

Summary and Recommendations

Attainment of Goals

The IMS Formative Evaluation Plan (on which this study was based) listed a number of goals. The plan also specified the bases for facilitating and measuring the attainment of these goals. The extent to which the goals were attained has been presented in earlier chapters; it is the purpose here to identify these goals more specifically and to summarize and interpret the results presented earlier.

It must be emphasized with respect to all that follows that only the first six levels of IMS are covered. Only very limited conclusions regarding the latter three levels may be inferred from results presented here.

Goal 1: The IMS Behavioral Objectives and materials are satisfactory from the standpoint of mathematical correctness and consistency and preparation for further study in mathematics.

The main basis for determining the extent to which this goal was attained is the report by Scandura (Appendix IX a). Scandura reports a small number of minor inconsistencies and errors but views these as superficial rather than basic faults. No entire skill folders or lines of development linking folders were found deficient. A number of those errors he cited were corrected in the normal course of revision, but others remain to be corrected. Correction of a small number of deficiencies cited by Scandura depends on editorial rather than mathematical considerations.

Goal 2: IMS Behavioral Objectives and materials are satisfactory from the standpoints of learning theory and the study of child development.

The report by Gagné (Appendix VIII) concerns itself primarily with this goal. In general his conclusion is strongly affirmative to the effect that the goal has been met. The discussion in Gagné's report regarding the desirability of a more hierarchical sequence of skills (depending on what the individual student has previously mastered) is not intended to imply a deficiency in the present system. Rather it is a recommendation for further development should funds for so substantial a project become available.

Gagné suggests that testing may play too prominent a part in the present system. That it could, if misapplied, is readily acknowledged by the developers of IMS. However, many features of the teacher training program are designed to promote constructive use of testing. This topic is discussed in more detail on page 68.

Goal 3: The learning materials and teaching aids are attractive.

That this goal was met can be stated without qualification. Moreover, similarity of style and format probably means that the conclusion will hold for the latter three levels as well as the first six. Out of 196 teachers responding to a questionnaire item regarding this goal, 195 answered positively. On a less systematic note, the IMS artists received dozens of spontaneous letters of appreciation from students using the materials.

Goal 4: Providing activities and work pages assists the pupil in achieving curriculum goals more than work pages alone.

In an early research proposal, it was planned that actual use of activities by students be recorded to permit comparison of achievement with that of students for whom no activities were prescribed. The funding agency did not approve that proposal, holding the procedures too extensive and costly. Therefore, in the presently reported research, it was necessary to rely on teacher opinion regarding the efficacy of activities. The situation is further complicated by the fact that activity pages for Levels III and IV were not distributed until mid-year; those for Levels IV and V were not completed in time for use by students. Further, 52% of teachers claimed not to have used available activities (Teacher Survey #3), no doubt for a variety of reasons, some valid, some invalid. This result is viewed largely a failure of teacher training or the result of no teacher training in some cases, and yields recommendations regarding further teacher training (see pages 75-76).

At the end of the year, 92% of the teachers who had used activities agreed that they enhanced achievement over that based on skill pages alone.

Goal 5: IMS learning materials and teaching aids are pedagogically sound.

Throughout the year, teachers forwarded reports of unsatisfactory student responses or reactions to materials. These reports were tabulated and summarized to locate problem areas. In addition, teachers were asked on two occasions to list pages or skill folders they thought should be revised. The areas reported by substantial numbers of teachers were not extensive and resulted in a moderate number of revised pages (see Chapter VI).

In answer to several direct questions on Teacher Survey #3 (Appendix V c) regarding the pedagogical soundness of the materials, 71% to 99% of teachers responded positively.

Goal 6: IMS teacher training materials are effective.

Goal 7: IMS teacher training procedures can be accomplished in an average of 15 hours of instruction.

The broader issue with respect to these goals is the overall effectiveness of the IMS teacher training program. As reported earlier (page 77), approximately one fourth of those trained found the training inadequate, citing lack of opportunity to become familiar with the IMS instructional materials as the primary fault. To alleviate this problem, new teacher training sessions were redesigned to allow more contact with materials. Both the original and revised schedules for these sessions cover about 15 hours of presentations on three days. The success of the change remains to be seen.

With respect to Goal 6, a specific item explored this question on Teacher Survey #3 (Appendix V c). Of those trained by IMS, 86% responded positively. In interpreting this outcome, IMS personnel believed it may have been influenced by the dissatisfaction referred to above rather than perceived inadequacy of the training materials themselves. Also, the question may have been misinterpreted as referring to availability of instructional materials. Apart from the preceding, there was other evidence of inadequate teacher training. However, it is impossible to separate these instances according to whether the teachers involved were among the 35% trained by IMS. Reports by monitors, EC's, principals and others concerned:

Failure to let students take responsibility for their own learning.

Misapplication of testing procedures.

Failure to prescribe activities.

Failure to vary prescriptions according to pre-test results and student characteristics.

In most cases these deficiencies were corrected during the course of the year. Nevertheless, regardless of their source, they strongly imply the need for a thorough and careful teacher training program.

Goal 8: The stocking procedures recommended by IMS provide adequate supplies of materials to meet pupil needs.

Teacher Survey #2 (Appendix V b) revealed that approximately 25% of teachers continued to experience supply difficulties as late as March of the school year. All such problems were investigated. The results of these investigations and study of levels and rates of pupil progress within the system yielded revised stocking strategies for subsequent installations.

Goal 9: IMS tests have good psychometric properties.

Chapter II discusses in detail the results of investigation with respect to this goal. In addition, the tests were examined by experts in the field of mathematics and learning theory. In summary, it may be said that, except for isolated inadequate items, the tests are of very high quality. This conclusion is further supported by the almost complete absence of Incident Reports or other evidence of general difficulties concerning testing. A number of Incident Reports concerned isolated errors (later corrected), but generalized problems were not found.

Goal 10: Cost of IMS materials is $10 per pupil or less for schools of moderate size or larger.

As presented in Chapter V, this goal was met with respect to schools entering IMS in the fall of 1971. Cost of IMS materials over a five-year period was estimated at $3.20 per student per year.

Goal 11: IMS materials are sufficiently durable to be reusable.

As related to cost estimates, the projected period of reusability is five years with replacement (due to wear) of about 2% per year. No evidence from using schools indicated a likelihood of exceeding this allowance. Further, on Teacher Survey #3 (Appendix V c, item 9) only 8% of teachers expressed negative reactions with respect to durability.

Goal 12: Students take responsibility for operation of the system. (50% of fourth grade students write their own prescriptions.)

Statistics from Teacher Survey #2 (Appendix V b) give strong evidence that this goal was attained. These results are reviewed in Chapter III, pages 44-46. Reviewed in Chapter IV is perhaps the more important finding that success in mathematics achievement seems positively related to the degree of student participation in operation of the system (see Inter-School Differences, page 61). However, it was the concensus that aides are required to introduce IMS in the first grade, and the preceding comment does not cover IMS usage at this level.

Goal 13: Students achieve the Behavioral Objectives at the rate of one IMS level per school year on the average.

Since the average student using IMS in 1970-71 covered 1.28 levels of IMS, there is every reason to believe this goal was attained. Especially since this goal was made in less than a full year. Further, the apparently good psychometric properties of the tests used to certify progress within the system lends confidence to this conclusion. With greater familiarity with the system on the part of teachers and students, progress rates may increase.

Goal 14: Students at and above grade level on standardized normative tests at the beginning of the school year gain an average of a one year grade equivalent score by year's end under IMS.

This goal was not met during the first year of operation for students at and above grade level. Instead, students six months below grade levels or lower had score gains equal to approximately a one year grade equivalent score change. This surprising outcome is attributed to the fact that brighter students were, on the average, assigned to work far below grade level based on the mastery levels they could demonstrate at the beginning of the school year. As a result of this discrepancy, they spent all or the bulk of the year mastering below grade level topics formerly learned more superficially. This apparently superficial learning did not hamper performance on the standardized tests but resulted in low IMS placement and prevented their reaching new topics during the year. The discrepancy for below grade level students as measured on standardized tests was not nearly so great, and these students' grade equivalent change scores were consequently much higher. This entire phenomenon is discussed in great detail in Chapter IV pages 50 - 60 and represents a major outcome of the research reported herein.

With respect to the future, there is every reason to believe that brighter students will regain their positions with respect to grade level topics after a one to two year "catching up" period. Their progress rates within IMS were much greater than those of below grade level students. Therefore, the apparent deficiency in achievement should vanish for brighter students. Use of IMS beginning in the first grade should prevent this problem from developing.

Recommendations for Further Research

The primary questions remaining to answer concern Levels VII, VIII, and IX. As these levels come into use during 1971-72, the same goal areas just presented need to be investigated with respect to the new materials. This extended verification of system characteristics is important because the new Levels VII, VIII and IX differ in certain respects from the earlier levels. For a brief discussion of these differences, see page 87.

In addition to monitoring the use of the new materials, it is recommended that data continue to be collected with respect to Levels I - VI, though perhaps on a smaller scale than reported herein. Questions which might be answered by this investigation are:

1. To what extent have revisions been successful?
2. What rates of progress within IMS are observed as students and teachers become more familiar with the program?

3. What changes in standardized test scores are observed for above grade level students as these begin to "catch up" to grade level topics within IMS?

It may be noted at this point that questions regarding effectiveness of changes in teacher training procedures will be investigated through a grant from the National Science Foundation. The primary purpose of this grant is to train approximately 500 teachers for expanded use of IMS. Provision is made for evaluation of the training, especially with respect to questions raised in this report.

Several areas of investigation were not possible during 1970-71 due to lack of resources. These include:

1. Systematic observation of classroom activities to determine proportion of time usage in various categories, such as waiting for materials, taking tests, working with learning pages, participating in activities, etc. Findings of disproportionate time usage could have implications for many aspects of the system.
2. Study of individual uses of learning materials would show the relative effectiveness of various prescription and materials usage styles for different types of students. Such a study could lead to changes in materials and recommendations regarding prescriptions.
3. Materials could be further upgraded by an observational study of classroom difficulties encountered

by students. Teachers complained at times of the number of trivial questions asked by students who ha' trouble interpreting materials. While some of this problem may be endemic in all groups of children, certain materials in IMS may aggravate it. If these materials could be identified and revised the system might be improved substantially.

The foregoing do not exhaust the possibilities but are presented to show the broad areas of possible further research. In some respects this research and effecting changes therefrom will be increasingly difficult as IMS becomes more widely used. The cost of revision materials for 23 schools is much less than for 150 or 1500. Therefore, this report is concluded with a plea for support for continued research. IMS has shown itself to be a high quality, robustly successful system; it can attain even higher levels of excellence through systematic application of results reported herein and those from further research studies.

Appendix I

Suggested Materials List for IMS

Suggested Materials List for IMS

Materials have been divided into four classes:

A. Supplies--includes general office and school supplies normally already included on school purchase orders.
B. Math materials to buy--includes items that are specifically math oriented.
C. Materials to make--includes cards used in activities.
D. Materials to bring from home.

Items are listed in alphabetical order. In some cases, suppliers are listed from whom the materials may be purchased. A list of suppliers whose catalogs will be helpful is included. Some materials listed under "Materials to Make" may possibly be bought, while materials listed under "Math Materials to Buy" may be constructed. Starred items are considered essential to IMS.

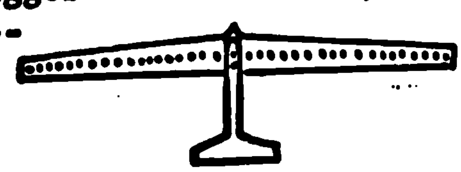
A. Supplies

Ball
Calendar
Chalk
Construction paper
Crayons or pencils
Graph paper
Gum labels
Index cards (see Materials to Make)
Magnet
Magic Marker
Masking tape
Mirror
Newsprint
Oaktag
Overhead or Opaque Projector
Paper clips
Paste
Pipe cleaners
Plasticine
Rope
Ruler
Scissors
String or yarn
Test tube
Yardstick

B. Math Materials to Buy (incomplete in upper levels and geometry)

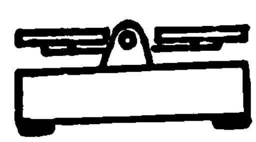
* essential to IMS

Abacus (suggest H & M Assoc.)
Ascoblocs (suggest H & M Assoc.)
Attribute blocks--pattern blocks and colored string may be used.
(suggest Webster Div., McGraw-Hill)
Automatic calculator (suggest SEE)
Beads--to string (suggest Ideal)
Building blocks (suggest Play Skool)
* Centimeter rods (suggest Cuisenaire)
* Clock--hands should move with synchronization
Counters--may be bought or collected--beans, corn, stones, etc. (suggest Ideal, Milton-Bradley)
Dice--or paint dots on cubes
Dienes blocks (suggest Herder & Herder)
Drum and drumstick
Flannel board or magnetic board (suggest Ideal)
Geoboard and elastics (suggest Cuisenaire or H&M)
* Liquid measuring kit--should be plastic and include cup, pint, quart, gallon (suggest REC)
Mirror cards (suggest Webster Div., McGraw-Hill)
* Number balance--



numbers to 18 if available.
(suggest SEE)
* One-inch colored cubes (suggest McGraw-Hill)
* Pan-balance scale-- suggest

in preference to



(suggest SEE)
Pattern blocks--(suggest SEE or McGraw-Hill)
Pegs and pegboard (suggest H&M)
* Play money--include coins (suggest Ideal, Milton-Bradley)
Primary ruler (suggest SEE)
Primary shapes (suggest H&M)
Stick counters, popsicle sticks, or toothpicks can be used.
* Unifix cubes--pop beads may substitute but one or the other is needed.
(suggest REC)
Walk-on number line--may be made out of oilcoth or floor tiles.

C. Materials to make

The following cards are used only in activities. They may be made as the activities are used, may be pre-constructed, or in some cases, may be bought. The method used to make the cards would have an effect on the supplies list. Index cards, or heavy grade paper that is cut, may be used.

CARDS: (suggest Ideal and Milton-Bradley)

ADDITION-SUBTRACTION STATEMENT--problem statements indicated either by "+" or "," with or without sums or differences:

[5, 2 → 7] [5, 2] [5 - 2 =]

ARROW CARDS--for use with 1-100 number chart:

[↑ 1] [→ 3] [↓ 2] [← 1], etc.

ASSIGNMENT CARDS--cards with two sets of dots: [o | oo]

CLUE CARDS--use number 1-6 for each direction:

[up 1] [down 1] [left 1] [right 1] [move 1]

DAILY ACTIVITY CARDS--showing activities relating to specific days of the week, e. g., church on Sunday, etc.

DOLL CLOTHER DOT CARDS--numbers and sets to 10:

DOT CARDS--cards showing dots, one to ten:

[o] [oo] [ooo]

FRACTION CARDS--including [1/4] [1/2] [1/3] [1]

MONEY CARDS--cards showing pictures of coins and groups of coins.

MULTIPLICATION COMMUTATIVE--front has: [6 (2's)], back has [2(6's)], etc.

MULTIPLICATION-DIVISION STATEMENT--see Addition-Subtraction.

MULTIPLICATION PICTURE CARDS--pictures in set groupings on front (: : :), with designation of ___ sets of ___ each on back.

NUMERAL CARDS--one numeral per card.

Frequency of use:

numerals 1-10	71 times
numerals 1-25	33 times
numerals 1-100	10 times
numerals 10, 20...	1 time
stand-up numerals (1-10)	6 times

ONE MORE-ONE LESS CARDS-- [1 more] [1 less]

ONES, TENS CARDS-- [ones] [tens]

OPERATION CARDS-- [+] [-] [=] [plus] [equals]

[minus] [>] [<]

ORDINAL CARDS--ordinal numbers, first-tenth.
PICTURE CARDS--with circled subgroups

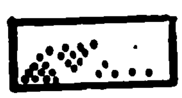
 ; or word-situation problems

PLAYING CARDS--regular cards with honors (king, queen, etc.) removed.
PUZZLE CARDS--pieces that fit together to match numeral with corresponding set pictures.

(suggest Jigsaw numerals, SEE)
RAISED OBJECT CARDS--sets of objects 1-10, with felt, sandpaper, etc. pasted.
SET-PICTURE CARDS--sets showing numbers 0-10, with corresponding pictured shapes or objects.

[3 xxx]

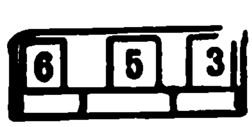
STRUCTURED GROUP CARDS--shows structured groups to 25.



WORD-NUMBER CARDS-- [one], [two], through [ten].

Additional materials to make.

DESK NUMBER LINE--paper strips number 1-10 for Level I, 1-18 for Level II, etc. Masking tape may be stuck to desk for more permanent type. (suggest Ideal)
MONEY TRANSPARENCIES--for overhead projector. Shows pictures of coins.
NUMBO CARDS--similar to Bingo cards. Numbers vary with activity.
POCKET CHART--for display purposes. Library pockets may be glued to a large tagboard.
SHOW-ME CARD POCKET--consists of tagboard folded and stapled with room for three numeral cards to be displayed.



D. Materials to bring from home

Bottles and jars
Buttons
Candles
Clothespins
Coat hangers
Egg cartons
Kitty litter
Magazines and catalogues
Milk cartons
Paper boxes or crates
Paper cups
Paper plates
Plastic eating utensils
Sand
Toys

SOURCES OF MATERIALS

Cuisenaire Company of America, Inc.
12 Church Street
New Rochelle, New York 10805

Educational Development Center
55 Chapel Street
Newton, Massachusetts 02160

Herder and Herder
232 Madison Avenue
New York, New York

H & M Associates
Math Media Division
P.O. Box 1107
Danbury, Connecticut 06810

Ideal School Supply Company
Oak Lawn, Illinois 60453

Webster Division
McGraw-Hill Book Company
Order Service Department
Manchester Road
Manchester, Missouri 63011

Responsive Environment Corporation (REC)
Learning Materials Division
Englewood Cliffs, New Jersey 07632

Selective Education Equipment, (SEE)
3 Bridge Street
Newton, Massachusetts 02195

Selsco
5100 West 82nd Street
Minneapolis, Minnesota 55431

Appendix II

Supplies and Materials Questionnaire

SUPPLIES AND MATERIALS QUESTIONNAIRE

SCHOOL ____________________

SUPPLIES

Please check (✓) each of the following that is used in your school in connection with IMS. Put two checks (✓✓) if you think an item is of particular importance or is used in substantial quantity.

____Ball
____Calendar
____Chalk
____Construction
____Crayons or pencils
____Graph paper
____Gum labels
____Index cards
____Magnet
____Magic Marker
____Masking tape
____Mirror
____Newsprint
____Oaktag
____Overhead or Opaque projector
____Paper clips
____Paste
____Pipe cleaners
____Plasticine
____Rope
____Ruler
____Scissors
____String or yarn
____Test tube
____Yardstick

PURCHASED MATERIALS

Item	Available				Well used	
	Yes	No	Number	Brand	Yes	No
Abacus						
Attribute blocks						
Automatic Calculator						
Beads--to string						
Building blocks						
* Centimeter rods						
* Clock						
Counters						
Dice						

Item	Available Yes	No	Number	Brand	Well used Yes	No
Dienes blocks						
Drum and drumstick						
Flannel Board or magnetic						
Geoboard and elastics						
* Liquid measuring kit						
Mirror cards						
* Number balance						
* One-inch colored cubes						
* Pan-balance scale						
Pattern blocks						
Pegs and pegboard						
* Play money						
Primary ruler						
Primary shapes						
Stick counters						
* Unifix cubes						
Walk-on number line						

* essential to IMS

Please list other purchased items below:

____

____

HOME MADE MATERIALS

Please list below home-made or improvised materials such as drill cards for number facts, fractions kits, egg cartons, milk cartons, kitty litter, etc., that are used profitably with IMS at your school. Continue on back of page.

____

____

Appendix III

Workshop Evaluation Form

I M S

WORKSHOP EVALUATION FORM

KEY: SA (Strongly Agree), A (Agree), ? (Undecided), D (Disagree), SD (Strongly Disagree)

1.	The objectives of this workshop were clear to me.	SA	A	?	D	SD
2.	The objectives of this workshop were realistic.	SA	A	?	D	SD
3.	The participants accepted the purposes of this workshop.	SA	A	?	D	SD
4.	The objectives of this workshop were the same as my objectives.	SA	A	?	D	SD
5.	I have not learned anything new.	SA	A	?	D	SD
6.	The material presented seemed valuable to me.	SA	A	?	D	SD
7.	I could have learned as much by reading a book.	SA	A	?	D	SD
8.	Insufficient attention was given to problems which might be encountered in installation of IMS.	SA	A	?	D	SD
9.	The information presented was too elementary.	SA	A	?	D	SD
10.	The speakers really knew their subject.	SA	A	?	D	SD
11.	I was stimulated to think about the topics presented.	SA	A	?	D	SD
12.	We worked together well as a group.	SA	A	?	D	SD
13.	The group discussions were excellent.	SA	A	?	D	SD
14.	There was little time for informal conversation.	SA	A	?	D	SD
15.	I had no opportunity to express my ideas.	SA	A	?	D	SD
16.	I really felt a part of this group.	SA	A	?	D	SD
17.	My time was well spent.	SA	A	?	D	SD
18.	The workshop met my expectations.	SA	A	?	D	SD
19.	Too much time was devoted to trivial matters.	SA	A	?	D	SD
20.	The information presented was too advanced.	SA	A	?	D	SD
21.	Too much time was spent on theory.	SA	A	?	D	SD
22.	The schedule should have been more flexible.	SA	A	?	D	SD
23.	Objectives to be achieved were clearly stated at the beginning of the workshop.	SA	A	?	D	SD

24. Objectives of the workshop were achieved. SA A ? D SD

25. The presentations of the workshop coordinators were necessary for the achievement of the objectives. SA A ? D SD

26. Not enough time was spent practicing skills learned in the workshop. SA A ? D SD

27. Materials provided were helpful in the learning of IMS procedures and principals. SA A ? D SD

28. In general, sessions held each day were:
a) too frequent b) about right c) too infrequent

29. In general, the sessions held each day were:
a) too long b) about right c) too short

30. The background you brought to the workshop as compared to the amount of background presupposed by the presentations and source materials was:
a) much greater b) somewhat greater c) about the same
d) somewhat less e) much less

31. How many opportunities were there for you to interact with the instructors of the workshop to get individual attention?
a) a great many b) some c) few d) none

32. How many opportunities were there for you to interact with the other workshop participants?
a) a great many b) some c) few d) none

33. To what extent do you feel that your understanding of behavioral objectives has been increased during the workshop period?
a) a great deal b) some c) little d) none

34. To what extent do you feel that your understanding of IMS has been increased during the workshop period?
a) a great deal b) some c) little d) none

35. Rate yourself on the amount of confidence you have in being able to teach the IMS mathematics program in your school.
little ___ ___ ___ ___ ___ much

36. The objectives of the workshop could have been attained best by:
a) present method b) more lectures c) more programmed material

37. If you had to do it over again, would you participate in this workshop you have just completed?
a) yes b) no c) not sure

38. If a workshop such as this is held again, would you recommend to others like yourself that they attend?
a) yes b) no c) not sure

39. In terms of learning the content of this session, the length of this workshop period was:
a) too long b) about right c) too short

40. To what extent were the objectives of this workshop attained?

41. What other objectives should be included for future workshops?

42. In your opinion, what were the major strengths of this workshop?

43. In your opinion, what were the major weaknesses of this workshop?

44. Additional comments about this workshop:

Appendix IV

Monitor Report

INSTALLATION MONITOR REPORT*

SCHOOL: ______________________ PRINCIPAL: ______________

CITY: ______________________ DATE: ______________

PURPOSE: ____

____

____

I. Observations:

A. Teachers ______________________________________

____

____

B. Aides ______________________________________

____

____

C. Students ______________________________________

____

____

D. Materials ______________________________________

____

____

E. General ______________________________________

____

____

II. Suggestions to RELCV:

A. ______________________________________

____

____

* Subject to further development

II. Suggestions to RELCV (cont.):

B. ____

____

____

____
Monitor

Appendix V a

IMS Survey #1

IMS SURVEY #1

NAME TOTAL RESPONDANTS = 178*

SCHOOL

GRADE

* 4 1st grade	33 3rd grade	35 5th grade	4 no grade given
38 2nd grade	40 4th grade	24 6th grade	

# of Omissions PERSONAL DATA

Responses hereafter are for the 175 "yes" respondants to question 1.

) 1. Are you using IMS in your classroom now? Yes 175 No 1

) 2. Total years of teaching experience: 10.8 average

) 3. Prior experience with IMS: 6% Yes 94% No

) 4. Prior experience with IPI or other individualized mathematics system: Yes 13% No 87%

) 5. Highest degree held: Bachelors 83% Masters 17% Doctors ____

) 6. Background in mathematics:

Average for an elementary teacher ____

Above average ____

Below average ____

1 = below average
2 = average
3 = above average
average response = 2.20

) 7. Do you feel your math background is satisfactory for teaching with IMS? Yes 95% No 5%

) 8. Did you attend an IMS Workshop? Yes 44% NO 56%

If your answer to #8 is "No," how many hours of formal training in IMS procedures have you had? 8 hr. average

) 9. Do you have a teacher aide for work with IMS? Yes 88% No 12%

If your answer to #9 is "No," and you feel you need one, please list the duties you think the aide should perform:

IMS GOALS

IMS has been developed to achieve a number of goals. Some of these are listed below. Please indicate whether or not IMS has achieved these goals, based on your experience to date. It is understood that your opinions may be only tentative at this point. You may omit items if you have no basis for giving an opinion.

(3) 1 The learning materials are attractive.

100% Agree

____ Disagree

Suggestions for improvement:

(19) 2. The use of graphics makes IMS interesting to pupils.

98% Agree

2% Disagree

Suggestions for improvement:

(18) 3. The availability of concrete, pictorial, and abstract presentations for teaching the same objectives permits the accommodation of individual differences.

97% Agree

3% Disagree

Suggestions for improvement:

(5) 4. [illegible] enjoy working with IMS materials.

99% Agree

1% Disagree

Suggestions for improvement:

(18) 5. The teaching aids are attractive.

99% Agree

1% Disagree

Suggestions for improvement:

(34) 6. The provision of activities as well as work sheets permits the teacher to assist the pupil in achieving curriculum goals.

86% Agree

14% Disagree

Suggestions for improvement:

(5) 7. IMS teacher training materials are effective.

86% Agree

14% Disagree

Suggestions for improvement.

(17) 8. The supply of IMS materials in my school is adequate to meet pupil needs.

51% Agree — Suggestions for improvement:

49% Disagree

(11) 9. IMS materials are sufficiently durable to be reusable.

97% Agree — Suggestions for improvement:

3% Disagree

(8) 10. IMS laminated materials are easy for pupils to use.

95% Agree — Suggestions for improvement:

5% Disagree

(51) 11. Pupils in the higher grades can assume many of the responsibilities which normally require the assistance of a teacher aide.

91% Agree — Suggestions for improvement:

9% Disagree

(22) 12. IMS enables the teacher to spend more time giving individual mathematics assistance to pupils.

72% Agree — Suggestions for improvement:

28% Disagree

(4) 13. Pupils are able to score accurately their own tests.

12% Agree grades 1-3 | 62% grades 4-6 | Suggestions for improvement:

88% Disagree | 38%

(19) 14. Pupils clean and replace the materials without assistance from the teacher.

83% Agree | Suggestions for improvement:

17% Disagree

(9) 15. IMS procedures for keeping track of pupil progress provide the teacher with an accurate picture of each student's achievement at any point in time.

97% Agree | Suggestions for improvement:

3% Disagree

16. The training you received prior to starting the school year provided a sound basis for using IMS in the classroom.

63% Agree IMS workshop attendees | 41% non attendees | Suggestions for improvement:

37% Disagree | 59%

(73) 17. IMS is more effective than the system you used last year.

69% Agree | Suggestions for improvement:

31% Disagree

IMS Problems

If you have no basis for an opinion on an item, simply omit your response.

1. A Placement Test is needed for Level I to determine whether students should begin with Level II.

80) 84% Agree

16% Disagree

2. A Pretest is needed for Level I to permit more accurate prescription writing in Level I.

1) 91% Agree

9% Disagree

3. What is the prevalent student opinion of IMS?

1) 98% favorable

2% unfavorable

4. What is the prevalent parent opinion of IMS?

9) 73% favorable

27% unfavorable

. To what extent do parents understand IMS reporting of student achievement?

32% Almost all understand

68% A substantial number do not understand

. Do measurement activities involving use of string, hands, toothpicks, etc. work out well?

38% Yes

62% No

Do carts serve adequately for filing and keeping track of skill folders?

90% Yes

10% No

____ We do not use carts (this response counted as an omission)

Skill folder keys need to be reprinted full size.

61) 74% Agree

26% Disagree

9. Could some children in your class profit more from some math program other than IMS?

47% Yes — If yes, please describe characteristics:

53% No — **Almost all "yes" respondants cited difficulty and lack of drill for low ability students.**

10. Check the math program which:
(a) Is easier for the teacher to work with in the classroom

33) 26% IMS   74% conventional

(b) Requires less planning or other outside preparation by the teacher

36) 47% IMS   53% conventional.

11. Placement tests should not be laminated.

39) 50% Agree

50% Disagree

111) 12. To what extent should placement tests be given in second grade?

____ They should be given in all areas

____ No Placement Tests are needed

They should be omitted in some areas when children have no prior IMS experience and all are likely to fail.

1 = all areas
2 = some areas
3 = no 2nd grade placement
average response = 1.25

List areas: __________

13. Are lower level skill folders satisfactory for older children who need remedial work?

75) 91% Yes

9% No — If no, list skills that are noticeably bad in this respect (for example, Numeration II, Skill 2):

14. Does the "curved number line" approach in Time, Level II work so well?

(118) 42% Yes

58% No

15. What kind of writing instrument for the laminated sheets do you like best of those you have tried? (Please give brand name and model or identification number.)

16. What is your biggest problem with IMS?

Teachers find their time so fully occupied by answering procedural questions that they are unable to give individual instruction on mathematical problems. (It is hoped this problem will subside as children and teachers become more familiar with IMS.)

MATERIALS REVISION

It is our plan to reprint and redistribute during the course of the school year some of the skill pages or other materials that need revision. Please list below no more than ten skill folder pages or tests that need immediate revision. These should be the ones that cause the most trouble during the math period.

1. ____

2. ____

3. ____

4. ____

5. ____

6. ____

7. ____

8. ____

9. ____

10. ____

Appendix V b

IMS Survey #2

IMS SURVEY #2

Name ______________________________

School ______________________________

Grade ______________________________

Please answer all questions for which you have sufficient information. Some questions are similar to those of the previous survey in order to permit changes of opinion and responses by those who omitted earlier.

1. Are you using IMS in your classroom now?

   _____Yes

   _____No

2. Did you attend one of the regional IMS Workshops in Winston-Salem, Chesapeake, or Columbia held during the summer of 1970?

   _____Yes

   _____No

3. Did you have formal training or experience in IMS procedures other than that covered in 2 above?

   _____Yes, training conducted locally the summer before or during the school year by non-IMS personnel. How many hours of local training? _____

   _____Yes, experience and/or training from the prior school year.

   _____Yes, other. Please explain: ______________________________

   ____

   ____

   _____No formal training or experience prior to using IMS this year.

4. Was the preparation you had prior to teaching with IMS this year adequate?

   _____Yes

   No

5. Please check below any kinds of materials which have been or are not adequately supplied in your school.

In short supply now	Previously in short supply	
____	____	Special pens or pencils
____	____	Skill folders*
____	____	Manipulative materials

*Please list below the skill folders you find should be stocked more heavily in the carts:

____

____

____

6. In some cases, supply problems are related to local storage conditions. Please check if either of the following are problem areas in your school.

_____Lack of carts or storage space has caused problems.

_____School layout prevents efficient use of available materials.

7. In your grade, approximately what percentage of the children could score accurately their own check-up tests?

_____0 - 25% _____25 - 50%

_____50 - 75% _____75 - 100%

8. Do you encourage or require children to do any of the following tasks?

Approximately what percentage of your children actually do these tasks with reasonable success?

Yes	No		% Successful
____	____	Score skill pages	____
____	____	Score check-up tests	____
____	____	Score pre-tests	____
____	____	Write prescriptions	____
____	____	Obtain and return materials	____

9. Which of the following best characterizes student opinion of IMS?

_____Favorable

_____Mixed

_____Unfavorable

10. Which of the following best characterizes parent opinion of IMS?

_____Favorable

_____Mixed

_____Unfavorable

11. To what extent do you think parents understand certain features of IMS?

Almost all understand	Many do not understand	
_____	_____	Each student works at his own level.
_____	_____	Each student works at his own speed.
_____	_____	Completion of a level represents mastery, not exposure as in the textbook approach.

12. Do teachers need to keep a separate set of Guidelines at their desks?

_____Yes

_____No

13. Should keys be laminated?

_____Yes

_____No

14. Do you find IMS materials generally effective for helping students achieve the IMS Behavioral Objectives?

_____Yes, with the possible exception of: *Multiplication I, Skill 2; Multiplication II, Skill 6; Measurement II, Skill 1; Division II, Skills 2,3; Time III, Skills 2,3.

_____No

*These skill folders will undergo extensive revisions.

If other skill folders have proved particularly unsatisfactory please list them here:

Level	Strand	Skill
____	____________________	____
____	____________________	____
____	____________________	____

15. Does provision of activity pages in addition to work pages assist in achievement of IMS Behavioral Objectives?

______Yes

______No

16. Does IMS enable the teacher to spend more time giving individual assistance to students?

______Yes

______No

17. Does IMS seem more effective than the mathematics system you used previously?

______Yes

______No

Appendix V c

IMS Teacher Survey #3

IMS TEACHER SURVEY # 3

May 21, 1971

PLEASE DO NOT OMIT ITEMS.

If you are not sure of a response, mark the choice which seems closer to your belief.

1. The learning materials are attractive.

99% Agree Suggestions for improvement:

_____Disagree

2. The use of cartoon characters and other drawings makes IMS interesting to pupils.

98% Agree Suggestions for improvement:

_____Disagree

3. The availability of concrete, pictorial, and abstract presentations for teaching the same objectives permits the accomodation of individual differences.

98% Agree Suggestions for improvement:

_____Disagree

4. Pupils enjoy working with IMS materials.

99% Agree Suggestions for improvement:

_____Disagree

5. Use of manipulative materials assists pupils in mastering objectives beyond achievement based on skill pages alone.

93% Agree Suggestions for improvement:

_____ Disagree

6. The provision of activities assists pupils in mastering objectives beyond achievement based on skill pages alone.

92% Agree NON-USERS EXCLUDED

_____ Disagree

101/196 My students have not used activities extensively enough to permit judgement.

Suggestions for improvement: 52% of responders had not used activities to any extent.

7. IMS teacher training materials used in IMS summer workshops are effective.

124/196 I did not attend an IMS summer workshop

86% Agree Suggestions for improvement:

_____ Disagree NON-ATTENDEES EXCLUDED

8. IMS User Guides are effective.

93% Agree NON-USERS EXCLUDED

_____ Disagree

32/196 User Guides have not been readily available in my school.

Suggestions for improvement: 16% of responders in this category.

9. IMS materials are sufficiently durable to be reusable.

92% Agree   Suggestions for improvement:

_____ Disagree

10. IMS laminated materials are easy for pupils to use.

96% Agree   Suggestions for improvement:

_____ Disagree

11. IMS enables the teacher to spend more time giving individual mathematics assistance to pupils.

84% Agree   Suggestions for improvement:

_____ Disagree

12. Grade taught _____. (We recognize that the grade taught will have a bearing on your responses to questions 13 - 17.)

1	2	3	4	5	6	OMIT	TOTAL
15	37	44	38	38	22	2	196

13. Almost all the pupils in my class obtain, clean, and return skill pages with very few errors.

71% True   Grades 1 - 3   81%   Grades 4 - 6

_____ False

14. Half or more of my students write (or could write) their own prescriptions.

22% True   Grades 1 - 3   81%   Grades 4 - 6

_____ False

15. Half or more of my students can (or could) score their own skill pages accurately.

40% True Grades 1 - 3 87% Grades 4 - 6

_____ False

16. Half or more of my students can (or could) score their own check-up tests accurately.

40% True Grades 1 - 3 75% Grades 4 - 6

_____ False

17. Half or more of my students can (or could) score their own pretests accurately.

10% True Grades 1 -3 64% Grades 4 - 6

_____ False

18. IMS procedures for keeping track of pupil progress provide the teacher with an accurate picture of each student's achievement at any point in time.

94% Agree Suggestions for improvement:

_____ Disagree _______________________________

____

____

19 Please compare IMS with the usual textbook based approach to mathematics instruction. Check the one which you think is more effective for the following:

	MORE EFFECTIVE IMS	Text Book
Teaching of concepts	76%	____
Teaching of skills	71%	____
Teaching of applications	80%	____
Teaching high ability students	84%	____
Teaching low ability students	72%	____
Teaching medium ability students	83%	____

19. (cont.)	IMS	Text Book
Motivating students	93%	
Accomodating individual differences	98%	
Arranging coverage of needed topics in mathematics	79%	

20. Considering all aspects of effectiveness, both those listed in 19 and others you may think of, which approach do you consider generally more effective?

91% IMS

_____ Text Book

Appendix VI

Incident Report

INCIDENT REPORT*

SCHOOL: ____________________ PRINCIPAL: ____________________

CITY: ____________________ DATE: ____________________

I. Observation: ____________________

II. Suggestions to RELCV: ____________________

____
Teacher

* Subject to further development.

Appendix VII

EC Questionnaire 3-1-71

EC QUESTIONNAIRE 3-1-71

Name ______________________________

School ______________________________

1. Please list the number of classes and approximate numbers of students in IMS in your school as of March 1, 1971.

Grade	1	2	3	4	5	6
No. of Classes	___	___	___	___	___	___
Appr. No. of Students	___	___	___	___	___	___

2. We will soon print and distribute replacements for certain skill pages. Please count the number of folders in your school as listed below so that we can send the correct numbers of replacements:

Level	Area	Skill	No. of Folders
II	Numeration	8	______
II	Division	2	______
II	Measurement	1	______
IV	Addition	1	______

3. We need to have a fairly precise picture of how aides (if any) are used in your school. Please explain below if the following questions do not seem to permit an accurate characterization of your aide situation.

PAID AIDES		VOLUNTARY AIDES	
___Yes ___No	Do you have paid IMS aides? (If answer is no, omit questions below.)	___Yes ___No	Do you have volunteer IMS aides (parents, high school or college students)? If answer is no, omit questions below.
___Yes ___No	Do paid aides work directly with students during math period?	___Yes ___No	Do volunteer aides work directly with students during math period?

PAID AIDES

___Yes ___No Are paid aides usually present in the IMS room during the math period?

___Yes ___No Do paid aides score tests, record progress or do other clerical jobs within the system?

______ No. of min. For the average teacher approximately how much paid aide time is given for IMS each day?

______ No. of min. Approximately how much longer would the average teacher have to work each day if paid aides were withdrawn from IMS work?

______ Total full-time IMS aides How many full-time paid IMS aides does your school have? (Do not report aide usage on non-IMS work. Total need not be a whole number, e.g., 3 3/4 full-time aides might represent 2 full-time on IMS, 3 half-time on IMS and one half-time worker used only 50% on IMS.)

VOLUNTARY AIDES

___Yes ___No Are volunteer aides usually present in the IMS room during the math period?

___Yes ___No Do volunteer aides score tests, record progress or do other clerical jobs within the system?

______ No. of min. For the average teacher approximately how much volunteer aide time is given for IMS each day?

______ No. of min. Approximately how much longer would the average teacher have to work each day if volunteer aides were withdrawn from IMS work?

Other comments or explanation of aide usage: ______________________

____

____

____

____

____

4. Are any classes in your school not entering IMS this year due to problems connected with availability of materials?

_____Yes

_____No

_____How many classes?

If "yes," please tell how many classes are affected by each of the following problems.

Enter number of classes affected.

_____School layout or floorplan requires additional materials.

_____Not enough carts (or shelves) are available.

_____Level VII and higher materials are needed.

_____Manipulative materials are needed.

_____Heavy concentration of students at lower levels requires more materials.

If the above does not account for all classes not in IMS due to materials problems, please explain below:

____

____

____

____

____

____

____

____

Appendix VIII

A Review of the Individualized Mathematics System (IMS)

by
Robert M. Gagné

March 31, 1971

Report of

A Review of the Individualized Mathematics System (IMS)

by

Robert M. Gagné
Florida State University

Submitted to the Regional Education Laboratory for the Carolinas and Virginia, Chapel Hill and Duke Streets, Durham, North Carolina 27701.

A Review of IMS

Scope of Review

This review has the intention of examining and commenting on IMS as a system for learning. Having this purpose, the reviewer has been particularly concerned with the following aspects of the system:

1. The learning objectives of the system, and their ordering from level I to IX. This examination has been conducted by reference to the list of behavioral objectives, and the representation made of them in the Guidelines and Skill exercises. A sampling technique was employed here.

2. The ordering of topics within each skill level. Again, the objectives were examined, and sampling was used to gain an understanding of their meaning in operation at various skill levels.

3. The kinds of pupil activities as represented in skill sheets and activity sheets, the manner of presenting them, at various levels and areas.

4. The testing-prescription cycle, as described in user guides and as illustrated by pre-tests, directions for prescription, post-tests, and skill sheets.

5. A consideration of the rationale for learning provided by the IMS system.

It should be apparent from this list that there are definite limitations to the scope of this review, which arise both from restrictions of time and from limits on the capability of the reviewer. It is assumed that these other aspects of the system may be otherwise evaluated, either by examinations of the system by specialists with different capabilities, or by the use of empirical data obtained from measures of pupil performance, or both. To be specific, this reviewer has not attempted to draw inferences or conclusions about the following aspects of the IMS:

(1) the precision or validity with which the mathematical content is represented;
(2) the logical defensibility within the domain of mathematics of the ordering of topics which relate to each other (such as addition and subtraction, or multiplication and division);

(3) the existence or desirability of alternative methods of performing mathematical operations; or
(4) the evaluation of goals in elementary mathematics reflected by the totality of objectives, levels I through IX.

Learning Objectives and their Ordering

Two major characteristics of the IMS can be seen by examining the lists of objectives throughout nine levels, and comparing these with their representations in skill sheets and pre- and post-tests. First, there is the matter of whether the objectives are stated in such a way that they communicate (primarily to the teacher), the purpose of the learning to be accomplished. Second is the question of how these objectives are ordered, and the extent to which this ordering represents a reasonable approach to pupil learning.

Communication by objectives. In general, it is apparent that a serious attempt has been made to state objectives in objective, communicable language referring to pupil performance. These statements usually communicate well, and appear to do the job of making clear to the teacher, and through her, to the pupil, the nature of the task to be learned. In the operation of the system, the objectives appear on the Guideline sheets, and the teacher can then make an immediate comparison of the skill exercises which correspond.

The communicability of the objectives does vary somewhat in effectiveness, and many of them could be improved if it were important to the system for this to be done. From the standpoint of statements which convey an immediate impression, by themselves, of what the corresponding skill exercise is like, many of them leave something to be desired. For example, an objective such as the following does a pretty good job of immediately defining the necessary skill exercise (II Addition, 3): "Given the words 'plus' and 'equals', matches them respectively with the symbols '+' and '=', and vice versa". In contrast, the following statement does not provide adequate information (II Addition, 1): "Writes the cardinality of each of two sets and the cardinality of the two sets combined (to a sum of 18)". This statement is in a different form; it does not clearly identify the stimulus situation; and its verb does not clearly specify the behavior (as distinguished from the response). An alternative statement, avoiding these difficulties, would be: "Given pictures or objects representing two sets and their combination set, identifies the cardinality of each set by writing a numeral".

Many other examples could be given of relatively good, and relatively less good, communication by these statements of objectives. I shall not try here to convince by piling example upon example. I simply want to say that communicability of these objectives is improvable, if it is important to do so. I am less sure that it is important to undertake such improvement, because it seems easy enough for the teacher to look at the skill exercise in order to confirm the meaning of the objective. For those who wish to prepare items which test the capability to be learned, it is less easy. My suggestion would be that all objectives be written in a standard format, using a standard set of major verbs. The format is: (1) Given (the stimulus situation); (2) the major verb identifying the kind of intellectual processing required; (3) the object of the verb, including the mathematical purpose of the objective; (4) a gerundive phrase denoting the response; (5) limitations on the scope, if any. Using such a scheme, II Numeration 8, for example, would be written as follows: "Given two numerals representing whole numbers, identifies the relationships of equality, greater than, and less than, by placing $>$, $=$, $<$ between pairs of numerals".

Ordering of objectives. When one examines the sequence of objectives within a given area, throughout the nine levels, it is apparent that there are many progressive sequences, and that they make generally good sense so far as learning progressions are concerned. For example, it is clear that VI Subtraction 1, "Computes the difference of two whole numbers requiring regrouping (minuends to 1,000)" has been preceded by a sequence of skills in V Subtraction, which includes subtracting with regrouping involving two and three-digit numbers (3, 4, 5); subtraction without regrouping of three- and four-digit numbers (2); and that these in turn have been preceded by mastery of subtraction facts through 20 (1). One can follow the sequence further to IV Subtraction, where the tasks are solving two-digit subtraction problems (2), and other operations requiring checking (1, 3). The concrete conceptual bases for these subtraction operations are established in III Subtraction, (1, 3, and 4), and earlier still in II Subtraction (3, 4, 5), and the concepts of "taking away" (2, 3) and "one less than" (4) in I Subtraction.

I have sought out similar sequences in the other skill areas, including addition, multiplication, division, fractions, and so on. It is clear in each case that the sequence makes rational sense as a learning progression. This is true also when one examines some "subordinate themes" not necessarily in the mainstream of objectives, such as equalities and inequalities. For example, V Mixed Operations 3, asks the student to identify equalities and inequalities for expressions involving addition, subtraction, multiplication, and/or division. These operations have, of course, been previously taught separately. But in addition, one can also trace a progression of the concepts of equalities and inequalities through IV Addition 3, IV Subtraction 4, IV Multiplication 1, III Numeration 8, III Addition 2, III Subtraction 1, II Numeration 8, II Addition 3, II Subtraction 2, 6, II Multiplication 4, I Addition (1, 2), and I Subtraction (1, 2, 3, 4). In other words, there is evidence that learning sequences have been carefully planned throughout the IMS continuum, and this appears to be true whether one traces them out within a given skill area, or, for what may be called "subordinate themes", among various skill areas.

The question as to whether the ordering of skills to be learned appears correct can therefore be answered quite confidently in the affirmative. A much more difficult question, however, is whether when viewed from the standpoint of efficient learning hierarchies, any skills have been omitted. In fact, within the time available to me, I cannot adequately answer this question. As an example of what would be required, I select VI Fractions 4, "Finds the L. C. D. for a given set of fractions".

The subordinate skills required for this activity would appear to be the following, which could readily be represented as a hierarchy (c. f., Gagné, 1970):

1. Given whole numbers, identifies the factors yielding each as a product.

2. Divides whole numbers (to 999) by small prime numbers to obtain factors.

3. Obtains product of successive multiplication of small whole numbers (for example, 2 x 3 x 5 = ?).

4. Checks results of division by multiplication.

These subordinate skills are, in fact, represented in various subdivisions of the IMS Continuum. For example, identifying the factors of whole numbers occurs as VI Multiplication 6; dividing whole numbers as VI Division 2; obtaining products of successive multiplication as VI Mixed Operations 3; and checking results of division by multiplication as VI Division 4.

Thus, it is clear from this example that the necessary subordinate skills for learning a particular skill are represented. It is notable, though, that the sequence for their learning is neither stated nor implied, and that as a consequence any given pupil may come up with "missing" subordinate skills. It may be noted that both the target skill and its prerequisites, identified in the previous paragraph, all occur at Level VI. A rough sequencing, designed to insure that subordinate skills were mastered before superordinate ones were presented, would place these subordinate skills at Level V (or, alternatively, the objective VI Fractions 4 at Level VII). A more precise sequencing would probably require a rearrangement of many of the specific subordinate skills in the Continuum, as well as a different structure for pre-tests (to be discussed later). However, at this point it may be noted that no obvious omissions of subordinate skills have been discovered by a sampling procedure.

Empirical Evidence of Skill Dependencies

The data obtainable from student progress and test records should provide a rich source for the conduct of additional formative evaluation of IMS. The developers of the system are doubtless aware of this point, but I point it out here with the intent of providing some additional emphasis.

What must be sought in the examination of such data is not simply "difficulty", but evidence of dependency. The procedure may perhaps best be described abstractly. Suppose that a "normal" sequence has been hypothesized as Skill A--Skill B--Skill C. Of 100 children who have attained Skill A successfully, 60 are able to accomplish Skill B on their first try, whereas 40 are not. Out of the 60 who are successful on Skill B, 54 (90%) are able to attain Skill C on their first try, and 6 (10%) are not. Of the 40 children who have not learned Skill B, 2 (5%) are able to attain Skill C on their first try, whereas 38 (95%) are not. These results indicate the dependency of Skill C on Skill B. To repeat the contrast that has been illustrated: of those who mastered Skill B before attempting Skill C, 90% succeeded; of those who did not master Skill B before attempting Skill C, only 5% succeeded. These two percentages differ markedly, and one is justified in inferring dependency of C on B. In contrast, if the two percentages found were, say, 52% and 47%, the evidence for dependency would be at most exceedingly weak.

Of course, the hypothesized dependencies (sequences) may sometimes be more complex, since a given skill may be supposed to depend on prior learning of two or more subordinate ones. The basic logic, however, remains the same in such instances. The possibilities of determining efficient sequences of mathematics skills by means of such analyses of data would appear to be highly promising.

Activities and Skill Sheets as Vehicles for Learning

This reviewer has examined the Skill Sheets and Activities for a variety of learning objectives throughout the continuum of areas and levels. Such a review, of course, does not make possible detailed judgments of which are good, better, and best. Presumably, evidence of this sort may best be obtained from direct evidence attending the use of the materials, such as teachers comments, student scores, etc.

On the whole, the learning activities embodied in this system appear to be remarkably good. Their advantageous features include the following:

1. The skill sheet exercises are generally clear, and the pictorial and diagrammatic features contribute much to this clarity.

2. As a consequence, it seems likely that these exercises require minimal verbal directions to the pupil. This advantage is of particular consequence to a system of individualized instruction.

3. Generally, the pictorial aspects of the skill sheets command attention and interest.

4. There is considerable variety in the specific representations of skill problems. A respectable amount of evidence shows such variety to be facilitative of learning and transfer.

5. The skill exercises appear to be carefully matched to the objectives; that is to say, they are valid in content.

6. The Activities are, generally speaking, imaginative and varied. They provide considerable flexibility to the teacher for the conduct of classroom activities.

One characteristic of the Activities may deserve further comment. Generally speaking, they appear to be representations, often in the form of group activities, of the same learning reflected in the skill sheets. They may thus provide additional opportunities for learning and review. This is, of course, one possible use of Activities, and it may be the most important one. Another possibility which might be given further consideration in future development is the use of Activities to promote transfer and problem-solving. Not many of those currently existing could be considered to fall into such a category. Such Activities would be designed deliberately to be "mind-stretching", to permit various kinds of unanticipated outcomes, and to emphasize applications of mathematical operations. They would, in short, more frequently require the generation of solutions to novel problems by students.

Tests and Testing

Tests for this program appear to be carefully designed. The items of Placement Tests, Pre-tests, and Check-tests are generally clear and easy to understand. They are varied in content, and their diagrams and pictures are appealing and helpful.

The system for testing, as described in the User Guide, Volume 2, is highly reasonable and systematic. In practice, it may well result in the impression of "too much testing". Overcoming this kind of difficulty might be accomplished by various procedures having the aim of making instruction more like testing and testing more like instruction. In fact, these elements are difficult to distinguish. Other specific ways to reduce the impression of "too much testing" include (1) reducing the frequency of use of Placement Tests, when the position of the student is evident from other measures; and (2) reducing the frequency of usage of the Post-test, when it is judged that its function can be served by Check-tests.

It should be realized that I am not able to make specific recommendations about reductions in the frequency of "testing", since the major evidence of its desirability must c me from experience with the use of IMS itself. However, the practical pressures for cutting down on the time for testing may be considerable in a program based upon such a systematic procedure for assessment as is IMS. Should such pressures be acceded to, it is obviously desirable that this be done in such a way that the basic purposes of assessment not be sacrificed.

The Testing-Prescription Cycle

As has been previously stated, the cycle of assessment and prescription is a highly systematic one, and the benefits of such procedures in improving student achievement should become apparent in those schools which use the system. The testing-prescription cycle has the evident purpose of making it possible for each pupil to begin learning new skills at a point which reflects his previous learning, to demonstrate the attainment of these new accomplishments, to review them when necessary, and to proceed to acquire other skills which advance his level of achievement in a planned manner. Basically, it is a system which bases advancement in skill on prior accomplishment (mastery) of prerequisite skills.

What happens when a pupil is assigned the task of learning a new skill, and fails to do so? According to User Guide, Volume 4, the teacher may assign alternative work pages, or perhaps accompany these with some tutoring. Here a specific limitation of the system becomes apparent--the extent to which precise diagnosis is possible with IMS. I mention this limitation because it is of particular interest to me. It needs to be recognized, I believe, although any revision of the system to remove it would probably have to be rather extensive. Accordingly, whether such revision should be undertaken would have to consider costs as well as possible benefits.

The crux of the limitation in the diagnostic feature of IMS is this: there is a lack of specificity in proceeding from (1) what the pupil doesn't yet know how to do, as revealed by a Pre-test, and (2) what he should do to learn it. The Pre-test itself does not provide information which is diagnostic, in a precise sense, of what is needed for the pupil to attain a skill he doesn't yet have. It is conceivable that in some instances he needs nothing more than verbal directions, whereas in others, an entire set of subordinate skills may need to be learned.

Let me illustrate this point with an analysis of the third item, first page, of II Numeration, representing Skill 1. Suppose it is found that the pupil cannot do this task, "Write the number word, then match with the picture." One cannot tell from this item by itself whether he (1) fails to know the name of the numeral; (2) cannot write the name of the numeral; (3) cannot identify the numbers describing the sets of dots. It is even conceivable that he is (4) unable to relate a printed word by a directional line to the corresponding number of dots (although this is least likely).

This means that the Pre-tests are not diagnostic in any precise sense, although probably that is what they should be. Accordingly, the diagnosis-prescription process is fairly loose, in this system. Increasing this precision would not have the aim of making the system less flexible, and such need not be the case. Instead, increased precision of diagnosis would have the purpose of enhancing the efficiency of the entire learning system.

What would be required to improve the precision of diagnosis-assignment? First, the Pre-tests would need to be redesigned so that each item used to measure the accomplishment of a particular objective were followed by other items which measured the achievement of <u>subordinate skills</u>. Second, since these subordinate skills would have to be known, each objective would have to be analyzed so as to relate it to relevant subordinate skills, in the manner indicated by the discussion in the previous section of this report, entitled "Ordering of Objectives". Were both these efforts to be undertaken, it would then be possible to have Pre-tests which provided precise diagnostic information, since they would make possible the identification of precise skills the pupil had or had not yet achieved. In use, such tests would provide the teacher with information making possible an equally precise determination of what the pupil needed to do to attain the desired proficiency.

The Learning Rationale for IMS

As a learning system, IMS has a rationale which appears highly practical, and runs somewhat as follows. First, determine in a rather general way what the child already knows how to do, and what he doesn't know how to do (using Placement Tests), within the several content areas of elementary mathematics. Next, determine which objectives he can meet within each area, at the level indicated by the previous placement test, this time using Pre-tests. Following this, make assignments of skill activities, accompanied by other class Activities, which will enable him to acquire the skills (objectives) indicated to be missing by his Pre-test performance. Determine that these have been learned by Check-tests, and that related sets of them have been learned and retained, by means of Post-tests. Further assignments are then made on the basis of these results.

I want to point out to you, not in the sense of criticism, that the IMS is a system of only moderate precision. A highly precise learning system would proceed as follows. Following the placement test, a pre-test would be given which indicated (1) what objectives the child has already attained; (2) which he had not yet attained; and (3) which subordinate skills (objectives) related to those identified in (2) were still missing. Having this information, the teacher (or other person) would identify for the child the precise skills he needed to learn. Having learned these, the child would then be able to achieve the particular objectives previously found missing. According to theory, he would do this more or less immediately, and without a great deal of "practice". The essential conditions of learning would be the availability of these missing subordinate skills. Thus, the expectation would be that once these missing subordinate skills had been identified and mastered, learning of the new skill would occur very rapidly. This would mean greater efficiency for the system as a whole.

Summary and Conclusions

1. IMS is a learning system for elementary mathematics which has the potential for increasing the levels of achievement of children over those obtainable with a more loosely planned system. In particular, this result may be expected because of the procedure of testing--prescription and recycling which aims for mastery of the skills of mathematics, and which bases progress in assignments on achievement. Because of this procedure, it becomes unlikely that children will get "left behind" through being unable to keep up with the remainder of a class.

2. The several excellent features of the system include: (a) well-defined objectives; (b) an apparently comprehensive coverage of mathematics skills, arranged in sequences which are generally feasible for learning (although specific exceptions may exist); (c) well-designed, interesting, and attention-holding skill exercises appropriate to each objective; (d) a variety of relevant class Activities providing considerable flexibility to the teacher; (e) a systematic set of procedures for placement, pre-testing, assignment, and post-testing, designed to make possible student progress in learning based on "mastery".

3. Additional formative evaluation may find it possible to take into account the following kinds of possible improvements. These are listed here without consideration of their probable costs, but only in view of their desirability.

a. Identification and certain rearrangements of objectives, particularly across skill areas, based upon analysis of data indicating dependence of each skill (objective) upon others.

b. Increased emphasis in Activities upon application, transfer of learning, and problem-solving. This also implies a somewhat altered purpose for such Activities, as well as conditions of use, from that currently described.

c. Decrease in the frequency of "testing" versus instruction, without sacrificing the fundamental assessment purposes of the system. For example, it is conceivable that greater reliance could be placed upon indications from Check-tests, rather than upon Post-tests. A definite recommendation cannot be made here, however, since much depends on information derived from usage of the tests in an operating situation.

4. Increased precision as a learning system would be attained by redesigning Pre-tests so that they would provide precise diagnostic information. Such a change would, however, require a substantial effort, since it would need to begin with an analysis of each objective into its component subordinate skills. In use, such a system would be expected to decrease the need for "practice" of skill exercises, and thus result in greater efficiency of learning. However, the practical outcomes of such a system have not been verified; accordingly, a recommendation for IMS to undertake it does not seem appropriate. Obviously, though, someone should.

Appendix IX a

Specific Suggestions on I.M.S.

by
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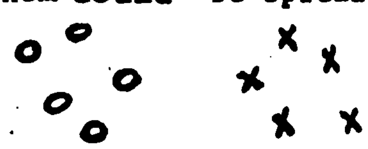
Specific Suggestions on I.M.S.

Numeration I, Skill 1

- p 1. Put another man at the bottom.
- p 3. Put the 2nd diver closer to the bottom. (He is now in the middle, as measured by the ladder)
- p 25. The dogs are mirror images, and hence not quite the same. Turn one of the dogs around.
- p 31. Delete reference,on Contents and Procedure page, to "end of the road." The end of the road is over the horizon, Suggest "Circle the car farther from the boy. Mark "X" on the car which is nearer the boy."
- TA-3 This page does not tell me what I (as a teacher) am supposed to do.

Numeration I, Skill 2

- p 2. Delete the lines from pole to fish; the child is to draw the lines.
- pp 4-8. Almost all of these examples line-up the sets to be matched. More of them could be spread around a little, e.g.



Numeration I, Skill 3

- pp 5-8 Put capital"M"on "More" and capital "L" on "Less". (Small letter 1 looks too much like number 1.)
- p 12-13 Use capital M and L.

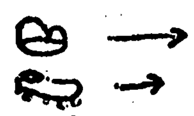
Numeration I, Skill 4

- pp 1-6 There is no need to have <u>all</u> of the pictures in each example identical. There could be some variety.

Numeration I, Skill 6
pp 1-7. Contents and Procedure page is not clear about what is to be done. Child should put an X on each object in a set as he counts.
pp 1-8. See objection to Numeration I, Skill 4.

Numeration I, Skill 7
TA-1 The meaning of number sentences must be explained to the child; they have not been introduced before.

Numeration I, Skill 11
pp 13-14. It is not clear, from Contents and Procedure page, what is to be done here.

Addition I, Skill 3
pp 8,9. The notation  etc.
is unclear (although it may be clear to the children).
p 10. The notation is wrong. In Example 1, $N\{O\} = 1$, $N\{\Delta\} = 1$, $N\{O\Delta\} = 2$. You mean the number of circles, number of triangles, etc. Replace $N\{O\}$ by $N\{O's\}$, $N\{\Delta\}$ by $N\{\Delta's\}$ etc.

Addition I, Skill 4
For clarity, the objects being counted should be given.

p 1. 1. How many apples?
2. How many birds?

p 2. 1. How many children?
2. How many pencils? (Delete the tables)

p 3. 1. How many animals? (Delete the children)
2. How many trees? (Delete the squirrel)

p 4. 1. How many teeth?
2. How many birds?

p 6. 1. OK
2. How many men were there then?

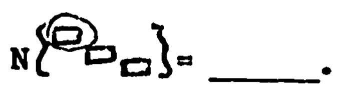
The objective states that the child should use manipulative devices. This is not necessary, although it is possible. Change objective to "Solves one-step story problems (sums to 10)."

Subtraction I, Skill 1
pp 1-11. Drawing a line through the middle of a set does not make it any smaller. Suggest circling the extra elements of one set to make the equivalent. (As in Subtraction I, Skill 2.)

Subtraction I, Skill 2
Much of this material (pp. 2, 10-13) requires the reverse of the stated objective. The Contents and Procedure page includes "and vice versa" in the statement of the objective. This should be added to the booklet statement of the objective.

Subtraction I, Skill 3

pp 14,15. The notation here implies that a set equals a number (which of course it does not). Put "N" before each set. e.g.



Subtraction I, Skill 4

pp 6-12. The word "less" here refers to an operation. But on pp 1-5 the word "less" referred to a relation. To avoid possible confusion, suggest replacing "less" on pp 6-12 by the word "minus".

p 15. The symbol "□→1" in the heading has no meaning. It could be deleted.

Subtraction I, Skill 5

Manipulation is not essential here (although it is allowed). Restate objective as "Solves one-step story problems (numbers 1-10)."

pp 1-6. These pages involve writing a story to describe a picture. They do not get at the stated objective.

TA-2 Story 1 is the <u>only</u> one here that asks "How many more?" (The others all ask "How many were left?") Some of the other stories could be rewritten to ask "How many more?"

TA-3 Stories 7 and 11 are the only ones that ask "How many more?"

Multiplication I, Skill 1

p 10. Suggest coloring the noses red or deleting the word "red".

p 11. As described in the Contents and Procedures page, only one child will have the opportunity to discover; the others will learn from the explanation.

p 20. The airplanes could be 1 set of 3 or 3 sets of 1; point this out in the Contents and Procedures page.

Multiplication I, Skill 3

p 5. Example 3. Flyers do not have wings. You could use birds instead.

Division I, Skill 1

Add (no remainders) to the statement of the objective.

A. It is not clear how the chart is to be filled in when there are remainders. Give an explanation or use only examples with no remainders.

Fractions I, Skill 1

p 9. It is not clear whether the cup is cut in half or not. In terms of volume it is; in terms of handles it is not. Use a glass instead 

p 13. The headings imply that one= 4, one-half = 2, etc. Change the "one" heading to "whole", or "all".

p 13. 3rd Example. 1/2 of 5 $\neq$ 3. An extra whistle is needed in the left column.

Mixed Operations I, Skill 3

Change objective to "Solves simple story problems involving addition or subtraction (whole numbers to 10)" since manipulation is not essential.

Time I, Skill 1

p 3. Example 2 seems to have nothing to do with the stated objective.

Measurement I, Skill 1

p 21. The correct heading is "Nearest and Farthest" since more than 2 things are compared.

p 22. Make heading "X Nearer to  ".

p 23. Make heading "X Farther from  ".

TA-3, TA-4. These involve near<u>est</u> and far<u>thest</u>.

Measurement I, Skill 2

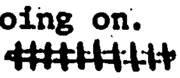
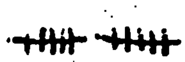
TA-1, TA-2. Instructions are needed about what to do when there are remainders.

Numeration II, Skill 2

p 8. Order must be specified. Make titles
X the first.
X the third from the left.
X the fifth from the left.
X the seventh from the left.
(Children cannot be expected to know the usual left to right order.)

p 11. Here first is on the <u>right</u>, which reverses our usual order (see comment on p 8.).

Numeration II, Skill 3

p 5. Suggest grouping these by 10's instead of by 5's, to show what is going on.
e.g.  instead of  .

Numeration II, Skill 4

All of the activities here involve a <u>sequence</u> of number lines, rather than <u>a</u> number line. Change objective to "Writes the whole numerals from 0 to 25 at the appropriate points on a given number line or a given sequence of partial number lines."

Numeration II, Skill 5

The expression "Structured groups" implies something in abstract algebra. "Structured group" here means "set with elements grouped into 10's". Change objective to read "States, selects, and writes cardinality of sets whose elements are grouped by 10's (to 25 elements)."

pp 10,11,12,14.

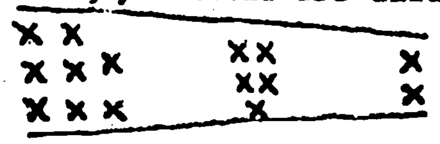
The correct heading is "How many white rods?" (If you allow longer rods, the answer is 1, 2 or 3 in each case, which is not what it means.)

Numeration II, Skill 7

p 11. is not listed on Contents and Procedures page.

Numeration II, Skill 8

p 1. In order to demonstrate that numerosity, not size, is of interest, you could use different sized sets, e.g.



p 12, number 7. Replace 27 by 17. (Children are not assumed to have mastered 27)

Addition II, Skill 2

Recognition of the symbol N for cardinal number is implicitly assumed; it is not a stated objective and is not tested.

p 14. We take <u>unions</u> of sets and add <u>cardinal</u> numbers. A letter N before each set should be added.

e.g.

3 + 5 = 8

Addition II, Skill 3

pp 6,7,8. Make the number of spaces match the number of letters in the word.

Addition II, Skill 4

pp 5,6. p 5. cannot be used to help with p 6. since they are back to back.

Addition II, Skill 5

Delete "Uses manipulative devices to" from objective. (they are not required)

Addition II, Skill 6

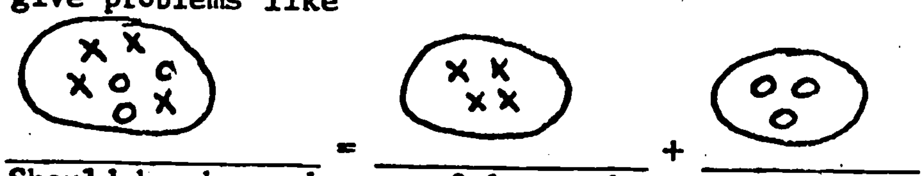
p 1. "Yes" can never be a correct answer to the second problem.

p 7. Kangaroos do not live in the jungle. Suggest you change them to lions.

Subraction II, Skill 1

p 3, Problem 3. Move sets so they are over the blanks, not over the equal sign.

pp 3-6. These don't involve the stated objective at all. They are simply addition problems. To get at the objective you could give problems like



p 10. Should be changed as pp 3-6 are changed.

Subraction II, Skill 2

There are no examples requiring use of both symbols "-" and "=" to make true statements. Some should be added.

Subtraction II, Skill 4

pp 9,10. All examples on pp 1-8 are written horizontally, but examples on ✓-up pages are written vertically. Suggest writing some examples vertically on pp 1-8, and some horizontally on pp 9-10.

Multiplication II, Skill 2

In the objective, replace "pictured" by "given". (As worded, objective implies that the child will form the array, which is not the case here.)
The assumption is made that the child knows the "values" of different colored rods. This is never stated as an objective.

Multiplication II, Skill 6

pp 4-7, 9-13, 15.

It would help if distinct shirts, vans, pictures, etc. were labeled, perhaps with letters, so the child would know they were distinct.

Division II, Skill 1

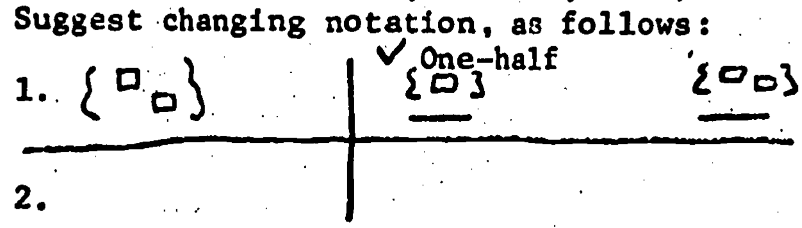
pp 3-12. Suggest replacing "Left" by "Left over". (Left is the opposite of right.)

Fractions II, Skill 1

p 1. Suggest replacing heading "One" by "Whole".

pp 4,5. Suggest replacing heading "One" by "all". (It appears as written, that one = 6, one = 4, etc.)

pp 8-12. Suggest changing notation, as follows:



Fractions II, Skill 2
p 12, Example 2. Add another dot.
p 16. To clarify notation, suggest changing example 2 to read

1/2 of (○'s +△'s)
(○and △ are used as icons here, not as pronumerals.)

Mixed Operations II, Skill 1
pp 7-9 A standard convention when using pronumerals is that in a single equation, the same number must go into a given shape, no matter how many times that shape is repeated. If two different numbers are allowed, 2 different shapes must be used. Therefore, for all equations with 3 numbers to be filled in use 3 symbols, e.g. ○, △, □.

Mixed Operations II, Skill 2
p 7, Example 2. Carrier pigeons do not carry children!

Money II, Skill 3
pp 3,4. Indicate to teachers that there is more than one correct answer, e.g., 8¢ buys 2 balls (2¢ left over) or 4 pencils, or 2 balls and 1 pencil, or 1 pencil and 1 apple (1¢ left over). Items could be chosen to make prices more realistic.

Time II, Skill 2
pp 5-6 The objective implies the ability to fill in all numerals. One clock face should be given with none of the values filled in.

Measurement II, Skill 1
p 1, Example 3. Neither line is shorter. Suggest putting the whole sentence on 1 line so the reader will know he is to fill blanks. (It looks like he is to compare the length of line segment A and line segment a.)

Numeration III, Skill 2
pp 3,4. A starting point should be given. For example, the hidden number on p 4. can be 48 or 24, depending on where one starts.

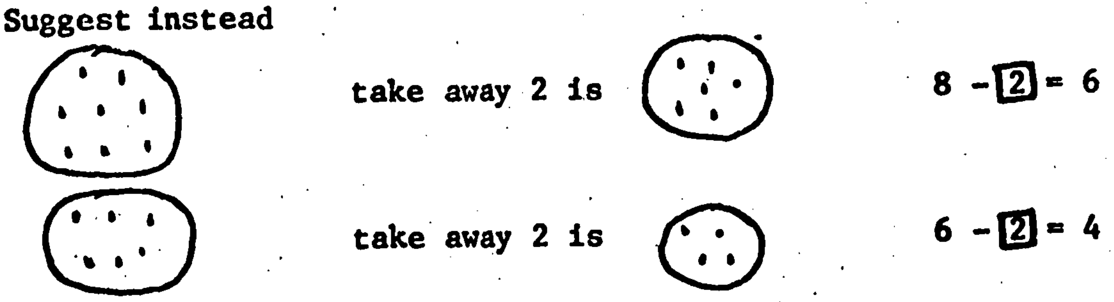
Numeration III, Skill 5
See objection to Numeration II, Skill 5. Change objective to "States, selects, and writes cardinality of sets whose elements are grouped by 10's (to 100 elements)."

Numeration III, Skill 8
p 1. Change lines so that they do not seem to form an inequality sign. (See Subtraction II, Skill 1.)

Addition III, Skill 5
p 5. A capital N is needed in front of each set. We add cardinal numbers, we take unions of sets. (See Addition II, Skill 2.)

Addition III, Skill 3
A. In number sentences like □ + ____ = □, use distinct pronumerals, e.g. □ + ____ = △, unless the numbers are supposed to be the same.

Division III, Skill 1
p 4. Very confusing. Some arrows (horizontal ones) represent subtraction and some (slanting ones) represent equality. Suggest instead



etc.

Division III, Skill 2
pp 8,9. It really is not necessary to use rods here. All you have to do is count.
p 12. To fit the accepted convention on pronumerals suggest changing to

5. □ x △ = 9
6. △ x □ = 16
9. □
x △
15

Fractions III, Skill 2
p 12, Example 5. This is not divided into halves, but one can shade one half. Change this to halves or to thirds.
Example 9. Same as Example 5. Change this to thirds or to fourths.

Time III, Skill 3
All of these pages may cause later confusion. "36 marks to the ↓ " means "36 minutes after the hour" and "24 marks after the ↓ " means "24 minutes before the hour." Suggest change all of these to replace "____ marks after ↓ " with " ____ marks to 12." This will avoid confusion with the word"after".

Measurement III, Skill 1

p 5. Unclear. What is number 6? Does number 8 refer to the diameter of the reel or the length of the tape?

Measurement III, Skill 5

p 3. Unclear. Does number 3 refer to one paper clip or the whole box? Does number 8 refer to one staple or the whole box? Does number 9 refer to one tissue or the whole box?

Numeration IV, Skill 4

Change the objective to make clear what a "structured group" is. (See Numeration II, Skill 5 and Numeration III, Skill 5.)

Numeration IV, Skill 5

p 5. The pattern in numbers 3, 4 and 5 is not clear; how are children supposed to figure it out?

p 6. Use blanks instead of squares to avoid the pronumeral problem.

Numeration IV, Skill 8

p 1. Replace "one before five means 1 less than 5" by "I before V means 1 less than 5"; replace "one before ten means 1 less than 10" by "I before X means 1 less than 10".

Addition IV, Skill 1

p 6. Problem 2 and 5 are confusing; suggest deleting them or replacing them by problems like number 6.
This page could include some problems using zero.

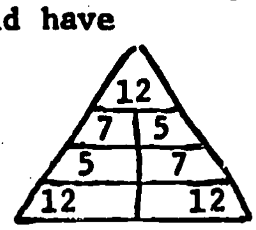
Addition IV, Skill 5

Change objective to "Solves column addition problems with three or more single digit addends (whole number sums to 25)."

Subtraction IV, Skill 1

pp 3-5. Label an intermediate point on the number line, e.g. 9 or 10.

p 8. To make the subtraction triangle here like the ones on pp 9-10, it should have

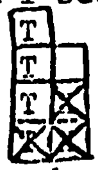


Subtraction IV, Skill 2

p 2. Make shading clearer.

p 3. Up to the point, every block has represented 1. Now some of them represent 10. To make this clear, suggest writing the ones in the left column with T's e.g. [T]

Then problem 1 becomes



$$\begin{array}{rr} 4 & 3 \\ -\,1 & 2 \\ \hline 3 & 1 \end{array}$$

(Shading seems bad as it stands, because only shaded blocks were subtracted before.)

Multiplication IV, Skill 2

p 4. Very confusing. Suggest making the number line horizontal and having it go from 1 to 40.

TA-3. 2 lines up from bottom. Replace "3 x 4" by "4 x 3".

Multiplication IV, Skill 6

The objective implies that the child can do pages like page 7 with all of the numbers left blank. There should be some problems like this.

Multiplication IV, Skill 7

p 3. Give one more answer in each column to make the pattern clear.

p 4. You could delete the shading. The fact that 2 x 2 = 2 x 2 is just one more example of the commutative law. It is important that the child know that in the number sentence $\triangle + \square = \square + \triangle$, the numbers may be the same.

p 5,8. Delete the shading (except where the product is too large).

Multiplication IV, Skill 9

Basic assumptions should be stated as follows:

p 1 no. 1. Each coach needs 4 horses.
p 2 no. 1. Each load has 5 poles.
p 3 no. 3. Each stool has 3 legs.
p 7 no. 2. Each sloth has 4 legs.

Fractions IV, Skill 5

In the objective, replace "using pictures" by "given pictures." If the child is to construct his own pictures, as implied by the present wording, then extra pages must be added requiring this.

Money IV, Skill 1

p 1. Delete 0 → in each case; it is confusing. Just leave a blank.

Measurement V, Skill 1
p 7. An empty bushel basket should be included here as measuring instrument for use with the apples. Delete "1 peck
1 bushel".

Numeration VI, Skill 7
p 17,18. Heading on last column is ambiguous. Suggest changing to "Neither prime nor composite" or just "Neither".

Multiplication VI, Skill 1
A review page is needed at the beginning to do problems such as 3 x 10 = ____, 4 x 50 = ____, 5 x 70 = ___ (as in Multiplication V, Skill 6).

Multiplication VI, Skill 2
Between pages 9 and 10 there should be a review page of problems to be done in their head, such as

3 x 4 + 2
6 x 8 + 3
7 x 5 + 4 etc.

This is a prerequisite skill for pp 12-16.

Multiplication VI, Skill 6
The short cut procedure given on pp 13-14 was already given in Numeration VI, Skill 8. It could be used from the start on this skill.

Multiplication VI, Skill 8
p 12. In problem 7, there is no higher count on the 5's.
In problem 8, there is no higher count on the 7's.
In problem 11, an exponent is needed on the first 5.

Division VI, Skill 1
Needs a review page with problems like 3 x 40 = ____, 7 x 30 = ____.

Division VI, Skill 2
pp 8,9. A worked-out problem where you subtract 200 fours would be helpful. Suggest changing problem 1 on p 9. to

4) 908	= 227
-400	100 fours
508	
-400	100 fours
108	
- 40	10 fours
68	
- 40	10 fours
28	
- 28	7 fours

Division VI, Skill 2 pp 18,19,21.
Skill 3 pp 3,5,6.
Skill 4 pp 3,5,6.
More space is needed on these pages because the child must use the distributive law to do the divisions.

Division VI, Skill 4
p 5. Problem 2. Lost line should be
$7\overline{)173} =$ _____ (instead of $5\overline{)173} =$ _____).

Fractions VI, Skill 2
This entire section should be rewritten. It makes extensive use of the unjustified fact that

$$\frac{a}{b} \times \frac{c}{d} = \frac{a \times c}{b \times d}.$$

It also uses the unjustified assumption that

$$\frac{a}{b} \div \frac{c}{c} = \frac{a \div c}{b \div c}.$$

Fractions VI, Skill 3
pp 8,9. Delete. These use the unjustified fact that

$$\frac{a \cdot c}{b \cdot d} = \frac{a}{b} \cdot \frac{c}{d}.$$

p 12. Delete last half.

Mixed Operations VI
Suggest replacing the word "variable" by the word "unknown" in the statement of the objective.
p 10. The 10 litre GT is especially neat. But how many people will get the joke?

Mixed Operations VI, Skill 4
The left to right order is a correct convention on addition and subtraction. But it is <u>not</u> an accepted convention on multiplication and division. That is, $8 \div 4 \times 2$ is ambiguous without parentheses.
pp 4-12. Should be rewritten to include the left to right convention on addition and subtraction, but it should be pointed out that there is <u>no</u> convention on multiplication and division.

Time VI, Skill 3
pp 5-10. These problems suffer from the same ambiguity as those in Time V, Skill 6, p 6. Use of the phrase, "days (or weeks) later", may clear up some of the ambiguity (e.g. Bill got to Germany 2 weeks later, Eddie finished the tree house 3 weeks later).

Measurement VI, Skill 1

p 1. You do not use inches of wood. You use square inches. Rewrite the problem.

Measurement VI, Skill 2

p 2. Number 1. Preserves are also sold by weight. Since either answer is correct, suggest deleting the problem.

Numeration VII, Skill 1

p 7. A VW weighs about 2,000 pounds, not 4,000 pounds.

Appendix IX b

General Report on I.M.S.

by
Joseph M. Scandura

GENERAL REPORT ON I.M.S.

PART A. ADDITIONAL GENERAL COMMENTS

The I.M.S. materials seem to provide a useful set of materials for teaching the usual elementary school arithmetic skills. The objectives are specific enough to be useful, without being overly specific. With the exception of the specific changes suggested in the first report, they are clear, comprehensive, and precise.

The teaching materials provide for achievement of the stated objectives. They should be suitable for a wide spectrum of schools and children. The materials should enable most children to achieve the stated objectives. However, it should be recognized that some children will not meet the stated objectives after using these materials only. Specific suggestions should be made to the teacher for additional work on each major type of objective for children who do not reach criterion. Better yet, supplementary materials might be prepared (see Part B of this report).

The following are some general reservations about the I.M.S. materials.

1. Arrows are used indiscriminately with no immediately apparent thought or planning. In mathematics, arrows are generally used to represent functions (or mapping or correspondences) and vectors. In these materials they are used in many ways, with no apparent pattern (see Numeration I, Skill 10; Addition I, Skills 2 and 3; Subtraction I, Skills 3 and 5; Fractions II, Skill 1; Division III, Skill 1 (on page 4, arrows have two different meanings on the same page); Money IV, Skill 1).

All uses of arrows should be checked, to see if some order can be created in their use.

2. The general convention of pronumerals is not followed. That is, in the number sentence $\square + \triangle = 8$, one is allowed to substitute distinct (or equal) numbers for $\square$ and $\triangle$. But when a pronumeral is repeated in a number sentence (e.g. $\square + \square = 8$) you must substitute the <u>same</u> number in each case. The I.M.S. materials violate this general convention.

An attempt was made to list all places where this occurred on specific pages.

3. Children may need help with some of these materials. The individual pages, in many instances, do not make clear what needs to be done. Even the Content and Procedures pages are not specific enough in some cases.

Some specific places where this occurs are:

Money I, Skill 2, p 6

Measurement I, Skill 1, pp 16,17

Measurement II, Skill 1 (all pages)

Measurement II, Skill 4, pp 9,10

Multiplication V, Skill 5, p 4

4. The meaning of division is reversed part way through the materials, but this is never pointed out. In Division III, Skill 1, it is stated that in $a \div b = c$, $a =$ the total number of elements, b represents the number of subsets, and c represents the number of elements in each equal subset.

Later this is reversed, so that b represents the number of elements in each subset and c represents the number of subsets. The relationship between the 2 kinds of problems is never made clear. (It is stated that repeated subtraction solves the second situation.) The fact that the same division problem can be used to solve both kinds of example should be made clear.

5. The fact that $(a \times b) \div c = a \times (b \div c)$ is used in Division VI, Skill 1 but it is never explicitely justified.

6. Some pages in several sections require abilities beyond the stated objective. However, in general, the additional ability is not required on the check-up pages.

Some specific places where this occurs are:

Mixed Operations I, Skill 3, pp 1-4

Time I, Skill 1, p 3

Numeration II, Skill 8, pp 17,18

Subtraction II, Skill 5, pp 1-5

Numeration IV, Skill 5, p 1

Measurement V, Skill 2, p 6

Measurement V, Skill 3, pp 7,8

7. In Numeration III, Skill 11, the general structural properties of Roman numerals are not explained, nor is the general subtraction principle explained. Everything is strictly rote. Even p. 12 seems to require translation to Arabic numerals and then translation of the sum back to Roman numerals. Some explanation of the general procedures for writing Roman numerals would be desirable.

The same applies to Numeration IV, Skill 8.

8. Many number lines are represented as sequences of shorter number lines. Whenever possible, it might be better if the page was turned sideways, the scale made smaller, and the entire interval under consideration

put on a single line.

9. In many instances (e.g. □ x △ = 20), there are several correct answers. This should be pointed out to the teacher.

PART B. SUGGESTED NEW DIRECTIONS

Although the I.M.S. materials cover the stated content objectives quite adequately (subject to the reservations stated in Part A.) there are three basic needs which are not met directly. Several members of the Mathematics Education Research Group (MERG) are engaged in development projects aimed at these needs. They merit attention by R.E.L.C.V. as a possible direction for further development in conjunction with MERG.

The purpose of the first is to devise efficient, self-instructional materials to teach and/or provide review in the basic arithmetical skills of addition, subtraction, multiplication, and division. It is highly likely that some children will not master these skills after using the I.M.S. materials, and efficient back-up materials are needed. The second project is aimed at developing a systematic way of teaching children to think critically while reading (i.e., to read critically), and is based on a behavioral analysis of the process in terms of logical reasoning. To these, I would add the critical need to train teachers how to systematically provide their students with opportunities to increase their ability to learn new material of a technical sort, to communicate with precision, and to reason logically. While not normally considered to be part of mathematics, these basic processing abilities are critical not only in mathematics itself, where they obtain perhaps their clearest expression, but also in the everyday world of reality.

It is easy to justify inclusion of these three projects in further development aimed at an idealized mathematics curriculum. Children in the Philadelphia schools, for example, particularly those in West and North Philadelphia, average several years behind the national norms in arithmetic. Many of these children could be expected to learn the arithmetic skills from the I.M.S. materials. But many others would undoubtedly fail to master them. Working individually with these children could severely limit the time the teacher has available for dealing with many of the equally, if not more, important aspects of mathematics education; meaning, processing skills (e.g., reasoning), and relationships to other subject areas and to reality are some of the more obvious. Hopefully, the inclusion of back-up self-instructional aids for teaching the basic arithmetical skills will relieve the teacher of part of this responsibility, thereby providing more time for emphasizing meaning, processing skills and the rest. It cannot be taken for granted that teachers will automatically do this, however, and the other two projects are designed to help insure that the change does occur.

One of the most critical of these needs is for the student to see the importance of precise logical thinking in areas outside of mathematics as well as within the subject itself. The ability to read critically has to be one of the more important areas in which this skill is needed. This is an area where development is definitely needed, because in spite of the concern many have expressed about critical reading, very few materials exist for teaching it. Educational products which are designed to deal with the problem in a systematic way are nonexistent. The difficulty is that there has been no adequate conceptual base for dealing with the problem. MERG feels that it has such a base and is presently trying to demonstrate its value.

It is also hoped that by providing teachers with self-administered instructional aids to use with their pupils (e.g., the arithmetic skills materials), they will have more time and be more willing to engage in a period of inservice education and/or classroom practice designed to improve their ability to teach basic processing skills. In view of their great importance, one could hardly do otherwise than to make provision at the earliest possible time for improving such skills in any educational program designed for educating the disadvantaged child.

In the remainder of this section, specific projects for meeting these three needs are described, together with descriptions of what has been done so far.

1. Arithmetical Skills Project

The arithmetic skills project has been sponsored by the Mathematics Education Research Group (MERG) on a limited basis for approximately one year. The work has been done under my direction by Jeannine Gramick, Debra Whitley, and John Durnin. At the present time, the major part of the engineering described below, as well as some of the development and evaluation of prototypes, has been accomplished. Large scale development and revisions remain for the future.

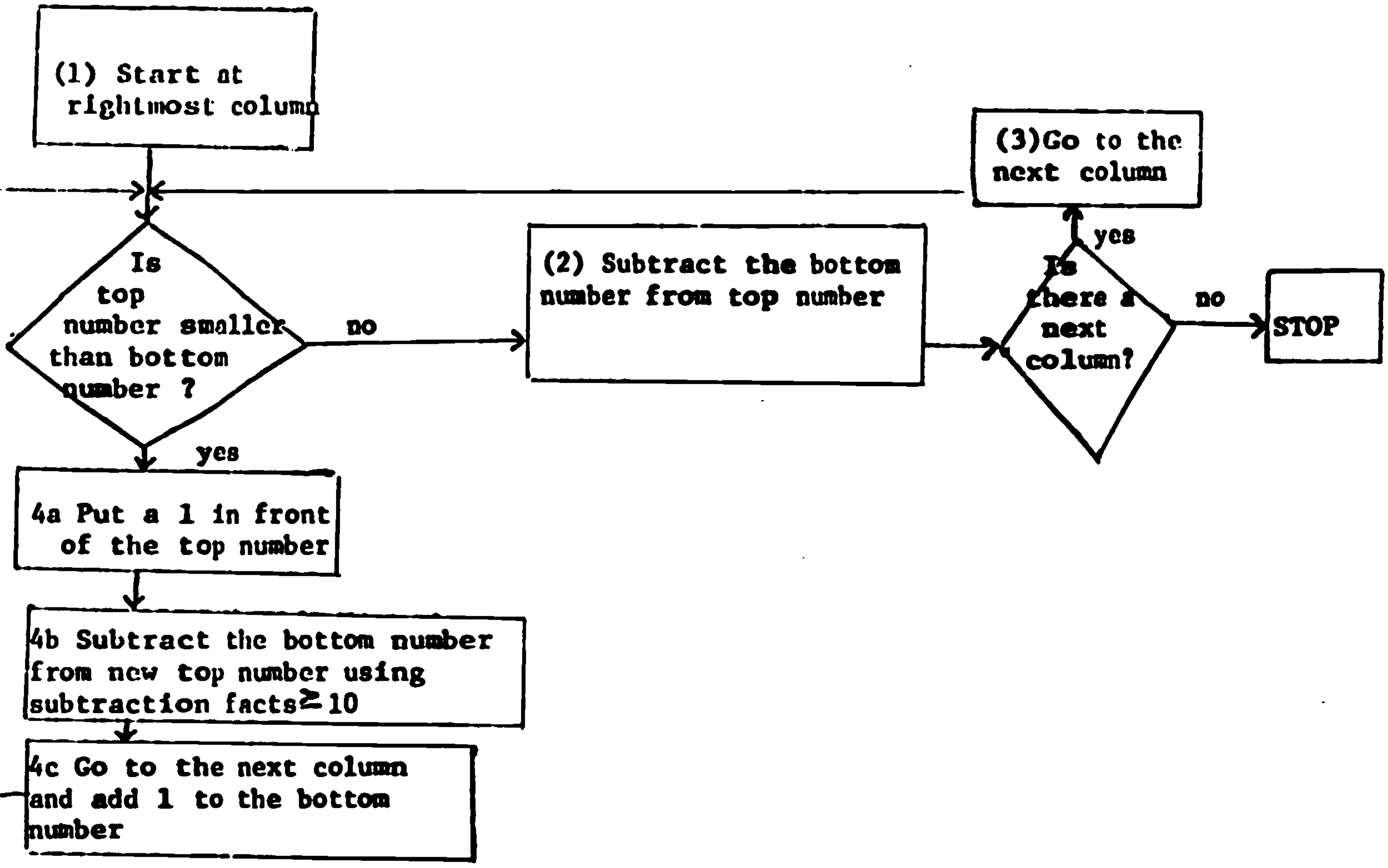
Recent basic, theoretical advances here have provided us with a basis for ordering competencies (i.e., rules, algorithms, or paths thereof) according to difficulty. This type of ordering makes it possible to increase the efficiency of the assessment procedure and to systematically sequence the instruction in teaching each of the arithmetical skills.

The first step in engineering the project was to refine the (technological) goal -- that is to specify those aspects of the total project which might be engineered by building on available conceptualizations. In the present case, our goals were to identify: (a) the most efficient procedure possible for performing each kind of computation, (b) the best way to sequence instruction on the parts (i.e., the paths) of this procedure, and (c) an efficient method for assessing mastery at each stage.

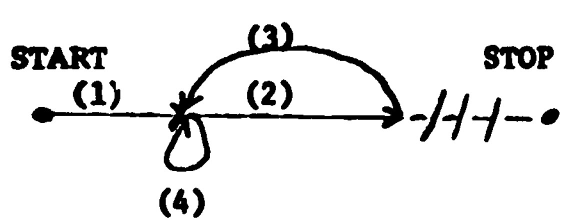
The next step was either to adopt an existing engineering plan, or to devise a new one, for achieving the above goals. (a) In order to find the most efficient procedures possible, which were compatible with the usual computational algorithms, we proceeded as follows. For each arithmetic operation, flow charts were prepared for the common algorithms in order to specify precisely what was involved at each step. Programming techniques were then used to combine the alternative algorithms, to eliminate redundancies, and otherwise come up with the best possible algorithm. This typically involved minimizing the number of paths involved, but such considerations as difficulty of the paths, and prerequisite abilities which could safely be assumed of the pupils, were also involved. The procedure used for subtraction can be represented as follows.

Insert Figure A here

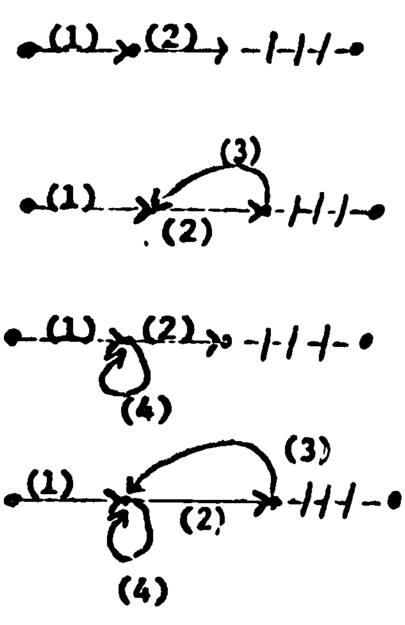
Figure A



Directed Graph



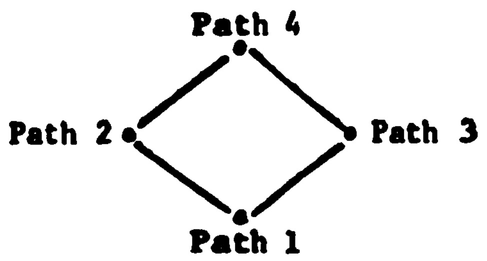
Paths



Instances

1. 7 − 3
2. 368 − 241
3. 1563 − 875
4. 8456 − 29

(b) The directed graph at the bottom of the figure is a form of representation we have developed, which is useful both in pinpointing equivalence classes of tasks for testing and in arranging paths according to difficulty. In fact, all that is necessary in arranging (sequencing) paths according to difficulty is to choose the most direct path (e.g., Path 1) first, then the next most direct paths (e.g., Paths 2 and 3)--there may be more than one, and so on. The partial ordering imposed in this manner on the above subtraction algorithm may be represented by the following lattice.



It is this ordering then that provides the basis for sequencing the instruction.

(c) The ordering provides the basis for sequencing the testing. Our assessment procedure involves selecting just single test instances from each equivalence class of tasks (where each path corresponds to a distinct equivalence class). The ordering of paths according to difficulty, increases the efficiency further by making it possible to introduce a conditional testing procedure. The basic rationale is that if a pupil succeeds on tasks corresponding to more difficult paths in a hierarchy, then there is no need to test him on less difficult ones. Where the more difficult task is failed, of course, additional testing will be necessary.

In the above discussion, we have used the algorithm for subtraction to illustrate the engineering plan for achieving the indicated goals. This process has also been carried out for the addition, subtraction, multiplication; and division algorithms. Thus, at the present time, we have completed most of the engineering for computation with the whole numbers and could begin work with fractions and decimals if resources were available.

The actual development of usable products is at the prototype stage. The plan used to date involves the eventual use of two- or four-track cassette tape recorders, together with student workbooks. The idea is to provide the child with a self-instructional mode which he can use to work at his own pace, and to minimize the amount of effort required of the teacher so that she will be free to devote herself to the explanation and exploration of important underlying concepts. As a first step in this direction, we have been working on preliminary versions of the workbooks and scripts for the tapes. Due to cost factors, the latter have been tried only with single-track tapes.

Tentative plans call for building in motivation through a variety of devices. One such device that has already proved useful involves putting teaching and review in a game context where possible. Another way to increase motivation would involve the use of four-track tape recorders. (Such recorders will also be necessary if we are to capitalize fully on the engineering that has already been done. Thus, in addition to switching among different cassette tapes according to his needs, the child would be able to switch from track to track within any given tape.) Our hopes are that providing the child with a choice of tracks (i.e., a variety of review modes -- some involving games) will tend to increase his span of attention, and inject a bit of the unexpected (i.e., "What kind of review am I going to get?") into an otherwise repetitive, but important,task. In addition to providing variety, we also plan to reward success more directly by including a few minutes' worth of music, jokes, and/or humorous commercials and dialogue on the "success" channels.

Although the development plan has appeared promising in preliminary tryouts, the skills project clearly points to the need for further basic work in the areas of motivation and memory. Hopefully, such work will lead to the development of systematic engineering techniques which will make it possible to deal with these aspects of development in a more effective and efficient way.

2. Critical Reading Project

The immediate goal of this project is the development of self-instructional materials for testing and teaching critical reading skills in urban schools. Many children who have learned to read in a more or less technical sense cannot read critically. They can translate written statements into sounds and know what these statements mean, but ideas come through as fragments which are, for the most part, unrelated to the more comprehensive whole. Ultimately, we hope to expand the scope of the project to deal with reasoning more generally, and at younger age levels. (Some suggestions are sketched below for moving in this direction.)

In helping to meet these needs we have been able to draw on two basic ideas (conceptualizations) and one technology. A behavioral analysis of the process by which meanings are related reveals the involvement of what are called semantic inference rules. Semantic inference rules parallel the syntactic versions characteristic of symbolic logic, and operate on meanings.

The second conceptualization is at base a taxonomy for classifying meaningful reading contexts according to the generality of the semantic inference rule required to reason effectively in that context. Given any particular (syntactic) inference rule, for example "A implies B," "A;" therefore, "B," the generality of the corresponding (semantic) inference rule needed would depend, for example, on the amount of irrelevant information contained in the reading context. The more redundant information included, the more general the(semantic) rule required. In all, five essentially independent dimensions, ordered according to difficulty (and hence, according to degree of generality required of the underlying semantic inference rule), were identified along which reading contexts can vary.

In addition to these conceptualizations, qua conceptualizations, a potentially useful engineering technology has already been developed. This involves a technique for assessing behavior potential on classes of tasks which vary along a set of independent dimensions. The technique is described in its original form in Scandura (1968) building on the experimental results of Scandura and Durnin (1968).

These conceptualizations provided a basis for the systematic attainment of the following aspects (i.e., the technological goal) of the critical reading project. The first goal was to specify the kind of behaviors involved in the use of each semantic inference rule, e.g., the ability to detect valid inferences, contradictory statements, and invalid inferences, all in the context of written materials. The second was to specify the dimensions, and the levels along these dimensions, over which the stimulus materials for each inference rule may vary. The third major goal was to determine the most efficient way to sequence the testing and instruction so as to determine in exactly what reading contexts each child can use each logical rule, and to expand these contexts as much as possible.

The engineering plan used involved first selecting the most common logical inference rules and specifying precisely the various dimensions, and levels along these dimensions, over which actual stimulus contexts (i.e., reading passages requiring use of these rules) may be realized. Next, we had to actually construct, for each inference rule, reading passages with specified levels along each of the dimensions. We then had to refine the testing procedure given in Scandura (1968) and to extend it so as to sequence the instruction from level to level. Because it is not yet feasible to attempt a fully algorithmic analysis of semantic inference rules, however, some form of inductive method (i.e., learning by example) must be used within any given level. A direct expository approach requires precise specification of underlying rules.

In order to actually develop a usable product, it was necessary to incorporate the engineered materials into a more general plan which took other factors into account, motivation being perhaps the most crucial. We attempted to build motivation into the materials by making the "stories" short and as interesting as possible. Short, frequent subtests were also included, so that each child would not only get adequate reinforcement and sufficient practice, but so that he would get extra practice where needed.

As in all development, of course, we also had to deal with questions of format. After full consideration of the alternatives, it was decided to initially limit ourselves to a reading mode, specifically a mode designed for children reading at the third and fourth grade levels. Workbooks and pre-recorded tapes are now being prepared. Although they are primarily designed for self-instruction, these materials could also be used in group instruction. Here, the teacher would have the students use the workbooks and generally follow the scripts from which the tapes are to be made.

Even if the initial tryouts of the prototypes are successful, we want to keep open the possibility of trying other modes before undertaking large scale development. It may be desirable, for example, to modify the materials for use with younger children by introducing a pictorial and/or aural mode. In particular, using such modes could make it possible to work with nonreaders as well as readers.

3. Processing Skills Project

In this final section, we describe a development project aimed at meeting the critical need for awareness and successful teaching of the more general process abilities, which are critical in performing a wide variety of mathematical tasks. As many schools presently exist, this need is twofold: first, to increase the teacher's awareness of and training in these processing skills; and second, to develop instructional material for the student which maximizes his opportunity to acquire these skills.

The conceptual base for this project includes the taxonomy of process abilities in mathematics which is described fully in Chapter 1, Mathematics: Concrete Behavioral Foundations.*Briefly these abilities are: (1) detecting regularities, and the reverse ability of (2) particularizing; (3) interpreting mathematical descriptions, and the reverse ability of (4) describing mathematical ideas; (5) making logical inferences, and the reverse ability of (6) axiomatizing. This conceptualization derives from an attempt to define operationally what it means to "think mathematically."

In addition to this taxonomy, which by itself would constitute a fairly limited conceptualization, we have available a theory of knowledge which provides the basis for an "algorithmic analysis". This analysis involves systematic identification of the tasks to be learned, formulation of these tasks in terms of (observable) behaviors to be elicited, formulation of an efficient rule for solving each task, elimination of redundancies, searching for higher-order rules, and finally eliminating those rules which can be derived by application of higher-order rules.

Finally, logical analysis of the rules introduced to generate various classes of tasks provides a conceptual base for Gagne's "task analysis," which may be used for the identification of prerequisite abilities. In describing the engineering phase of the proposed project, we shall see how these conceptualizations can be systematically brought to bear in the attainment of our goals.

The first step in engineering the plan is to refine the (technological) goal -- i.e., to identify those elements in the development that can be dealt with systematically, based or available conceptualizations. Evidently the following aspects of the present project should be susceptible

*Harper & Row, 1971.

to this kind of engineering: (a) developing introductory materials explaining the taxonomy to pre-and elementary school teachers, and training them explicitly in the processing skills; and (b) developing specific curriculum materials for use in the schools which systematically teach and emphasize the use of processing skills in performing a variety of mathematical tasks.*

The second phase is to devise systematic techniques for achieving the two technological goals above, based on the indicated conceptualizations. (a) The processing skills themselves as well as the overall taxonomy, constitute the subject matter content of the introductory material for mathematics teachers. Here, the technique would be to apply "algorithmic analysis" to the existing descriptive literature, in order to develop material which teaches the subject more efficiently.

(b) To develop the curriculum material for students, we would first collect subject matter (from existing school curricula) illustrative of the processing skills, and systematically identify the process abilities involved using the taxonomy. Other tasks requiring processing skills would be devised from scratch to fill voids in the taxonomy. To the extent feasible, the material selected would then be systematically sequenced using task and/or algorithmic analysis.

The third phase is the actual application of these techniques to achieve an engineered plan. Some work in this direction has already been carried out -- in particular, members of the Mathematics Education Research Group have completed an algorithmic analysis of Chapter I,

*At the present time, we leave open the question of how closely such curriculum materials should parallel existing subject matter curricula in mathematics. While a close parallel might facilitate the immediate applicability of our material in the schools, it could diminish the efficiency of teaching the processing skills.

Mathematics: Concrete Behavioral Foundations.

In the fourth and final phase, those responsible for the engineering would cooperate with those responsible for the development, in identifying explicitly those aspects of the development which must be dealt with on more intuitive grounds. For example, here we can identify the motivation of teachers, motivation of students, decisions regarding media or presentation, and those aspects of the sequencing not governed by task and/or algorithmic analysis.

The responsibility of the developers is to come up with and implement a practical plan for incorporating the engineering into a usable product. (a) For example, having decided on the potential value of a workbook for training teachers in the taxonomy of process abilities, the developers must rework the engineered materials into a workbook format so as to build in the non-engineered elements of motivation, sequencing, and so on.* (b) Likewise, a medium of presentation would be selected for the curriculum material, and the developers would have the responsibility of synthesizing the engineering and the non-engineered aspects such as motivation into a final product suitable for the schools.

*This process is now complete for the workbook accompanying Chapter I of Mathematics: Concrete Behavioral Foundations. Task analysis was not used to engineer the sequencing of the workbook material; this was inherent in the chapter itself.

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Appendix X

Cover Letters for the Teacher Surveys

December 18, 1970

The next EC Meeting will be held January 15, 1971, in Durham. I will advise you of the exact location and agenda the first week of January.

Enclosed is a set of materials contributing to our evaluation as follows:

1. The first Teacher Survey - Please get all teachers who are or will be using IMS this year to fill out a copy. If you are a classroom teacher please out a copy yourself.

2. Incident Report Forms - Please duplicate additional copies of these if you need them or collect incident reports on plain paper. If materials are involved, the Incident Report should identify the page and problem that caused trouble. The few we have recived thus far are inadequate in that they contain comments, not the incidents that gave rise to the comments. There are places on the Survey for comments and opinions.

3. Error List #3 - These are errors which you reported that were not on any prior list. Please continue to collect errors. Incident Reports are the best way, since finding an error is an incident. However, please ask teachers to explain and give level, page, and problem number of errors carefully. Some we received could not be tracked down.

4. A Census Report Form - Please fill this one out for the period ending January 15, 1971, just as you did for the one covering through November 30, 1970.

   If more classes or groups have moved into IMS in your school since November 30, please record them on a separate report form. (Two are provided in case you need them.)

Please bring all of the above items with you to Durham in January. There is no need to mail them ahead of time unless this is more convenient.

Thank you for your cooperation and let me know if you require any further information.

Sincerely,

Robert B. Frary

Robert B. Frary
Research Associate

RBF:clg
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regional education laboratory
for the carolinas and virginia

March 8, 1971

Enclosed are copies of two new survey forms. Let me explain each in turn:

1. EC Questionnaire (one copy only) Please fill this out so that we can standardize some of our information about schools.

2. Teacher Survey #2 This survey is only for teachers now using IMS. It clarifies some of the questions raised by the earlier survey and seeks some new information.

Please return the completed forms to me by mail as soon as possible.

As you may know by now, it was necessary to change the date of the principals' meeting to March 19. The next EC meeting will take place as planned in April. At that time we will probably want to get your ideas on how many of each folder should be stocked in your school for future usage. The date will be announced in early April (probably April 16 or 23). Do you have a preference?

Have you had an opportunity to collect any children's favorite story lines for use in IMS-2? You may remember my mentioning this at the last EC meeting. Any documentation you could provide would be helpful. Perhaps you could get some imaginative themes from children in your school or a nearby junior high school. Mathematical content is not necessary.

Thank you very much for your help.

Sincerely,

Robert B. Frary
Research Associate

Enclosures
RBF/swb

mutual plaza (chapel hill and duke streets) durham north carolina 27701 telephone 919-688-8057

REGIONAL EDUCATION LABORATORY

FOR THE CAROLINAS AND VIRGINIA

May 21, 1971

Dear Teacher:

This is the final IMS survey which should be answered anonymously. A number of questions on earlier surveys are being repeated for two reasons:

1) A number of responders omitted items on earlier surveys, thus indicating they had not reached a conclusion. On this survey, please do not omit items. If you are not sure, mark the choice which seems closer to your belief.

2) In some cases opinions change with time, and we want to record any shifts that may have occurred.

Thank you for your cooperation both in using IMS and in helping in our formative evaluation. Because of your assistance, IMS should be a much better system as it is used in more and more schools.

Sincerely,

Robert B. Frary
Research Associate

Enclosure

RBF/swb

Mutual Plaza (Chapel Hill and Duke Streets) Durham, North Carolina 27701

regional education laboratory
for the carolinas and virginia

May 21, 1971

Here is the final set of evaluation materials for your school. Please give each teacher using IMS a questionnaire and emphasize that we would appreciate their marking every item even if they have not completely made up their minds on a question. (This is explained on the questionnaire cover letter.) Of course, you should fill out a copy. Since the questionnaires are anonymous, please keep a checklist so that you can tell when all teachers have returned We would like to have 100% returns on this questionnaire.

Census forms are enclosed for the end-of-year results. Please remember to report the levels the students will enter next, not the levels they have completed. In other words, base the final report on anticipated fall, 1971, placement (assuming no loss over the summer).

Please return the completed questionnaires and census data as soon as possible. Final census results will be returned to you shortly. The final report summarizing all evaluation outcomes will be completed late in the summer and multiple copies will be sent to all schools.

Finally, thank you for your fine cooperation throughout the year. It is a big job to make real improvements in the way children are taught, and you have done more than your share.

Best wishes for now. I hope we will have an opportunity to meet or work together again.

Sincerely,

Robert B. Frary
Research Associate

Enclosures

RBF/swb

Appendix XI

Results of the Item Analysis of Posttests

Results of the Item Analysis of Posttests

Test	No. of Cases	Skill	Prob. Nos.	Comments
Num. II	112	6	29-31	Older, less bright students missing these. Reason obscure.
			34	Teaching materials have no practice for case of zero tens along with nonzero units.
		7	36-37	Revise test item. Nonconventional no. line representations not in teaching materials.
		8	44-46	Test format confusing; revise.
Add. II	43	2	6	Teaching materials lack emphasis on addition of zero.
		3	10-12	Problem format too difficult for younger and low ability children. Nothing similar in teaching materials.
Subt. II	78	2	8-11	General evidence of unsuccessful achievement, but could be problem format on test.
Mult. II	93	1	3	Sets of 1 not covered adequately in skill folder.
		2	9-11	Problem format may be too difficult. Add a worked example.
			12	Materials lacking example using one row or one column.
			14	Require specific response.
		4	21-26	Revise items to conform to materials Provide intermediate steps.
		6	32-34	This skill folder and corresponding test items already revised.
Div. II	91	1	3-8	Test and related materials already revised.

Test	No. of Cases	Skill	Prob. Nos.	Comments
Div. II	91	2	9-17	Test and related materials already revised
		3	18-24	
		4	27	Revise item to eliminate reading requirement.
Frac. II	81	1	5	Move irregularly placed square into pattern.
M. Op. II	84	1	4	Materials need more emphasis on adding zero.
		2	8	Materials need more multiplication problems along with addition.
Meas. II	109	1	9	Items already revised.
		2	20,21	Revise items so block divisions can be seen through shading.
		2	22,23	Frequently missed on posttest, yet very similar to checkup test. Reason obscure.
		3	24-30	Items already revised.
		4	35	Item already revised.
		5	36-39	Change format so all responses require writing a letter. Include item with bulky but light and small but heavy materials on scales.
Num. III	112	7	30-33	Change items using "smallest" rather than "least."
		8	34-40	Materials may need to be revised to provide more practice. Test items should be preceded by worked example.
		9	41-44	Same difficulty as Num. II, Skill 6. Older, less bright, students missing items. Worked example might help. Teachers may need to prescribe activities for older students.
		10	45-48	Same comments as for Skill 9.
		11	49-54	Teaching materials need more items requiring students to write rather than choose responses.

Test	No. of Cases	Skill	Prob. Nos.	Comments
Add. III	39	2	15	Students may need more practice with numbers greater than ten at this point.
Subt. III	57	1	10,11	Students may need more practice with problems of the form 10=___-5.
		2	18-21	Too difficult for older less bright students. Reason obscure.
Mult. III	79	3	25	Multiplication by one causing difficulty. Materials provide practice; therefore, reason obscure.
Div. III	89	3	21	No practice for two different division statements related to 5 x 2=10, viz. 10 ÷ 5=2 and 10 ÷ 2=5.
		4	22	Too difficult for younger children. Worked example might help.
Frac. III	159	2	19	More practice needed involving shading of non-contiguous areas.
		5	41	Test item already changed.
M. Op. III	99	2	11	Too difficult probably due to inadequate materials coverage of half dozens in Meas. II, Skill 4.
		5	35,40, 41	Materials need more practice with items of the form □-4=16-5 and 16-5=12-□.
Time II		Insuffucient cases to analyze.		
Money III		Insufficient cases to analyze.		
Meas. III	94	1	4,5	Yardstick needs to be redrawn.
Num. IV	142	2	19	Materials do not teach counting backward.
		8	47,49	More practice needed in changing Roman numerals to Arabic (not the reverse).
Add. IV		2	10-13	Change problem format to that of check up test.
			14-20	Problems should be preceded by worked example.

Test	No. of Cases	Skill	Prob. Nos.	Comments
Subt. IV	69	4	37	Two correct choices (item has been revised).
Mult. IV	124	No deficiencies detected.		
Div. IV	105	1	4	Changes item to show divisor.
		2	17-19	Change to format of Item 16. (Questions do not conform to materials
		4	29	Replace item so that only a single response is required.
Frac. IV	105	2	9,12, 14,17	Materials do not sufficiently cover case in which numerator is greater than 1 and number of items in picture is 2, 3 or 4 times as large as denominator.
		5	37-40	Already changed to conform to materials.
			41-43	Should have worked example.
M.Op. IV	140	1	9-10	Eliminate double responses. Show worked example.
Money IV	72	No deficiencies apparent.		
Time IV	81	5	19-23	Problems generally too difficult. Revise to conform to checkup test.
Meas. IV	110	3	12	Materials do not teach reading between marks on thermometer, but this is covered by objective.
Num. V	91	No deficiencies apparent.		
Add. V	86	No deficiencies apparent.		
Subt. V	82	1	13	$\square - 4 = 4$ too difficult. Reason obscure.
		5	44-48	Show worked example. Eliminate "Use ______."
			50	Students need more practice with regrouping minuends containing zeros.
Mult. V	94	No deficiencies apparent.		

Test	No. of Cases	Skill	Prob. Nos.	Comments
Div. V	103	3	21-24	Some tendency for brighter children to miss these. Format differs from checkup tests but not from some of practice pages. A worked example may help.
			25	Frequently missed. This is only item which requires student to supply entire solution. Yet all checkup test items have this characteristic. Suggest more such items in format of checkup test.
		5	36,41	Omit items with remainder in testing this skill.
Frac.V	91	1	7	Materials do not cover cases in which representations of fractions are of this type.
		2	11,12	Too difficult. Reason obscure. May be lack of practice with sixths and sevenths.
M.Op. V	82	1	1,6	Show spaces for conversion to cups or pints. Make reconversion to quarts a separate problem.
		2	13	Item inappropriate.
			14	Format confusing.
Money V	69	No deficiencies apparent.		
Time V	72	2	7,11	Clock minute hand points between hour marks difficult to read. More of this kind of problem.
		4	20	Same as above.
Meas. V	91	3	16	Students probably confusing page width with test margins. Revise problem.
Num. VI	119	4	15	End points of number line segment probably not prominently enough marked. Add more of this kind of problem.
		7	32	Students need more practice with numbers not discernable as prime or composite through knowledge of multiplication table, e.g., 51, 57, 91, 121.

Test	No. of Cases	Skill	Prob. Nos.	Comments
Num. VI		8	34,35	Students need more practice writing larger numbers as products of primes. (These are on checkup tests.)
		9	38,39	Provide some test problems showing structure for answers, e.g., $24 = 2 \cdot 2 \cdot 2 \cdot 3 = 2^3 \cdot 3$. Then follow with problems in which students provide entire answer.
			42	Change to square of a prime, e.g., 49.
Add. VI	81	No deficiencies apparent.		
Subt. VI	77	2	13,15	Difficulty when number of decimal places not same in subtrahend and minuend. Materials need practice page devoted to this situation.
Mult. VI	79	4	17	Probably needs a worked example.
Div. VI	70	No deficiencies apparent.		
Frac. VI	58	2	9-15	G.C.F. not involved in teaching materials for this skill. Revise problems.
M.Op. VI	47	No deficiencies apparent.		
Money VI	51	No deficiencies apparent.		
Time VI	42	5	26	Materials need to provide more practice for items of this kind.
Meas.VI	47	5	23-27	Underline or use all caps for measurement units different from preceding ones in problem.