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ABSTRACT

The educational background and issues which shaped the design of the National Migrant Education Program Math Skills Information System are explained in this report, along with a full description of the features of the system and its operation. It discusses the variety of math skills information used to permit teachers to input and receive math skills information about migrant students in order to insure continuity of education. Discussion covers the (1) issues and factors affecting the design of the Migrant Student Record Transfer System (MSRTS) Math Skills Information System--its users, skills information needs, math skills hierarchy, continuity, "proper" math skills; (2) background and design considerations of the MSRTS Math Skills List--nature of math as a subject matter, anatomy of a math skill statement, selection of the level of detail at which to define math skills; (3) structure of the MSRTS Math Skills List--areas, topics, subtopics, skills, code structure, sequence of skills; (4) continuity and user information needs--need to know status of student regardless of teaching methods used; (5) Math Skills Information System reports (displays) and reference documents--volume of information, mini-skills lists, level of detail for reports, standard displays, standing orders; and (6) the system's operation. Also included are samples of reports and queries. (RS)

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NATIONAL MIGRANT EDUCATION PROGRAM

MATH SKILLS INFORMATION SYSTEM

Raul de la Rosa and Eugene deG. Hackett

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This document delineates the educational background and issues which shaped the design of the National Migrant Education Program Math Skills Information System, narrates the features of the system, and describes its operation.

For further information and/or acquisition of Math Skills Booklets contact your state director of Migrant Education, or:

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INTRODUCTION

The MSRTS Math Skills Information System is designed to permit teachers to input and to receive math skills information concerning migrant students in order to ensure continuity of education. During the design of the Math Skills Information System, literally hundreds of educators were consulted, some formally and in great detail, others informally and in lesser detail. These educators consisted of classroom teachers, aides, tutors, special resource teachers, math specialists, university faculty in math education, administrators, and others.

In the course of these consultations, it became apparent that math education is not the "logical", tidy, monolithic, universally consistent enterprise that a lay person might expect it to be. Math education, as with any other human endeavor, involves issues, diverse opinions, agitation for change, and traditional viewpoints. It soon became apparent that these issues, diverse opinions, ongoing changes and traditions would produce diverse user information needs and that a successful system design would have to provide for enormous differences among users. An example of these differences was the fact that over the past five years hundreds of math lists (or behavioral objectives, or class objectives, or criterion skills, etc.) have been created by school districts, by publishers, by consortiums of educational agencies, and others. Most of the skill lists, semantics aside, are largely identical. Yet each of these agencies would ardently defend their skill list as being vastly superior to all the others.

The cumulative effect of these differences in view-point and attitude was to impress upon the Math Skills System designers that such divergence did in fact exist and that no universal agreements, in all likelihood, were going to take place. Rather than seek "the right answers", the designers concluded that there were as many "right answers" as there were potential users of the system. Perhaps the most startling revelation, which emerged from the entire project, has been the discovery that whatever the issue, each educator often seems to be convinced that his or her position is "right" and was often unaware that different views even existed. This realization was important because it meant that each user will be looking at the system for what it can do for him or her individually.

A. Educational Issues and Factors Affecting the Design of the MSRTS Math Skills Information System

In an historic mission in Santa Fe, New Mexico, a wooden stairway spirals through two 360 degree turns from floor to choir loft. This structure is remarkable for two reasons. It is free standing, and it was built by an unknown carpenter in the 19th century using only a saw, a wood plane, a T-square, some homemade glue, and hot water. Scores of architects and engineers have marveled at its geometric, physical, and esthetic properties. The tools were simple, the product magnificent, but the skills of the builder were acquired during a time in which years of apprenticeship, training, and practice commonly were required before such advanced artisanship could be evidenced. In today's world, such skills are almost unknown. The pace of life neither permits nor requires the long, tedious acquisition of skills with simple tools in order to work so superbly. Today, more sophisticated tools fill the gap. Many people, using various power tools such as radial saws, drill presses, synthetic glues, etc., are able to build products of utility and beauty that would not be possible were only basic hand tools available. In fact, one could conclude that the sophistication of these modern tools helps to offset the lack of skills which the user has not had time to acquire. Although contemporary tools are quite sophisticated, they are relatively easy to use. Of course, the more extensive the project one undertakes, the more one must know about the use of these tools.

The analogy between relationship of human skills and th sophistication of tools can also be used with MSRTS. The MSRTS Math Skills Information System is a tool. It is a relatively sophisticated instrument because its users cannot afford the time that would be required to develop the skills needed to use a simpler one. To continue the analogy, contemporary tools such as the radial saw can be used with precision in a wide variety of tasks. Some of the tasks might be quite simple, others would require the user to know more. Consequently, with little knowledge, one might build simple articles, or one might, with more knowledge, build more elaborate articles. The same holds true for the MSRTS Math Skills Information System. A user may obtain relatively simple information by knowing very little about using the system. The user who learns more, however, could obtain more useful information.

The quality of instruction provided a migrant student depends, in part, upon the understanding that a teacher has of the student's strengths and needs as expressed by skills. Since skill information plays such a vital role, the user who learns how to use the MSRTS Math Skill s Information System best is in the position of being able to provide more exact and better quality instruction to the migrant student.

1. <u>Who are the Users of the MSRTS Math Skills Information System?</u>

The potential users of the Math Skills Information System are estimated to be between 70,000 and 100,000 regular classroom teachers, special resource teachers, classroom aides, tutors, and others. This vast array of people differ in their own perceived math skills information needs. The more prominent variations in needs are as follows:

a)	CURRICULUM	Ranges from concentration on so-called "basic survival skills" to emphasis on "total math conceptual development." Even when comparing two school districts' array of "basic survival skills", one is likely to find that what is a "survival skill" to one district may well be a "frill skill" to another district.
b)	SUBJECT MATTER AS DETERMINED BY GRADE LEVEL	Ranges from simple perceptual skills at the lower level to abstract concepts in algebra, calculus, and finite math in the higher grades.
c)	INSTRUCTIONAL APPROACH	Ranges from lockstep classroom instruction based on traditional texts to computer-based individualized instruction.
d)	PROGRAM DURATION (FOR INDIVIDUALIZED STUDENTS)	Ranges from seven-month, full-scale programs to six-week programs.
e)	PROGRAM SUPPORT PROVIDED THE CLASSROOM TEACHER	Ranges from none to specially-equipped resource rooms staffed by highly trained teaching specialists, tutors, and aides.
f)	IN-SERVICE SUPPORT PROVIDED THE USER	Some states are equipped organizationally and financially to provide strong inservice so that teachers and others working with the migrant student are prepared to use all available materials and facilities to advantage. Other states provide very little inservice support.
g)	USER ATTITUDE	Ranges from resigned cynicism to consuming dedication.
h)	FORMAL MATH BACKGROUND OF THE USER	Some aides and tutors must struggle to keep ahead of the students. From survey data collected it appears that about 5% of the K-6 regular classroom teachers possessed either a math minor or major. The remaining may have had as little as one course in math or as much as several. (The above figures are not the result of a controlled study and serve as rough indices only.)

The list could continue. However, it is unnecessary because the point to be made is that there is an enormous diversity of user situations. Each of these situations produces a slightly or radically different set of math skill needs. Moreover, all of the sources of diversity among users listed above are undergoing constant change. The public demand for accountability, the massive shift of education towards competency or skills-based criteria, the ensuing redefinition of subject matter are all forces which continuously affect the situation of each user.

The design of the Math Skills Information System does not meet the needs of any one group of user situations, as cited above, to the detriment of any other group. The design presented herein does recognize and make provision for all the diverse user needs within the constraints of the present MSRTS hardware and communication system. Each user in each situation directly affects the instruction of migrant students. To ignore the needs of a user is ultimately to ignore the needs of the migrant students under the tutelage of that user.

Educationally, one may not approve of many of the situations in which teachers instruct. One may not approve of the fact that certain teachers will receive little or no in-service in the use of the math skills system. One may not approve of a lockstep non-individualized environment for a migrant student; one may disagree with a certain instructional strategy or a curriculum or many other situational variables. However, despite the lack of ideal instructional situations, one cannot ignore the plain, hard, cold fact that every day of the year finds thousands of migrant students in each of these user situations, good or bad. Therefore, it has been the guiding philosophy of the Math Skills Information System that it should be designed to serve migrant students no matter what user situations they find themselves in. The MSRTS Math Skills Information System was designed to serve the math skills needs of all the users, not the few.

2. The Average (or Majority) Users - Who are They?

There has been a strong tendency in the development of computer based systems, in which education is also included, to conceive of a so-called "average" or "majority" user and then design the system to meet the imagined or measured needs of this mythical group. Such an approach has turned out to be disastrously ineffective in building educational systems. The reasons for the ineffectuality of this approach are not difficult to find. The most obvious are as follows:

1) There is usually no such thing as an "average" user teacher, nor is there usually a "majority" who expresses common user needs;

2) A system built to satisfy this imagined "average" or "majority" usually turns out to serve few users really well and the rest hardly at all.

It is unnecessary to design computer based systems in this manner. To do so negates the predominant value of computers which is its capacity to deal with large amounts of data in a short time. This capacity enables the computer to deal with individual cases. The MSRTS has yet to use this potential. Computers, as any other tool, can be misused. Not fulfilling the informational needs of individual users to satisfy some "majority" concept is such a misuse. As will be seen, the only frequently occurring characteristic to emerge from the study, from research, and from user consultation, concerning the design presented herein, is simply that the "majority" of users express very individualistic information needs.

3. Will the Real Hierarchy of Math Skills Please Stand Up?

During the course of designing this system, contact with a broad array of educators from classroom to administration revealed two significant but contradiotory beliefs concerning a hierarchy of math skills: many believe that a well-defined hierarchy of math skills exists somewhere, and no one claimed to know beyond a few major relationships of what the hierarchy consists.

The term hierarchy is used to imply a necessary learning sequence. For example, if there are four skills (A, B, C, and D), it is commonly believed that A must be learned before B, B must be learned before C, and C must be learned before D. If the teacher, therefore, knows that a student has attained skill C, then the teacher can automatically assume that the student must already have learned skills A and B, and the next skill the student should work on is skill D.

Beyond such gross hierarchial relationships as, "A student must be able to add and to subtract before he can learn to divide", educators either differ markedly or express great uncertainty about "necessary learning sequences." An example of this uncertainty centers around the skills employed in understanding Place Value. Here are, some of the opinions encountered concerning this subject:

a) Solid skills in place value are necessary before a student can learn to add, especially where "carrying" is concerned.

b) A student "acquires a sense of place value" when he learns to add.

c) Place Value is important but only as a support skill.

d) Place Value is not only a valuable skill to acquire to facilitate learning to add, it is also an important skill in itself because much computer arithmetic rests upon understanding how number systems operate.

Much of the "hierarchy" of skills seems to derive from the sequences of subjects presented, as they are presented traditionally in textbooks.

The simple fact is that there seems to be no universally accepted body of empirical data bearing on the issue. It is not the role of the MSRTS Math Skills Information System to unravel such diverse opinion. However, it is the responsibility of the MSRTS Math Skills Information System to be aware of this diversity of opinion so that it does not favor any one hierarchy over others.

4. Continuity: What Is It?

Related closely to the preceding issue is the question of continuity. Users, who tend to believe that the one and only correct hierarchy or necessary learning sequence of skills exists somewhere, also believe that the most important item of math information about an enrolling migrant student is simply "which skill the student attained most recently." This represents one concept of continuity. Other users, less certain that a strict hierarchy does exist, expressed a different perception of continuity in math instruction. These users voiced a need to know more about the student's general background strengths and weaknesses in math. They felt that continuity essentially means moving a student ahead when the student has the background of skills needed for him or her to be able to move forward. This latter group of users, naturally, had more extensive math skills information needs than the former group. Some users have observed that, because a student possesses a certain group of math skills, it does not necessarily imply the student has acquired all the pre-requisite skills for the next step. To point out that because a student knows his basic addition facts does not automatically ensure that the student is prepared to learn addition of multiple digit numbers, which involves carrying. The student may need work in place value or expanded notation before proceeding. Thus, as with other perceptions of math instruction, users expressed a number of differing opinions concerning what constitutes "continuity of instruction." The MSRTS Math Skills Information System is designed to function within this diversity of concepts concerning continuity.

5. Proper Math Skills - What Are They?

Users have expressed diverse opinions concerning "what constitutes proper math skills" for a migrant student or, for that matter, any other student. Recent public reaction to the purported decline in students' computational skills have led many communities to question their schools' math curriculum. Some of the controversy about "modern math" seems to revolve around the subject of Sets. Some users teach nothing about Sets. Other users see Sets as a foundation for learning additional math skills while yet a third group of users sees Sets as an important subject in itself. Once again, the role of the MSRTS Math Skills Information System is not to take sides in such issues. Its role is to provide that information which users of any persuasion express as a need.

6. <u>Conclusions</u>

1) The MSRTS Math Skills Information System is designed to meet the needs of all its users rather than one particular group.

2) The MSRTS Math Skills Information System is aware of but takes no position of advocacy in the following issues or other issues:

   a) curriculum;

   b) hierarchy of learning sequences;

   c) educational philosophy;

   d) skills importance or relevance;

   e) instructional strategy;

   f) diverse concepts of "continuity".

3) A well-planned system of some sophistication is required to meet diverse user needs while maintaining a neutral position with respect to issues that, in part, create user diversity.

4) Systems Sophistication should not make a user's job more difficult, but, rather, it should make it possible for a user to do his/her job more easily.

B. Background and Design Considerations Underlying the MSRTS Math Skills List

1. <u>Background of the MSRTS Math Skills Lists</u>

In 1973 the state directors of migrant education voted to adopt the Michigan Math Objectives to serve as a basis for creating a math skills list to be incorporated into the Migrant Student Record Transfer System. The math skills list was to serve as a catalogue of skill statements to permit teachers to describe the math skills acquired by migrant students. The list was to be independent of any particular math program and was in no way to be viewed as a curriculum or criterion set. The list was to be simply a language for transmitting math skills information from teacher to teacher via the MSRTS.

Since the state directors made that decision the following activities have taken place. Under the sponsorship of the Florida and California Migrant Programs, a committee of math educators and information system specialists from those states was formed and given the task of producing the desired math skill list. Realizing that the skill list would be used by all the states with potentially 100,000 or so teachers in the more than 7,000 school districts, the committee sought to have the list encompass as many different skills and orientations as was possible with the time and resources available. In pursuit of this comprehensiveness, two actions were taken. The first was to structure each skill statement so that it possessed enough generality to match skill statements used in many different states and programs. The second step was to ensure that:

A) each skill in the migrant math skill list corresponded to at least one (K-6) skill in other major skill lists that were available to the committee at that time, and

B) each skill in the major skill lists available to the committee corresponded to at least one skill in the migrant math skill list.

The committee drew comparisons between the migrant math skills list and skill lists from the state of Michigan; Dade County, Florida; the state of California, which was at that time developing a state assessment criterion set; and lists of skills received from various publishers of math programs. In addition to these lists, various committee members had written, or been part of a team who wrote, math objectives and skills for various school districts and counties across the country.

Having completed drawing up the preliminary math content, the skill statements were then written. Subsequent work, to refine the list, was sponsored by the state of Florida Migrant Program, and the state of Washington Migrant Program. In 1975, a committee of educators, representing the Western States Coordinating Council*, in consultation with teachers from their respective states, further refined the skills list. It is important to acknowledge the fact that no amount of committee refinement will produce a list which is 100% perfect. Only through teacher use and subsequent suggestions will the skill list begin to approach the form best suited to its purpose. For this reason, the skill list will undergo periodic changes to reflect necessary refinements.

It is intended that the skill list be cross-indexed to the skill lists used by various state and/or school district migrant programs. For this reason, the MSRTS skill list must include all skills to be found on other skill lists. This feature will require, initially, the addition of skills existing on other skills lists but not on the MSRTS skill list. The MSRTS skills list provides, in its technical specifications, a means whereby it can be placed on the computer in order to make updating possible.

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*WSCCME is a consortium of eight western states which has been formed in order to provide a means to achieve interstate planning for states sharing migrant children in common. The purpose of the organization is to plan educational programs which can provide continuity of education for these children.

In all, at least 150 educators have made direct formal contributions to the content, design, and organization of the MSRTS Math Skills List. These educators included classroom aides, regular classroom teachers at all grade levels, special resource teachers, math specialists, university faculty members from various departments of education, and administrators. In addition to imput by the above-listed persons, the MSRTS Math Skills List designers reviewed dozens of skill lists produced by publishers, school districts, and states.

2. <u>Design Considerations Underlying the MSRTS Math Skills List</u>

a. The Nature of Math as a Subject Matter**

Math is a series of subject matters, units which are both dependent and independent, continuous, and discrete. As long as a student continues the study of math, he or she will encounter new topics. A new topic may well call upon skills learned earlier, but it is distinct and different from previously learned skills and is not simply a strengthening of older skills. One such example is geometry. Learning and "performing" geometry may require that a student previously have acquired computational skills. However, acquiring skills in geometry involves far more than "extending" the computational skills. The terminology, axioms, elements, operations, procedures, and concepts of geometry are discretely different from those which the student learns in basic computation. In this sense geometry is independent of other math subject units. A little reflection will convince the reader that the same remarks hold true for all other math units such as measurement, algebra, trigonometry, sets, probability and statistics, calculus, etc. In these respects, math is very different from reading as a subject matter. Once past the acquisition of basic skills, reading seems to be largely a matter of extending and strengthening a finite group of skills such as decoding, comprehension, and study skills. This is not to imply that reading is a simpler or easier subject than math but to note that differences in various skills do exist. This difference has had substantial impact on the design of the math skills list and the displays of student's math skills status. For example, it may be meaningful and useful to inform a teacher that a student's <u>comprehension</u> skills are at a secondary level, but it would be practically meaningless to inform a math teacher that a student's addition skills are at a secondary level, especially if that student happens to be enrolling in a class which is midway through an algebra course.

**The remarks in this section are not meant to ignore the purely logical internal "connectedness" of mathematics (A La Russell & Whiteheads, Principia Mathematica, etc.). Rather they pertain to the behavior of students, teachers, school districts, publishers, etc., in teaching/learning math.

Even math skills with a small related group exhibit this independent yet dependent nature. For example, the adding of two, two digit numbers involving carrying cannot be said simply to be "more advanced" than adding two, two digit numbers which don't involve carrying. These two skills are qualitatively different because a completely different operation is involved. No amount of practice in adding numbers not involving carrying will "endow" a student with the skill of adding numbers involving carrying. Hence, each of these discrete skills requires a separate skill statement. This example is typical throughout math.

The nature of math, as it is taught, together with the other factors previously discussed, have resulted in a skill list containing hundreds of skills. Each skill statement in the list describes a skill which is qualitatively and/or operationally different from all other skills.

b. The Anatomy of a Math Skill Statement

The definition of a math skill used in the math skills list is as follows: A math skill is an <u>operation</u> performed over a mathematical <u>attribute</u> of an entity. From this definition of a math skill the definition of a math skill statement follows naturally: A math skill statement defining an operation involving a defined mathematical attribute of an entity.

The key words in the above definition are <u>operation</u> and <u>attribute</u>. These are the terms that must be made explicit in <u>each</u> skill statement. The adequacy of the definition was all <u>important</u> for it would determine the structure of each skill statement. This definition would produce skill statements that would be uniform throughout. It was felt that this uniformity would simplify the user's task of extracting the information carried by each statement. The application of the definition of a skill statement led to the anatomical structuring of each statement which is depicted on the following page. (Figure A)

c. Selecting the Level of Detail at Which to Define the Math Skills

A perennial problem in creating skill statements (and behavioral objectives, etc.) is choosing the proper level of definition. There is always a trade-off between <u>range</u> and <u>content</u> which are inversely related. That is, the greater the range of a skill statement, the less its content and vice versa. The <u>range</u> of a statement conveys a number of different conditions or, in this case, behaviors covered by the statement. The range of a statement generally conveys universality.

The <u>content</u> of a statement refers to its <u>specificity</u>. Obviously, the more specific a statement, the fewer behaviors are described by the statement.

NOMENCLATURE OF A SKILL

(GIVEN) THE ATTRIBUTE	(THE STUDENT) THE OPERATION
Given a single digit even number	The student names the number as "even".
Given the name "even"	The student identifies "even" (single digit) numbers.
Given the symbol ">"	The student names the relationship "greater than".
Given the relationship name "greater than"	The student identifies the operational symbol ">".
Given any pair of two digit whole numbers	The student computes the sum.

FIGURE A

Example: High Range (universality) low content (specificity):

It is cold in the winter.

Example: Low Range (universality) high content (specificity):

The mean temperature in Chicago during January is $30^{o}F$.

Two extremes illustrate the variables, range and content.

Statement A: The student can add numbers.

Statement B: The student can add the whole numbers 2 + 3.

Statement A has extreme range but very little content. It leaves unanswered the questions:

Can the student add whole numbers? fractions? decimals? any size of addends? any number of addends?

In a learning situation wherein a student is acquiring skills gradually on an ongoing basis, statement A does not permit one to describe student progress in sufficient detail. Statement B has little range but high content (specificity). It describes precisely a behavior acquired by the student. However, statement B is so specific that it also leaves many questions hanging. These questions may include such things as can the student add 2 + 4, 2 + 5, or 3 + 1? In fact, statement B leaves unanswered the general question of whether the student can add any pair of single digit numbers whose sum is less than ten. Were all skill statements written at the level of detail represented by statement B, it would require 20 separate skill statements to describe a student's ability to add all pairs of single-digit, whole numbers whose sum is less than 10. In writing skill statements, a proper balance must be struck between the universality and specificity of each skill statement. If a skill statement has too much range (universality) then it is vague and ambiguous and does not transmit sufficient information to a teacher. If, on the other hand, a skill statement is too specific (its content is high), then the skill statement imparts too little information regarding related skills. The result of too much specificity is the unnecessary proliferation of skill statements which are largely redundant.

To maintain this balance, the MSRTS Skill List used the following principle in selecting the level of detail at which to write individual skill statements: A separate skill statement shall be written for each skill which involves a qualitatively different operation from other skills. For example, adding 21 + 44, 86 + 13, etc., does not involve qualitative differences for, in each case, carrying is not involved.

On the other hand, 21 + 44 and 21 + 59 are qualitatively different and are instances of separate skills requiring separate statements. Insofar as possible, the above principle was followed in creating the MSRTS Math Skill Statements.

The Double Edged Skill

Another variable affecting the range and content of a skill statement is the existence of the "double edged skill". The formal recognition of this skill type clears up much confusion in the creation of math skill statements. Behaviorally speaking, most non-computational skills involve establishing correspondences between two sets of entities. Examples abound as can be seen below:

Example 1

(numeral) (word name for numeral)

"1" - "one"

"2" - "two"

Example 2

"sum" - - - - - - - - - - - - - - - - - - $\boxed{5}$ = 3 + 2

"product" - - - - - - - - - - - - - - - - $\boxed{12}$ = 4 x 3

Example 3

(the name of a relation) - - - - - - - (the symbol standing for the name of a relation)

"greater than" - ">"

Example 4

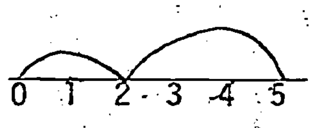
(a relation) (an instance of a relation)

greater than - - - - - - - - - - - - - - 5 is $\boxed{\text{greater than}}$ 2

Example 5

an equivalent number line representation of addition

an equivalent number sentence representation of addition



- - - - - - - - - 2 + 3 = 5

Notice that in the preceding examples correlatives operate in both directions, whether the sets stand in one-one, one-many, many-one, or many-many relation to each other.

Establishing correlations from one set to another is certainly a skill, yet what of the reverse? What of the behavior of recognizing reverse correlations? The reverse correlation, behaviorally speaking, is a different skill for the stimulus correlation and response are reversed.

Example:

given (the stimulus)	the student (response) names (by utterance, point, etc.)
a) A display of the numeral "2" - - -	the word "two"
b) A display of the word "two" - - -	the numeral "2"

So forms the "double edged skill".

A little analysis will show that most skill lists do not recognize, formally, the existence of the "double edged skill". The consequence of this lack of recognition is the arbitrary (by tradition, chance, or otherwise) selection of one corresponding direction or the other as the skill standing for the two way relationship. If the reader has been involved in working committees engaged in writing skills, he/she will undoubtedly remember the confusion resulting from the existence, but non-recognition, of the double edged nature of skills. One group within a committee will maintain stoutly that X is really the skill to be described; another group will protest that Y is really the skill to be described. All the while, both are correct: X and Y are simply the two skills required to establish a two-way relationship.

Whenever possible, reasonable, and useful, the skills in the migrant math skills list have been written as double edged skills with both directions of relationships treated as separate but equal skills.

Stimulus Form and Response Mode

Special consideration should be given one issue involving specificity which ultimately should be decided by user preference. This issue has to do with the forms of the stimulus and response which are either implied or inherent in any skill statement.

Some math teachers insist that the form of the stimulus is the key part of the skill statement. Four statements, which may or may not describe a skill depending upon the user's point of view, illustrate these views:

1) Given a written number sentence with the sum missing, the student can write the correct sum.

2) Given a written number sentence with the sum missing, the student can supply the correct sum.

3) Given a number sentence with the sum missing, the student can write the correct sum.

4) Given a number sentence with the sum missing, the student can supply the correct sum.

Statement 1: specifies the stimulus (written) and the form of the response (write).

Statement 2: specifies the stimulus (written), but leaves the response made unspecified.

Statement 3: leaves the form of the stimulus unspecified but specifies the response made (write).

Statement 4: leaves both the form of the stimulus and the response made unspecified.

The matrix below summarizes the situation.

FORM OF THE STIMULUS	FORM OF THE RESPONSE WRITE	 UNSPECIFIED
WRITTEN	STATEMENT 1	STATEMENT 2
UNSPECIFIED	STATEMENT 3	STATEMENT 4

A total of four skill statements would have to be written to express a skill which included specification of its stimulus and response modes.

In addition, the matrix presents a situation in which only one stimulus mode (written) and one response mode (write) are considered. The matrix below summarizes the situation if multiple modes are considered.

FORM OF THE STIMULUS:	FORM OF THE RESPONSE WRITE	 SPEAK	 UNSPECIFIED
WRITTEN			
SPOKEN			
UNSPECIFIED			

Now a total of nine statements per skill would have to be written to cover each single-edged skill. Add to these the response possibilities present when manipulatives (compass, protractor, blocks) are involved. To circumvent this endless proliferation of skill statements, the MSRTS Math Skills List makes no attempt to identify the stimulus or response mode of a skill. The list uses a very restricted set of verbs to describe the response; that is, the student "identifies" or "computes".

C. Structure of the MSRTS Math Skills List

1. Use of the Math Skills List

The MSRTS Skills List exists in two forms as a printed document and as a file in the MSRTS computer. The printed document skills list is for occasional, infrequent reference by teachers and is, therefore, organized as a reference document.

2. Organization of the Math Skills List

The Math Skills List is organized as follows: areas are made up of Topics; Topics are made up of Subtopics; Subtopics are made up of Skills. An area is the name of a large group of related skills. The areas of the present skill list (algebra and higher areas have not yet been included) are:

Area Number	Area Name
01	Readiness
11	Number Meaning
21	Whole Numbers
31	Fractions
41	Decimals
51	Percent
61	Measurement
71	Geometry*
81	Probability and Statistics*
91	Sets

*Very basic skills only

A Topic is the Name of a group of related skills within an area. A Subtopic is an abbreviated Phrase describing two or more related skills within a Topic. The grouping of skills into subtopics, within topics, within areas, plays an important role in this system as will soon be seen. These labels form a well defined set; each skill belongs to one and only one subtopic; each subtopic belongs to one and only one topic; and the content of each topic belongs to one and only one area.

3: The Code Structure of the Math Skills List

Each area of skills is assigned a unique four digit number. No two areas have the same code number.

Each topic is assigned a unique three digit number WITHIN each area. Two topics may have the same code number if, and only if, the topics belong to different areas. For this reason, when code numbers only are used to reference a particular topic, the area code must be included. For example, the code number 0301 means Topic 01 of Area 03; 0401 means Topic 01 of Area 04.

Each Subtopic is assigned a unique four digit code number.

Each Skill Statement is assigned a unique five digit code number.

The reasons for this choice of code numbering will become evident and will periodically be noted as the operation of the system is explained.

4. Sequence of Skills in the Skill List

The Skill List itself is included as Attachment B. The skill numbers appearing in the Skill List are the final numbers that will be used. The placement and sequence of skills in the Skill List is of importance both for using the Skill List as a reference document and for grouping skills under area, topics, and subtopics for teacher convenience. The sequence of skills in the Skill List MUST NEVER BE INTERPRETED TO MEAN A SUGGESTED OR IMPLIED LEARNING SEQUENCE! This point cannot be stressed often enough or strongly enough. Although no learning sequence is intended, the sequence of skills in the Skill List is generally similar to traditional sequences of math subjects found in textbooks, individualized programs, etc. In a study conducted in 1975, over 100 teachers were presented a listing of the skills, as represented by their subtopics with each subtopic being printed on a punched card. The teachers were asked to move any subtopic to any other topic and/or area that made more sense to them and to sequence the subtopic into any preferred sequence. In no case did more than 25% of the teachers express a preference for any subtopic to be moved from its present location in the Skills List. Overwhelmingly, the teachers preferred the sequence as it stood.

D. Continuity and User Information Needs

1. The Classroom Environment and its Effect on Math Skills Information Needs

As discussed earlier, the classroom environment, in which a migrant student receives instruction, ranges from lockstep instruction to computer-based individualized instruction. Between these extremes lie many variations and degrees of individualized instructional services provided the migrant student. As was also discussed earlier, the design of the Math Skills Information System was based upon the premise that the system must be useful to teachers instructing in the entire range of classroom environments. To ensure that this design goal would be followed, it became necessary to identify the particular math skills information needs that grew out of these different environments. Discovering these needs was done by discussion with teachers and by analysis. The outcome of this investigation shows that there is a common core of questions teachers would like answered concerning each enrolling migrant student regardless of the classroom environment. The actions a teacher takes based upon the answers to these questions differ according to the resources available to the teacher, but the questions remain fairly constant. Without exception, all the regular classroom teachers with whom this was discussed wanted to know how well the enrolling migrant student, in their words, "could handle the math subject being studied in the class at that time." More specifically, they wanted to know the enrolling migrant student's math skills status as compared to the peer group in the particular math subject under study.

At first glance, this question may seem to beg the issue of continuity. Upon closer examination it does not. There are only three answers to such a question:

a) The student is ahead of the peer group in the math subject under study;

b) The student is behind the peer group in the math subject under study; or

c) The student is about even with the peer group in the math subject under study.

If the student is ahead or behind (a or b above), then his/her continuity of instruction would be violated by remaining with that peer group in the math subject under study. If the student is about even, then, more than likely, his continuity of instruction would be preserved simply by letting the student receive the same instruction as that of the peer group in the math subject under study. Of course, the actions open to the teacher when the student is ahead or behind depend upon the available Migrant Program Resources that are available.

2. Effect of Available Program Resources on Math Skills Information Needs

In programs wherein special migrant program resources such as aides, tutors, special resource teachers or room, individualized instructional material are available, a series of questions arise:

a) Does the migrant student need such services?

b) If so, in what math areas, how much, what kind, etc.?

To be answered, these questions require considerable math skills information on individual migrant students. As will be seen, the Math Skills System provides reporting capabilities that would permit these questions to be dealt with. The more "action alternatives" available to a teacher, the more useful the Math Skills Information System will become in using those resources.

E. Math Skills Information System Reports (Displays) and Reference Documents

1. Volume of Information

Although the MSRTS Math Skills List contains hundreds of skills, no one teacher will work with more than a small portion of them. Moreover, during any particular time period, a teacher is likely to be interested in yet an even smaller group of skills. Accordingly, the skills retrieval strategy and the ancillary documentation of the Math Skills System have been designed so that teachers may work with small, relevant units of information.

2. Mini-Skills Lists

The Western States Coordinating Council for Migrant Education conducted a study to identify the groups of skills in which teachers at various grade levels were most likely to be interested. During this study, teachers were also asked to batch skills into units of related skills which they would like to be able to obtain as individual reports in the following grade level ranges: K-3, 4-6, and 7-9. For the convenience of teachers, Math Skills Lists will be provided according to the groupings (see Figure B). Thus, when a teacher must reference a skills list, the list will contain only those skills in which, and with which, the teacher has an interest and a familiarity. (These may be obtained directly from your State Director of Migrant Education or Mr. Winford "Joe" Miller, Director, MSRTS.)

3. Levels of Detail for Math Skills Reports (Displays)

Some teachers felt that they would usually prefer skills stated very explicitly in their displays. This meant that they preferred complete skill statements. Other teachers felt that they would usually prefer skill status to be stated in briefer form - at the subskill level. The remaining teachers felt that for them a mixture of skill level statements and subskill level statements would best suit them. The display capabilities designed into the system can accommodate these different levels of display detail desired by the teacher. To explain these levels of detail, a portion of the skills list has been illustrated in diagram form (see Figures C,D,E,F)

As a closing remark, the reader may wonder why these reports only contain skill statements for those skills that Juan has attained. Why not print statements for those skills that Juan has not attained under each description? Skills not attained are not printed because such an action might imply that the MSRTS Math Skills Information System is suggesting or mandating curriculum content.

4. Standard Displays

During the course of a year, a teacher may move through several math subjects. As migrant students enroll in a classroom, the teacher is likely to want to know the skills most recently acquired by the student; and the student's status in the math subject which the class is then studying. Provision for the former will be discussed later. For the latter, information concerning a student's status in the math subject which the class is then studying, two things must be known by the computer: the student's set of skills and his teacher's name.

To make it easy for teachers to indicate groups of skills about which reports are desired, three mini skills were batched into display groupings. These display groupings are the result of the Western States Coordinating Council's study of teacher's display preferences and are called Standard Displays.

By using the Display Numbers, singly or in combination, a teacher may identify to the computer groups of math skills which should be reported about migrant students enrolling in the teacher's class.

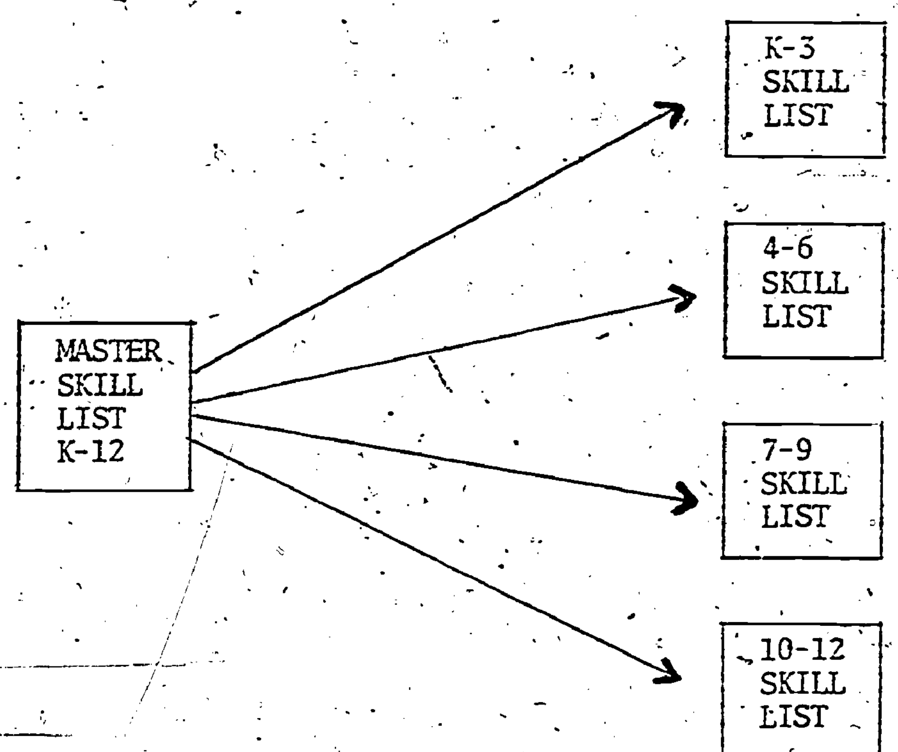


FIGURE B

		WHOLE NUMBERS			AREA
		BASIC CHARACTERISTICS			TOPIC
PLACE VALUES	EXPANDED NOTATION	NUMBER LINE	EVEN/ODD NUMBERS	COMPOSITE/PRIME NUMBERS	SUBTOPIC
SKILLS	SKILLS	SKILLS	SKILLS	SKILLS	SKILL STATEMENTS
08201	08501A	08801	09101	09401	
08202A	08501B	08802			
08202B	08501C	08803			
08203A	08502A	08804A			
08203B	08502B	08804B			
08204A	08502C	08805			
08204B	08503A				
08205A	08503B				
08205B	08503C				
		CONTENT			LEVELS OF DETAIL

FIGURE C

LEVEL OF DETAIL 1

GARCIA, JUAN M. 876438 : ROOM 75[illegible]
K-3 LEVEL STANDARD DISPLAY #7

AREA: WHOLE NUMBERS

TOPIC:	<u>BASIC CHARACTERISTICS</u>	SKILLS	STATUS
SUB-TOPIC:	PLACE VALUE	(08201-08205)	ALL
	EXPANDED NOTATION	(08501-08805)	08501,08502A&B 08503A&B
	NUMBER LINE	(08801-08805)	08801
	EVEN/ODD NUMBERS	(09101A-09101B)	09101A
	COMPOSITE/PRIME NUMBERS	(09401A-09401B)	NONE

FIGURE D

LEVEL OF DETAIL 2

GARCIA, JUAN M.   8769438   :   ROOM 754
K-3 LEVEL STANDARD DISPLAY #7

AREA: WHOLE NUMBERS

TOPIC: <u>BASIC CHARACTERISTICS</u>   <u>SKILLS</u>   <u>STATUS</u>

SUB-TOPIC: PLACE VALUE---------------- ---------- ALL
EXPANDED NOTATION--------- ---------- PARTIAL

SKILLS:	GIVEN	THE STUDENT
08501B	A TWO DIGIT NUMERAL	IDENTIFIES AN EXPANDED NOTATION FORM (USING NUMERALS) OF THE TWO DIGIT NUMERAL
08502B	A THREE DIGIT NUMERAL	IDENTIFIES AN EXPANDED NOTATION FORM (USING NUMERALS) OF THE THREE DIGIT NUMERAL
08503B	A NUMBER GREATER THAN 1,000	IDENTIFIES AN EXPANDED NOTATION (USING NUMERALS) OF THE NUMERAL

SUB-TOPIC: NUMBER LINE-------------- ---------- PARTIAL

SKILLS:	GIVEN	THE STUDENT
08801	A NUMBER LINE REPRESENTATION OF THE NUMBERS (1-10)	IDENTIFIES ONE OR MORE NUMBERS MISSING-FROM THE NUMBER LINE

SUB-TOPIC: EVEN/ODD NUMBERS---------- ---------- PARTIAL

SKILLS:	GIVEN	THE STUDENT
09101A	A COLLECTION OF NUMBERS	NAMES THE NUMBERS AS "EVEN" OR "ODD"
09101B	THE NAMES "EVEN" OR "ODD"	IDENTIFIES COLLECTIONS OF NUMBERS AS EVEN OR ODD

SUB-TOPIC: COMPOSITE/PRIME
NUMBERS------------------ ---------- NONE

FIGURE E

GARCIA, JUAN M. 8760438
K-3 LEVEL STANDARD DISPLAY #7

AREA: WHOLE NUMBERS

TOPIC: BASIC CHARACTERISTICS		SKILLS	STATUS
SUB-TOPIC: PLACE VALUE			ALL
SKILLS:	GIVEN	THE STUDENT	
08201	A SINGLE DIGIT (0-9)	NAMES THE PLACE VALUE OF DIGIT	
08202A	A TWO DIGIT NUMERAL (10-99)	NAMES THE PLACE VALUE OF A GIVEN DIGIT IN THE NUMERAL	
08202B	A PLACE VALUE NAME (ONES, TWOS) AND A TWO DIGIT NUMERAL	IDENTIFIES THE DIGIT IN THE NUMERAL OCCUPYING THAT PLACE	
08203A	A THREE DIGIT SEQUENCE (100-999) A PLACE VALUE NAME (ONES, TENS, HUNDREDS, OR THOUSANDS) AND A FOUR DIGIT NUMERAL	NAMES THE PLACE VALUE OF A GIVEN DIGIT IN THE NUMERAL. IDENTIFIES THE DIGIT OCCUPYING THAT PLACE VALUE	
08204A	A FOUR DIGIT NUMERAL (1000-9999)	NAMES THE PLACE VALUE OF A GIVEN DIGIT IN THE NUMERAL. IDENTIFIES THE DIGIT OCCUPYING THAT PLACE VALUE.	
08204B	A PLACE VALUE NAME (ONES, TENS, HUNDREDS, OR THOUSANDS) AND A FOUR DIGIT NUMERAL		
08205A	A FIVE (OR MORE) DIGIT NUMERAL (10,000-...)	NAMES THE PLACE VALUE OF A GIVEN DIGIT IN THE NUMERAL	
	PLACE VALUE NAMES (ONES, TENS, HUNDREDS, THOUSANDS, TEN-THOUSANDS) AND A FIVE (OR MORE) DIGIT NUMERAL	IDENTIFIES THE DIGIT OCCUPYING THAT PLACE VALUE	
SUB-TOPIC: EXPANDED NOTATION			PARTIAL
08501B	A TWO DIGIT NUMERAL	IDENTIFIES AN EXPANDED NOTATION FORM (USING NUMERALS) OF THE NUMERAL	
08502B	A THREE DIGIT NUMERAL	IDENTIFIES AN EXPANDED NOTATION FORM (USING NUMERALS) OF THE NUMERAL	
08503B	A NUMBER GREATER THAN 1000	IDENTIFIES AN EXPANDED NOTATION FORM (USING NUMERALS) OF THE NUMERAL	
SUB-TOPIC: NUMBER LINE			PARTIAL
08801	A NUMBER LINE REPRESENTATION OF THE WHOLE NUMBERS (1-10) WITH NUMBERS MISSING	IDENTIFIES ONE OR MORE NUMBERS MISSING FROM THE NUMBER LINE	

FIGURE F

SUB-TOPIC: EVEN/ODD NUMBERS--------------------	---------------PARTIAL
09101A A COLLECTION OF NUMBERS (BETWEEN 1 and 1,000)	NAMES NUMBERS AS "EVEN" OR "ODD" IDENTIFIES COLLECTION OF NUMBERS AS EVEN OR ODD
09101B THE NAMES "EVEN" OR "ODD" AND A GROUP OF NUMBERS	
SUB-TOPIC: COMPOSITE/PRIME NUMBERS -----------	----------------NONE

FIGURE F

5. Standing Orders

As described in this section, a teacher may elect to have students' skill status reported in the form of Standard Displays. The preceding material indicated how a teacher would identify Standard Displays.

A teacher may, in a workshop or individually, identify a number of different displays that he or she may desire to use at some time during the year. However, a teacher will not want to receive all displays on each student throughout the year. For example, a primary teacher may cover addition and subtraction of whole numbers in the fall followed by an introduction to fractions in the winter or spring. This teacher could have selected the following displays appropriate for math skills needs during this time period:

Standard Display Number	Area & Topic
8	Whole Numbers - Addition
9	Whole Numbers - Subtraction
13	Fractions - Basic Characteristics

In the early fall, a teacher might desire only skill information concerning the addition of whole numbers. Below is a list of things the teacher DOES NOT want:

a) reports covering skills in subtraction (display 9) or fractions (display 13) sent routinely on enrolling migrant students until the teacher reaches that part of the year in which the class is studying those subjects, and

b) to have to notify the computer of the displays desired each time a migrant enrolls in her room.

To circumvent these undesirable actions, the feature STANDING ORDER is provided. A Standing Order is simply a way for a teacher to give certain orders to the computer and have the computer routinely carry them out until notified to cease doing so.

A Standing Order permits a teacher to tell the computer:

a) which displays may be desired over some indefinite time period,

b) the date beyond which each display should be sent,

c) whether each display is "active." This is a simple on/off indicator used to activate/deactivate displays, and

d) the level of detail at which each display should be composed.

Once the teacher in the example had submitted a Standing Order for the displays the computer would carry out the Standing Order until the teacher modified the order. More specifically, the Standing Order would be kept on file at the computer. Using the Standing Order, the computer would compile the proper report on each migrant student enrolling in that teacher's class. The computer would continue to carry out this Standing Order until the teacher notified it to stop or until the end of the school year.

To keep a teacher informed as to his/her Standing Orders on file, each change to a teacher's Standing Orders will cause the computer to print a copy of the entire collection of Standing Orders for that teacher. This print-out would be mailed to the appropriate teacher.

6. <u>Options</u>

Use of the features, Standard Displays and Standard Orders, is optional on the part of the user.

As will be seen in the subsequent section, each teacher will receive some math skills information on each enrolling migrant student without exercising any of the above options. The optional features enable the system to meet the diverse informational needs of diverse users in diverse situations!

NOTE: Currently all states have terminal offices which house terminal operators. Terminal operators handle all transactions for each school district participating in the Migrant Education Program.

F. Narrative Description of System Operation

1. User Queries

Users retrieve math skills information on migrant students using Query transactions. The different Query transactions and their use are discussed in Section F-1. Query transactions occur at enrollment and may occur at any other time a teacher desires.

There are three major types of Queries as listed below:

Enrollment Queries,

Routine Queries, and

One-Shot Queries.

a. Enrollment Queries

Enrollment Queries are of two types:

Unspecified, and

Specified.

(1) Unspecified Enrollment Queries

An Unspecified Query is an automatic by-product of a conventional enrollment transaction as now used by the MSRTS and requires no additional data to initiate a response.

Before describing this response it is necessary to know one fact about the students' data base records. As students' math skills are reported to the System, the computer places the date the skill was reported in the student's record. It does not keep dates for all skills in a student's record. It maintains dates only for the six (6) most recently mastered and under study skills.

There are two automatic MSRTS Responses to an Unspecified Enrollment Query as follows:

Response #1: The computer searches the data base record of the student being enrolled. The computer identifies three of the most recent skills reported for the student: the computer then identifies the sub-topics to which the six skills belong. All six skills may belong to a single sub-topic or they may belong to several (up to five) sub-topics. The computer then identifies all skill numbers associated with the sub-topic. The computer next loops back through the student's data base record to identify the skills the student has attained under each of the (one to five) sub-topics. Using this set of sub-topics and skills, the computer makes up a Level 1 display. (See Figure D in Section E of Part I.) This display is sent back to the school as a part of a data base message.

The "looping" response described above is used for two reasons:

a) If just the three mastered and the three under study of the most recently reported skills are presented, it might give the teacher a fragmented picture of the student's status in those math subjects most recently studied. A sub-topic includes a small number of closely related skills. Analysis by sub-topic gives the teacher a much more coherent picture.

b) Individual skill statements would constitute too much data volume to transmit over the (slow) teletype network presently in use by the MSRTS.

Response #2: The computer repeats the same steps as in Response #1 above with these exceptions:

a) The student record is examined for the six (6) most recent skills;

b) A Level 2 display is printed on the computer printer (see Figure E3C in Section E of Part I); and

c) The display is mailed to the enrolling school.

(2) Specified Enrollment Queries

In addition to the data normally contained in a conventional enrollment transaction, two other items of information are given. They are teacher or home room ID and grade level of the student.

There are two MSRTS responses to this type of query.

Response #1: Identical to Response #1 for an Unspecified Enrollment Query.

Response #2: Response #2 makes use of the Standing Orders a teacher has previously placed on file in the computer. The computer simply reads the teacher's Standing Orders and generates the displays required by the Standing Order.

The displays of the enrolling student's math skills are printed by the computer printer and are then mailed to the enrolling school along with the student's usual records. Remember that the Standing Order tells the computer which math subjects to search for skills in the student's record and the proper level of detail at which to print the displays.

The computer retrieves the Standing Order appropriate to the enrollment transaction. Reference to the Standing Order permits the computer to obtain the Display definition from the Standard Display Table.

Summary

Both Specified and Unspecified Enrollment Queries automatically cause the computer to send a display of the enrolling student's most recent skills back to the enrolling school as a part of critical data.

Both Enrollment Query types also cause the computer to generate, automatically, a more detailed follow-up display.

The follow-up display generated in response to a Specified Enrollment Query is controlled by the enrolling teacher's Standing Order on file at the MSRTS.

b. Routine Queries

Essentially, a Routine Query is a transaction causing the MSRTS computer to respond identically to Response #2 of A Specified Enrollment Query.

It is a teacher's way of energizing a Standing Order at other than enrollment time. A Routine Query always operates on and through a Standard Order. The display to be generated by the computer is always a standard display.

c. One-Shot Queries

A One-Shot Query is a Query transaction which specifies its own Standing Order.

Once the One-Shot Query is processed by the MSRTS, the Standing Order in the Query Transaction is not retained. Since its Standing Order Data items and Display definitions are discarded after processing, the One-Shot Query transaction is valid for one and only one Query.

2. Input

There are two types of input for the Math Skills System:

a) Input to build and to maintain Standing Orders, and

b) Student skills attained.

To input student skills, the teacher or aide would use a form similar to the one shown below.

	MATH SKILLS	
VILLANUEVA, JUAN RAUL	05514161	
SCHOOL ID - BCBX		SKILLS UNDER STUDY
SKILLS MASTERED	DATE MASTERED	AT WITHDRAWAL

	MATH SKILLS	
VILLANUEVA, JUAN RAUL	05514161	
SCHOOL ID - BCBX		SKILLS UNDER STUDY
SKILLS MASTERED	DATE MASTERED	AT WITHDRAWAL

MATH SKILLS

VILLANUEVA, JUAN RAUL 05514161
SCHOOL ID - BCBX
SKILLS MASTERED DATE MASTERED SKILLS UNDER STUDY AT WITHDRAWAL

The teacher need only to record the four digit code number of the skill to be reported. The code number may be obtained from the teacher's Mini-Skill List or from the complete MSRTS Math Skills List.

(Actually, the skill code numbers could be entered on the spare copy of the student's MSRTS record.)

The skills recording form is sent to the terminal operator who enters the math skills codes into the MSRTS along with the usual update data.

VITA

Raul de la Rosa, author of this document, writes of the National Migrant Education Program Math Skills Information System from a wide range of professional experience and personal involvement with migrants.

Mr. de la Rosa, as the ninth of thirteen children born to migrant worker parents, knows first hand of the problems involving continuity of migrant records and instruction.

His educational background includes undergraduate work at Franklin College, Indiana and a M.A. from Middlebury College, Vermont and Madrid, Spain. He has studied additionally at Stanford University, California; University of the Pacific; Guadalajara, Mexico; and has been an Administrative Intern at California State University at San Jose.

Mr. de la Rosa has been involved much of his adult life with migrant education and concerns, having been a language specialist and teacher for the California School District, a managerial associate for Educational Factors, Inc. of California, and a Coordinator of Migrant Education for Monterey and San Benito Counties, California. Presently Mr. de la Rosa is the Director of Migrant Education for the state of Washington.