DOCUMENT RESUME

ED 097 352 TM 003 980

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TITLE	Identifying an Educational Need: Survival Skills in Arithmetic. A Real Situation and an Example of the Process.
INSTITUTION	New Hampshire State Dept. of Education, Concord.
PUB DATE	[74]
NOTE	15p.
EDRS PRICE	MF-$0.75 HC-$1.50 PLUS POSTAGE
DESCRIPTORS	*Arithmetic; Educational Assessment; *Educational Needs; *Money Management; Test Results
IDENTIFIERS	*New Hampshire

ABSTRACT

One model of educational needs assessment stresses: (1) deciding what students should learn in school, (2) measuring whether they learn it, and (3) looking at gaps between desired learnings and actual learnings to identify educational needs and priorities. In this study, it was assumed that practically all students should master consumer-producer-citizen arithmetic applications prior to leaving school. Data from the 1970 and 1971 testing programs showed how New Hampshire grade 10 students marked test items relating to such applications. The data for seven items are presented and discussed. The data suggest that a great many students were seriously deficient in performing simple arithmetic applications that may be important for everyday adult living (survival skills). How serious this is cannot be determined by one person, it must be decided by parents, citizens, students, teachers, school administrators, and finally by school board members. (Author/RC)

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NEW HAMPSHIRE STATE DEPARTMENT OF EDUCATION

Identifying An Educational Need: Survival Skills In Arithmetic

A Real Situation And An Example of the Process

One of the products of the FY 1974 Needs Assessment for ESEA Title III

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CONDENSATION

One model of educational needs assessment stresses: (1) deciding what students should learn in school, (2) measuring whether they learn it, and (3) looking at gaps between desired learnings and actual learnings to identify educational needs and priorities.

After identifying a need, decisions must be made as to how serious the gap is, particularly as a priority in comparison with other needs. Determining the priority involves considering whether it might be possible to close the gap, how much that might cost in time and other resources, and what might be the desirable and undesirable side-effects on the achievement of other goals by students. Although some consideration of ways of closing the gap is used in determining whether it is possible, at what cost, and with what side-effects; the actual approaches and programs to be used are chosen from among possible alternatives after the gap in learning has been prioritized. (This need-then-program approach contrasts with the stereotype of adopting an innovative program without clear ideas of what students need and whether the innovation may fill that need.)

In this study, it was assumed that practically all students should master consumer-producer-citizen arithmetic applications prior to leaving school. Data from the 1970 and 1971 testing programs showed how New Hampshire grade 10 students marked test items relating to such applications. The data for seven items are presented and discussed. The data suggest that a great many students were seriously deficient in performing simple arithmetic applications that may be important for everyday adult living (survival skills). How serious this is cannot be determined by one person, it must be decided by parents, citizens, students, teachers, school administrators, and finally by school board members.

It must be decided whether these and other consumer-producer-citizen applications of arithmetic are important objectives of schools. Emphases on these objectives would have both desirable and undesirable side-effects on achieving a wide variety of other school objectives, so should such emphases be made? Is there reason to believe that practically all students should and could learn these applications? (Achievement in arithmetic does seem more related to school programs than does achievement in reading comprehension, but arithmetic now requires continual reteaching, probably because students don't use it outside of the classroom unlike the many uses for reading.)

This is not a plea to drop the "new math" and to return to the traditional continual drill on computations: as adults of all ages can attest, schools never did give them a useful knowledge of arithmetic. All types of mathematics programs should be examined. Stressing arithmetic in the early grades won't help if students forget it because they don't use it. "Remedial" mathematics programs in secondary schools won't work if students have learned in elementary school that math is hard, isn't useful, and should be feared and avoided. Giving students pocket calculators is at best a partial remedy, because students' chief difficulties are in understanding the problems, not in the calculations.

Would many adults cope more successfully with various situations in life if they could comfortably use arithmetic? Are there ways by which practically all students can learn to use arithmetic?

Identifying An Educational Need: Survival Skills in Arithmetic

A Real Situation And An Example Of The Process

Introduction

These are the steps of one needs assessment model:

1. Determine learner-outcome goals
2. Learner goals refined to subgoals
3. Subgoals refined into performance objectives or desired learner outcomes
4. The selection or development of instruments designed to determine learner performances or perceptions of performances
5. The collection of data by use of the instruments
6. The comparison of desired learner outcomes with actual learner performances reveals some serious differences called educational needs

Each of these steps takes considerable time, so it would be many years before this would be accomplished for even a few subgoals. By making some assumptions concerning some probable direction of activities, it is possible to illustrate the process by an actual example. The example is real enough that an actual New Hampshire educational need may have been identified!!

Assumptions:

1. One goal* may be: GAIN A GENERAL EDUCATION, including DEVELOP BACKGROUND AND SKILLS IN THE USE OF NUMBERS.
2. One subgoal might be: THE STUDENT WILL USE NUMBERS TO SOLVE PROBLEMS THAT ARISE IN VARIOUS ADULT ROLES SUCH AS BEING A CONSUMER, PRODUCER, OR CITIZEN.
3. Some objectives might be specific to using or determining percentages, fractions, unit prices, price reductions during sales, and determining total profit from the profit per unit.
4. Selection of instruments could include selecting the Stanford Numerical Competence Test and the School and College Ability Test (Quantitative) because those tests were designed by groups of educators who selected items to measure various important objectives of arithmetic. (Some items in these tests seem to measure some of the consumer-producer-citizen objectives.)
5. The collection of data can include test and item scores from past testings, particularly if there is no reason to believe that results from new testings would be different.
6. If there is general agreement that the items do measure desired objectives and if the actual results are seriously lower than desired, then an educational need will have been identified.

Reasons why data from grade 10 arithmetic tests were selected

A. For quick example purposes, the choice was among readily available data sets.
B. Among the subtests available, reading comprehension and arithmetic applications probably have the most important and clearest subgoals. (The only reading comprehension items for which data were available are paragraph meaning items. Those items are complexly related to paragraphs and so are not easy to discuss. Vocabulary items would have been useful because they are highly related to paragraph meaning, but no vocabulary data were available.)

*A related goal may be: LEARN HOW TO BE A GOOD MANAGER OF MONEY, PROPERTY, AND RESOURCES, including DEVELOP ABILITY AND UNDERSTANDING IN PERSONAL BUYING, SELLING, AND INVESTMENTS.

C. When selecting hypotheses for a study, it is more efficient to work first on topics that are likely to produce results. There is a large amount of evidence from international, national, and regional studies that have shown that many adults and students do not have a useful knowledge of arithmetic, but there has been no detailed study in New Hampshire of students who are nearing the age when they will graduate or leave school.

D. Testing in grade 10 covers practically intact student groups; there are relatively few drop outs before then. The courses that students take in grades 10, 11, and 12 are unlikely to improve arithmetic scores; except perhaps for some vocational education courses such as business practice. Therefore, testing in grade 10 provides relatively good data on how well students are prepared to handle the numerical situations that they will encounter in their adult roles. (Grade 10 results depend upon the practices and curricula in all previous grades, so identifying a serious need at that level may result in a re-examination of mathematics curricula at all grade levels.)

E. If a need is shown in arithmetic applications, there seems to be more hope that corrective actions will be somewhat successful than if a need is shown in reading comprehension. This is because national and international studies suggest that student success in arithmetic is less highly related to motivation from home than is success in reading. Changes in school programs are therefore more likely to be successful in arithmetic than in reading. (One area for change might be in retraining teachers: one of the very few studies that has shown that student achievement in a subject was related to the teachers' knowledge of the subject was done on sixth grade arithmetic.)

F. The test planned for the 1974-75 school year is to be used in grade 10. The test contains a section of arithmetic applications items that could provide current data on items similar to those examined here. (The test also contains a section of vocabulary items, so reading comprehension can be checked next year.)

The Example Items

The items selected for presentation here are not a random sample of items from the tests. Instead, all items were examined and 21 of the 95 items seemed the most nearly related to consumer-producer-citizen applications of arithmetic. This method of selecting items that appear to measure what you want to measure is called "face" validity and in the current jargon it is called "criterion-referenced".

Among the 21 items, seven were selected for presentation here. Again, they were not randomly selected, instead, they were selected to cover certain topics at varying levels of difficulty. These selections may be some of the more difficult items, but that is not a bias as long as the content of the items is important and the items are not tricky. Considering that seven items are presented and that the data came from thousands of students, the results should be considered quite accurate. Like any other examination of a test, the reader should work each item and look for serious flaws--minor flaws can be found in anything written. Consider whether you think the items are related to useful consumer-producer-citizen arithmetic applications. While they certainly aren't real-life situations, they do seem to suggest that persons having trouble with these items would be likely to have trouble with real-life problems.

We do not have the item difficulty data from either the original norming of these tests in 1965 and 1955, nor do we have national norms for the years 1970 and 1971. We do have data that show that the total scores for New Hampshire students are very close to the scores of the national norm groups. This suggests that the New Hampshire item results are probably very similar to the national results. Anyway, national item norms are not needed for this study. Here we are examining items to determine whether they measure skills important to real-life situations. If New Hampshire students can't make useful applications of percentages, that can be very serious, even though students in other states are similarly handicapped.

Each item is discussed in detail when it is presented. This is necessary because measuring in school is never the same as when a person encounters a real-life situation. Students use various strategies when answering test items, and just slight changes in an item can greatly affect how many students have trouble with it. An item is only an approximate measure of an objective, and many students may give the right answer by methods that are not related to the desired objectives; extreme examples of these are cheating and random guessing, many less extreme methods including "test wiseness" are used.

Here are a couple of examples to show that test items should not be over-interpreted, because you are never positive why certain groups answer as they do.

(1) A seventh grade science item was tried out. "Where are wind-eroded rocks most likely to be found, in a desert or in an inhabited valley?" The brightest students knew there are more of those rocks in deserts, but they answered "in an inhabited valley" because there would be people there to find the rocks!

(2) A more subtle example is from the National Assessment of Educational Progress. "Do the police have the right to come inside your house any time they want to?" Students in the rural areas and villages of northern New England, whose neighbor may be local constable, might answer "Yes" without giving it much thought. Civil rights activitists and criminals would certainly answer "No". This item is supposed to measure the objective, "Recognize instances of the proper exercise or denial of Constitutional rights and liberties (illegal search)." It would be interpreted that students in northern New England do not know much about their rights.

In a multiple-choice item, the question or statement in the stem may not be perfectly clear but the available answer choices that are given do help to clarify the type of answer expected. Further, the better test companies try-out their items with small groups of appropriate students who discuss why they answered as they did (like the "rocks" example). Still further, the items are given to larger groups of appropriate students and item analyses (much like the data here) are computed. The results for various groups are compared to ensure that the more advanced students aren't reading into an item some ambiguities that don't bother the other students. Thus, item analyses have many uses for clarifying items.*

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*Older test critics seemed uniformed about item analyses and therefore said that the more advanced students were more likely to get items wrong. Newer tests critics think that item analyses are performed only to make tests to discriminate among students, and that it is not necessary to examine items for ambiguity by such actual tryouts and analyses. There is a grain of truth in each position, so item analyses must be done carefully.

These data are from items in two tests given to grade 10 students in October 1970 and 1971. The numbers of students tested was 6,482 in 1970 and 9,774 in 1971: these are large numbers in themselves and are high proportions of the approximately 13,000 students who might have been tested if all schools had participated. If any type of student is under-represented, it would be low scoring students for whom the schools considered the tests too difficult or who were given the test materials and didn't bother to mark answers.

The percentages of students in the Low, Middle, and High groups were determined in the year of the testing and so happened to be available for this study. These percentages were: Lo = 20 or 24%, Mid = 58 or 54%, and Hi = 22%. Because there are over 13,000 grade 10 students in the state, even 20% represents 2,600 persons.

Item I. Simple percentage computation.

30% of 30 =

	% selecting that response			
		Subgroups of total		
	Total group	Lo	Mid	Hi
*A. 9.0	61%	23%	63%	92%
B. 0.9	21%	36%	21%	7%
C. 90.0	12%	26%	11%	.+%
D. 60.0	4%	11%	3%	None
No answer	2%	4%	2%	.+%

This is a straight computation problem and not an application. It is included here for comparison with items that require an application of percentage.

This is uncomplicated. Any student who knows that 30% of 30 is about 1/3 of 30 can select among the wide range of answers without even doing the simple computation. Anyone selecting an incorrect option lacks the understanding that 30% is about 1/3 and also makes mistakes in the mechanics of decimal places.

About 61% of the total group marked the correct answer. There does not seem to have been much random guessing, that is most of the incorrect answers seem to have been selected because those students thought that they were correct: this is shown by so few students selecting D. and so many selecting B. This is what usually is found for multiple-choice items: students select the answer that they think is correct or they do some "informed" guessing, that is, they eliminate some answers and use partial knowledge to guess among the remainder. Perhaps 10% of the students selected the correct answer by partial or random guessing, so act ally only half of these students knew the right answer.

Percentages are often used in consumer arithmetic and are found in newspaper articles and many other sources of information for citizens. Presumedly, about half the students leaving schools to take on adult roles could easily acquire misinformation or be deliberately misled when percentages are used. (On the other hand, about half of the students solved this easy problem and may be able to make more difficult applications of percentages to real life situations. Notice that 92% of the Hi group answered correctly.)

Item II. An uncomplicated percentage application.

During a sale a $25 toaster was reduced 15%. What was the sale price?

	% selecting that response			
		Subgroups of total		
	Total group	Lo	Mid	Hi
A. $24.50	7%	10%	7%	1%
*B. $21.25	53%	21%	50%	90%
C. $22.50	22%	33%	25%	6%
D. $20.00	16%	33%	16%	3%
No answer	2%	3%	2%	None

This problem is like a simple consumer application of percentage. None of the possible answers is far wrong, so the student would probably have to compute an answer instead of merely estimating one.

After allowing for partial or random guessing, slightly less than half the students seemed to know the answer. The results for the subgroups suggest that not many students in any subgroup were pessimistic enough to select $24.50 (only $.50 reduction) as the sale price. On the other hand, 66% of the Lo group selected answers C or D, suggesting that they were using partially informed guessing, rather than computations, in answering the problem.

It is somewhat surprising that this item wasn't much more difficult than Item I. Perhaps if students can compute simple percentages, they can use percentages in relatively simple applications.

It looks as if at least half the students probably couldn't check whether the store made the proper reduction, even if they wanted to do so.

Item III. A somewhat more complicated percentage application.

The cost of an item, including a 20% luxury tax, was $384. How much was the tax?

	% selecting the response			
		Subgroups of total		
	Total group	Lo	Mid	Hi
A. $ 7.68	19%	23%	21%	11%
B. $32	20%	27%	22%	11%
C. $64	17%	16%	14%	22%
D. $76.80	30%	15%	29%	46%
E. $96	5%	7%	5%	2%
No answer	9%	11%	9%	8%

This is a somewhat more complex consumer-citizen application of percentage, but it is likely to be encountered by most people. Of course, most consumer-citizens don't bother to compute how much tax they pay, but more might do that if they could do it easily.

The answers are far separated in amount, so some estimation of the answer can be made. The $96 was pessimistically high for all groups. The $7.68 and $32 were optimistically low and attracted more than random shares of the Lo and Mid groups. The favorite answer, especially for the Hi group, is $76.80 which is 20% of the $384. Either they missed the word "including" or they made the easiest computation without worrying whether it was right!!

(If the final cost is 120% of the base price, then the 20% tax is 1/6 of $384 = $64. A quick way to estimate the answer is to compute the 20% of the final cost = $76.80 and then select the next lower answer, $64, because 20% of the base price would be somewhat lower than 20% of the final cost.)

The "no answers" could be due to the difficulty of the problem and also because this was the 21 item of a 25 item section. Nevertheless, there didn't seem to be much completely random guessing: actually, the Lo, Mid, and Total groups would have done better if they had guessed randomly (20% for each answer) and the Hi group did not do much better than that!! It seems as if grade 10 students can make simple applications of percentages but many of the best students do poorly on somewhat more complicated problems.

These three percentage problems (I, II, and III, suggest that about half these students can compute simple problems; slightly fewer can make simple applications, and very few can make somewhat more complicated applications as measured by these items.

Should and could schools prepare students to apply percentages when needed in real life situations? Perhaps many readers of this report would have missed one or more of these problems. They may feel that they are leading successful adult lives without needing to know much about percentages. On the other hand, some readers may know of times when a lack of knowledge in the use of percentages was disadvantageous to them and many may have picked up misinformation or lost money without being aware of it.

Here are some more arithmetic "applications" items. They are of various types but do not involve percentages. They are from the same two tests and for the same 1970 and 1971 samples of grade 10 students.

Item IV. Total profit.

George buys newspapers for 3 cents each and sell them for 5 cents each. How many newspapers must he sell to make a profit of $3.00?

	% selecting that response	Subgroups of total		
	Total group	Lo	Mid	Hi
A. 15	5%	11%	4%	1%
B. 60	21%	39%	20%	4%
C. 100	6%	12%	5%	2%
*D. 150	60%	28%	63%	83%
E. 600	7%	8%	7%	5%
No answer	1%	2%	1%	1%

The arithmetic isn't difficult nor is the reading for grade 10 students. There are two steps: subtracting 3¢ from 5¢ to find the profit per paper of 2¢ and the dividing $3.00 by 2¢ to find how many papers must be sold.

Although some of the Lo group and a few of the Mid and Hi groups may have somewhat randomly guessed answers A, C, and E; answer B was the most popular wrong answer for all groups. It is more optimistic to think that George could make $3.00 profit by selling only 60 papers, or perhaps that could be considered a pessimistic consumer reaction. To get answer B, the word "profit" must be ignored and the selling price of 5¢ was divided into $3.00.

All of the listed answers can be obtained by misusing some of the numbers in the problem; so randomly guessing an impossible answer couldn't be done. Nevertheless, probably not more than half the group would probably compute a similar problem. Granted, this is a test problem and not a real life situation, but it might be considered undesirable that so many students missed this example.

Many situations in the adult world--such as the large numbers of failures of small businesses, the surveys that show that few people realize that most businesses make less than 5% net profit on sales, and the consumer campaigns that utility companies "absorb" fuel price increases when the profits of those companies are far less than the increases to be absorbed--suggest that many consumers and citizens know little about computing profits. This is an extremely simple example of a complex topic, so the low results here indicate that more complex and real examples of profits are unlikely to be understood.

Item V. <u>Selecting needed data and computing number of units purchased from the total price and the cost per unit</u>

THE AUTOMOBILE TRIP

TRIP DATA

Price of gas	28.5 cents per gallon
Distance traveled	2000 miles
Hours spent driving	50

EXPENSES

Gas	$31.92
Oil	1.20
Depreciation	12.88
Meals	32.80
Hotel	42.00
Miscellaneous	10.40
Total	$131.20

Approximately how many gallons of gasoline were purchased?

	% selecting that response			
		Subgroups of total		
	Total group	Lo	Mid	Hi
A. 10	16%	19%	16%	12%
B. 90	16%	26%	16%	5%
C. 100	13%	19%	14%	7%
*D. 110	45%	23%	43%	70%
E. 910	5%	7%	6%	3%
No answer	5%	6%	5%	3%

This item is somewhat unrealistic in that persons usually use the unit price and the total number of units to compute the total cost. On the other hand, some persons might determine how much of something to order depending upon the amount of money that they have for that purpose. There is some reading and table use required, but calculations are only approximated.

The fact that over half the students did not select the correct answer may be undesirable. There seemed to be little random guessing, as is shown by the small percentages for answer E. Again, the optimistic answers are favored: even in the Hi group, 12% expected to go 2,000 miles on 10 gallons of gas! The 28.5¢ divides into $31.92 somewhat more than 100 times, but, as practically all students knew, not 910. Forgetting the "more than" might give 100, while considering it to be "less than" would give 90, as might reverse division.

Again comes the question, should practically all students be able to do a problem like this before leaving school?

Item VI. Relative sizes of fractions and decimals.

Which of the following is of greatest value?

	% selecting that response			
		Subgroups of total		
	Total group	Lo	Mid	Hi
A. 11/16	20%	16%	21%	22%
*B. .812	30%	22%	21%	59%
C. 5/8	45%	53%	53%	17%
D. .789	4%	7%	4%	2%
No answer	1%	2%	1%	.+%

This is not an applications problem, but fractions, decimals, and mixed numbers are often found in applications situations. For example, candy bar weights are now 1.06, 1½, 1.5, 5/8, 1.8, 1 1/8, and .95: students who want to consider quantity, as well as taste, should study those fractions and decimals; because the size of the wrapper is no guide.

There doesn't seem to be much random guessing. Answer D was seldom selected, probably because it is obviously smaller than answer B. It is really ironic that answer C, 5/8, the favorite choice of the Lo, Mid, and Total groups, has the lowest value! If students misread "greatest" to mean "lowest", then more would probably have chosen D. Even if they couldn't compare fractions with decimals, 5/8 is 10/16 and so is lower than 11/16: only in the Hi group was 11/16 selected more often than 5/8. In comparing fractions and decimals, 12/16 is 3/4 which is usually recognized as .75, and that is lower than either of the decimals given.

Random guessing among four answers would result in 25% correct. Only the Hi group did better than random guessing, and they brought the Total group above 25%. (Frankly, the fact that the Mid group selected a certain wrong answer more often than the right answer is surprising. A check of the 45 items in this test shows that the Mid group did that for 10 items. Even the Hi group selected a certain wrong answer more often than the right answer for the last two items in the test. None of these items appeared to be written deceptively.)

How valuable is it for adults to be able to compare decimals and fractions? This problem doesn't even require actual computations, instead, rough comparisons are all that are needed.

Item VII. Determining and using a unit price.

In one town tomatoes are selling at 3 pounds for 72 cents. At this rate, how much would you pay for 3½ pounds?

	% selecting that response	Subgroups of Total		
	Total group	Lo	Mid	Hi
A. $1.32	6%	14%	5%	1%
B. $1.08	36%	40%	42%	16%
C. $0.96	13%	19%	13%	4%
*D. $0.84	44%	23%	39%	79%
No response	1%	4%	1%	None

This is not a common application problem in this form. Usually there are two or more packages with different weights and prices, so the shopper may want to buy the one with the lower or lowest unit price. (Quite often for detergents, the best buy is the middle size: the largest size often has a higher unit price because many consumers buy the "economy" size without checking.) Even with laws about displaying the unit prices, many customers don't yet know how to use that information.

Again there doesn't seem to be much completely random guessing: the highest price was unpopular. It is unfortunate that the correct answer was the lowest, because many students might have picked a low price, such as $0.36, if it had been available. The most popular answer for the Lo and Mid groups was $1.08 which is 1½ of 72¢. Could those students have read 3½ as 3 + ½ of 3? That seems unlikely.

If 3 pounds cost 72¢, the 3½ pounds should cost a little (1/6) more, so the correct answer, 84¢, could have been obtained by estimating. The 96¢ is close enough to the 84¢ that a careful student would have divided 72 by 3 to get the unit price of 24¢ and then added ½ of the 24¢ to the 72¢ to get 84¢.

The determination of unit prices and the comparisons of various amounts to determine the cheapest per unit certainly seems to be a survival skill necessary for anyone who lives on a budget, even if many stores are required to post unit prices. This item does not measure unit prices directly and no low answer is listed, nevertheless, this item is related and it is much easier than most real-life situations. (In a grocery store, there may be three or more sizes of packages and there is usually a fraction or a decimal as part of each weight.) It would take too long for the shopper to compute unlisted unit prices, so methods of estimation should probably be learned. With over half these almost-adult students missing an item that is so easy to estimate or to compute, this may be quite unsatisfactory?

Summary and Interpretations

These items were selected from tests given in grade 10 in 1970 and 1971: most of those students started first grade in 1961 or 1962, so there may have been changes in schools since then. Nevertheless, very similar results would be expected if the tests were given today or in the near future. The scores of New Hampshire students are very like those of national norm groups; so this study was not to see whether we were "behind", instead, it was to see whether students had "survival skills" in certain applications of comsumer-producer-citizen arithmetic.

(After this report was drafted, a report was received from New Jersey. They had actually gone through all the steps of a needs assessment in reading and mathematics. They tested in the 12th grade in 1972 and in other ways their procedure and data differed, but their interpretations were somewhat the same:

> "Problem solving has been the curse of the high school mathematics teacher for years. Results from the test tend to substantiate a foregone conclusion. Students do not like nor do they do well on word problems. The only bright spots...were in...consumer problems (!!!). Word problems centering around per cent...had relatively low levels of correct performance. The performance of the non-college preparatory groups was disastrous." ...The college bound students did not fare much better. They showed strength in solving simple word problems, consumer problems and averages. All other areas would be viewed as weak.")

The results definitely seem to show that most of these nearly-adult students are poorly prepared to be careful consumers, producers, and citizens as far as using numbers are concerned. There is much evidence around us that many people have problems handling their money and that they are easily swayed by misleading numerical information from politicians, advertisers and the news media. There are probably many more mathematical illiterates than there are illiterates in reading. Although functional reading may be a more important survival skill than the functional application of arithmetic, the situation in arithmetic may affect many more persons and may be easier to correct.

Many adults seem almost proud to be "poor with figures". Whether this indicates that arithmetic applications really aren't important or whether those persons are trying to laugh off a known or unrealized handicap isn't easy to determine: perhaps those individuals and this country can afford to throw money around and to be misinformed. Actually ever since "an education" was considered to be "reading, 'riting, and 'rithmetic", mathematics has been rated second only to reading in importance as a subject to be learned.

Too often a change in an emphasis in education has been made without consideration of the side-effects on various other educational goals or whether what is planned in theory is implemented as planned and produces the expected results. Mathematics provides excellent examples of this. "Traditional" arithmetic produced rapid student gains in the mechanics of computations, so that was emphasized even though it was quickly forgotten and so had to be retaught in every grade: a student entering grade 5 said, "Our arithmetic book has five new pages this year." The arithmetic "concepts" were largely related to fancy words such as subtrahand and dividend. Practical applications were presented as "word problems" and were difficult to teach; so they were largely ignored or students were taught to look for key words in the written problems. Teaching key words was not very useful because the students couldn't do a problem that "wasn't written right" and especially because most adult needs for arithmetic applications are real-life situations and are not written in a textbook. One curriculum revision to correct this introduced the project method in which teams or classes of children simulated a store or some other real-life situation. That sounded wonderful, but in actual practice the children who were weak in arithmetic managed to avoid the activities relating to arithmetic--they painted the signs or wrote the letters. The "new math" was then introduced in the expectation that making computations and applications into meaningful operations could produce learning and reduce forgetting. That also sounded wonderful, but it was made too formalistic by mathematicians, was not understood by teachers, and the chief goals--improving applications and computations--seemed to be completely forgotten. This has resulted in the short-term rote memory of additional words and manipulations that are not taught as being related to "real" applications or computations: "new math" became an "end-in itself" rather than being a way to tie all sorts of goals for mathematics together for ease in learning and to improve understandability. Both the project-simulation method and the "new math" could contribute to useful knowledges of mathematics, but the implementation would have to be watched to insure that the purposes, and also the individual students, aren't forgotten. Probably the greatest problem would be in retraining the teachers as discussed in the next paragraphs.

These data suggest that relatively few adults are prepared in schools to handle easily the arithmetic applications useful in adult living. Among those who are successfully prepared, probably most of them enter occupations that use mathematics such as science, engineering, accounting, and many others. That doesn't leave very many for the two million teaching jobs. Elementary teachers are generalists who are probably attracted to the work because they like children. What little information that is available on how successful elementary teachers are in applying arithmetic suggests that relatively few are successful enough to be good models for children. (Some persons have <u>imagined</u> for years that many elementary teachers dislike arithmetic and don't consider it useful and pass those attitudes on to children even if they don't mean to do so. Unfortunately, there doesn't seem to be much data available to either reject or support this imagining.) This suggests considering whether the mathematics in elementary schools should be reduced to what most teachers are comfortable with or whether the teachers who are the most at ease with applications should do most of the teaching of elementary mathematics: the retraining of teachers who dislike mathematics may not be very effective.

The secondary teachers have always presented a problem. Most of them are very interested in their subjects and have specialized. A serious question can be raised whether such persons are appropriate teachers for students who need or want only a general knowledge. (Of course some specialists can teach interesting general courses and generalists who are ignorant of the wider aspects of a subject are likely to be unable to separate the important and basic concepts from the trivia; so there is no easy answer.) This specialization of teachers of all subjects is well illustrated in mathematics. In college a mathematics major studies largely calculus and other topics not very pertinent to what he will teach in secondary school. Fortunately, most were fairly successful when they were secondary students; so most of their teaching is based on what they learned when they were secondary students. Many learn advanced mathematics in college but don't learn areas of applications of elementary mathematics such as sciences, business, social statistics, trades, technologies, income taxes, and many others. Many may be unable to teach applications because they don't know the applications (When most students left school after grade 8, arithmetic applications in budgeting, buying a house, income taxes and others were taught in grades 7 and 8. When most students started staying in school for two to four years more, such content was appropriately dropped as being no longer of immediate pertinence for those grades. Unfortunately, very few schools introduced similar and expanded courses available to all students in grade 10 or 12. This may be because students don't want them, but it could be because high school mathematics teachers don't want to teach such courses. Actually, general mathematics in grades 9 or 10 contains some applications, but those courses are chiefly for only the students in the general educational stream.) In general, retraining of secondary, as well as elementary, teachers is likely to be needed.

The examples here were for only a few from consumer-producer-citizen applications. Many more objectives exist in those areas. Mathematics education also has sub-goals with many objectives relating to sciences, business, trades, technology, art music, statistics, logic, recreation, the beauty of proofs and patterns, and to the preparation of future mathematicians. The accomplishments on those objectives need checking. Any curriculum revision must consider the relative emphases for all objectives and a variety of programs for the variety of student interests.

It will take a long time to implement a change successfully. Is it needed? Does it deserve priorities in attention and resources? Does it conflict with or augment other educational goals?