

FOCUS ON EXCEPTIONAL children

Improving the Learning of Mathematics in our Schools

Lelon R. Capps and Linda Simon Cox

In the view of many Americans, our schools have failed to produce literate graduates. Although some people always have held this view, the launching of Sputnik in 1957 gave it national and international exposure. From that time forward the "failings" of our schools repeatedly have been the subject of media attention. These failings include failing to teach respect; graduating students who cannot read, write, or spell adequately; producing students who are not literate in geography, history, the sciences, or mathematics; and the list continues.

This discussion concentrates on the area of mathematics. Internationally our students are ranked near the bottom in comparative studies of mathematics achievement. The business community finds this appalling and demands a workforce that is better educated, possesses greater skill in mathematics, is more familiar with the technology necessary to conduct business and to communicate in today's world, and, above all, has "common sense" in making decisions. There is increasing concern that America is relinquishing its role as a leader in technological advancement. As a consequence, the schools are experiencing increasing pressure to solve these problems.

The discussion here examines one aspect of a potential solution to the problem of poor mathematics achievement. We focus on specific research findings in the area of forgetting, and examine the implications for year-round schooling. The implications, of course, go far beyond the mathematics curriculum.

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We contend that over the past three decades numerous and continual changes have taken place in the mathematics curriculum. Yet, none of these changes has silenced the critics or solved the problems. Could these continual changes in the mathematics curriculum have ignored other psychological and organizational factors that negate or neutralize the intended positive influences of the curriculum change? Over the past 30 years we have observed the move from the traditional mathematics curriculum to "new math," to "back-to-basics," to problem solving, and currently to changes emphasized in the *Curriculum and Evaluation Standards for School Mathematics* (National Council for Teachers of Mathematics, 1989). In April of 1991, the *Professional Standards for Teaching Mathematics* (National Council for Teachers of Mathematics, 1991) was released. The latest movement is characterized by the term *constructivism*.

Yet, this change in emphasis over the past 30 years has produced only limited success in raising student achievement and in satisfying the critics. Carpenter et al. (1984) reported the results of the National Assessment of Educational Progress from 1973, 1978, and 1982. Table 1 shows the change over the three assessments for 9-, 13-, and 17-

year-olds. The reader can readily discern the pattern over time and conclude that the curriculum changes over the specific time period did not produce an overall positive change in mathematics accomplishments of our 9-, 13-, and 17-year-olds.

TABLE 1
Mean Performance Levels on
Three Mathematics Assessments

Age	Number of Items	Mean Percentage Correct			Percentage Change 1973-82
		1973	1978	1982	
9	23	39.8	39.1	38.9	-.9
13	43	53.7	52.2	56.4	2.7*
17	61	55.0	52.1	51.8	-3.2*

*Change is significant at the .05 level.

In Table 2 the assessment results are examined by content areas. Here there are some significant changes for 9- and 13-year-olds, but 17-year-olds show no significant change. Note that the topics that have been more recent additions to the curriculum and have received increasing focus in more current curriculum materials predominate this list. Numeration has remained at a plateau.

TABLE 2
Change within Content Areas from 1978 to 1982

Content Area	Mean Change in Percentage Correct		
	Age 9	Age 13	Age 17
Number and numeration	.07	4.0	.0
Variables and relations	-1.3	3.2*	-.5
Geometry	2.0*	4.7*	.0
Measurement	.8	2.6*	-1.3
Probability and statistics	.2	3.7*	1.2
Graphics and tables	3.0*	3.2*	.4

*Change is significant at the .05 level.

One can only conclude that the many changes in curriculum have achieved mixed results. More recent topics added to the curriculum show some positive change. The more traditional topics show no change. With regard to technological literacy, we have no reliable information. The overall picture is not encouraging.

In its publication *Everybody Counts*, the National Research Council (1989) describes the challenges we face. These include:

- large numbers of students leaving school without the mathematical power necessary for productive lives
- a shortage of qualified mathematics teachers
- an increasing number of minority students

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- a lack of skill acquisition in mathematics to sustain our technologically based society
- failure to compete internationally in mathematical accomplishments
- a public attitude that accepts poor school performance in mathematics
- curricula that fail to reflect the increased demand for focus on higher order thinking skills, applications of mathematics to everyday uses, and the way students learn mathematics
- failure to include the calculator and computer in instructional practices for mathematics
- excessive reliance on standardized test scores to evaluate success
- failure to stimulate the mathematical interest of today's students.

To date, our answer to the challenges has been to:

- increase the number of required courses, with little agreement as to their content
- put greater force on standardized measurements with little concern for whether those instruments reflect the content taught or skills needed in the workplace
- increase use of test scores for teacher and school accountability.

What, then, is the answer to the dilemma? Obviously there is no single answer. It does seem obvious from the two preceding paragraphs, however, that curricular change alone is not an answer but, rather, a partial solution that needs support from other aspects of the schooling process. Three sources for consideration are discussed here:

1. The role language and symbolism play in learning mathematics.
2. The role of forgetting as it relates specifically to mathematics learning and the learning disabled.
3. The effect of our school calendar as a contributing factor to low achievement in mathematics.

THE LANGUAGE FACTOR IN LEARNING

Regardless of students' abilities, the teacher of mathematics must recognize that content is not taught without language. As a society, the myth exists that if you are a skilled reader, success certainly will follow in other subjects. How is it, then, that millions of excellent readers find themselves lost in mathematics classes, especially when asked to cope with the ever present word problem? Common sense tells us that in every lesson we teach, regardless of content, we first must have students succeed in understanding the language and symbolism of the specific con-

tent area. Hirsch's (1987) best seller on cultural literacy addresses this problem in an interesting manner, and it is suggested to all readers who wish to pursue the social implications of diverse populations that lack a broad base of common knowledge about our country's diversity.

Several barriers must be surmounted in the mathematics lesson for the learner to achieve successful outcomes. First, much of the language and symbolism of mathematics, or any other content area, is unique to that subject matter and would never be acquired through a reading curriculum. Words such as *denominator*, *addend*, *division*, *polygon*, *function*, and *factor* do not lend themselves to inclusion among the stories in a reading text.

As a natural consequence of the preceding barrier, a second one becomes obvious. We must recognize that the only place to learn the language and symbolism of mathematics is during the 40- to 50-minute mathematics lesson. A mathematics lesson must introduce words and symbols in much the same manner as new words would be introduced in a reading lesson. That sequence involves four basic steps. Listed in order, they are:

1. Listen.
2. Speak.
3. Read.
4. Write.

These steps, of course, can overlap, but basically we hear and speak a language before we learn to read and write it.

Unlike the language in reading programs with its constant reinforcement outside the instructional period and the school, the mathematics lesson must provide the reinforcement primarily within the lesson and the classroom. As a minimum, teachers must write the words and symbols on the chalkboard for students to hear and speak and read. Written assignments then must require more than computation. The assignment must call for written reinforcement of the language and symbolism as well.

To see implications for the teacher of students with learning disabilities, we need only be reminded of factors such as the following (Meyers & Burton, 1989):

- visual processing deficits
- auditory processing deficits
- kinesthetic deficits, and
- reasoning disorders.

In the mathematics lesson these deficits and disorders are magnified many times because of the uniqueness and abstractness of the mathematics language and symbolism. A special reason for the magnification relates to frequency of exposure to the language. Research from the field of

reading suggests that a student should hear, speak, read, and write the terms or symbols approximately six times in an introductory lesson. Even this will not ensure acquisition into the student's usable vocabulary. What is required further is approximately 30 subsequent exposures, in context over several months time. We suggest here that this single factor—overlooked by many teachers in regular and specialized classes—is a major, contributing factor to low achievement in mathematics.

To summarize this, we again note that although reading program vocabulary is reinforced constantly at home and in social interactions, this is not the case for mathematics vocabulary and symbolism. The lack of reinforcement outside the school must be compensated for during the mathematics instructional period and the students' school day.

FORGETTING AND RECOUPMENT

Cone's (1984) literature tends to support the conclusion that language factors unique in mathematics are much more subject to forgetting. And they are more influential on achievement than are language factors unique to the subject of reading.

Over the years, a limited amount of research has been conducted on the degree of skill maintenance or skill loss for nonhandicapped students in the basic academic areas of reading, language, and arithmetic. Morrison (1924) and Irmina (1928) reported general maintenance of reading skills over the summer, and Elder (1927) and Keys and Lawson (1937) actually reported some gain over the same noninstructional interval.

Bruene (1928) reported maintenance of language skills over the summer for nonhandicapped students. More recent work by Keys and Lawson (1937) and Beggs and Hieronymus (1968), however, reported significant losses in language skills following summer break.

The research on nonhandicapped students' mathematics skill retention over the summer suggests a consistently significant loss. Bruene (1928), Schrepel and Laslett (1936), Keys and Lawson (1937), and Beggs and Hieronymus (1968) all reported significant losses in arithmetic calculation or reasoning, or both, upon student re-entry in the fall.

Thus, although the literature suggests that nonhandicapped students display significant skills loss in arithmetic after summer break, this is less conclusive in language skills. The available empirical data regarding reading skills suggest no loss and possibly some gain.

The nature of "summer forgetting" is even less clear than its occurrence or nonoccurrence. In an attempt to assess the relationship between intelligence and summer forgetting, Kohlberg (1934) found no significant correlation. Yet, Bruene (1928), Breuckner and Distad (1924), and Cook

(1942) all reported a significant positive correlation between measured intelligence and retention. Tiedeman (1948) suggested that such losses occur more readily for specific subject content; and Schrepel and Laslett's (1936) findings suggested losses in concept formation and generalization skills. Parsley and Powell (1962) and Soar and Soar (1969) contended that skill retention over summer break is a function of individual student characteristics interacting with certain classroom conditions.

Although current research is sparse, two conclusions seem warranted from the preceding review. First, the evidence tends to favor a conclusion of significant forgetting in mathematics learning over summer vacation. Second, current researchers have a major opportunity to add to the information base regarding forgetting and recoupment among regular students.

Looking at literature for handicapped students' forgetting and recoupment, (Cone, 1984) presented a less clear picture. Special educators have advocated summer, or extended-year programs for students with severe handicaps, to reduce or eliminate the problem of summer forgetting. Fredericks et al. (1978) found a positive relationship between amount of instructional time and achievement gains for students with severe handicaps. In a review of the literature on the efficacy of extended-year programs, Magliocca and Barker (1981) reported that the literature is replete with reports of summer programming for handicapped children, almost all indicating significant growth in one or another of the skill areas for different categories of handicapped conditions. Behrens (1967) reported acceleration in language skill acquisition for children with hearing impairments.

Bateman (1968) reported significant gains in cognitive and language processes for retarded children in a 6-week summer camp. Taylor and Pollock (1968) showed similar gains for trainable retarded pupils when compared to similar programs for otherwise handicapped children.

Many authors have reported significant or substantial gains during summer programs, for a full range of handicapping conditions and for all age ranges (Abordo, 1977; Baken, 1976; Brown & Andrews, 1968; Chorost, 1975; Ellis, 1975; Fox, Wright, & Goldstein, 1967; Hourcase, 1977; Joiner, Lodato, & Stillman, 1972; Minton, 1976; Polansky, 1979; Riegel & Taylor, 1973; Spivack & Koskey, 1972; Starkovich, 1972).

Yet, Magliocca and Barker (1981) concluded that most reports do not include, as baseline, pupil performance levels at the end of the previous 180-day school year. Although evidence of gain is available, the literature is conspicuously lacking in conclusive data. Control studies with matched populations of handicapped children receiving and not receiving extended school-year programming are absent in the research literature.

More recent studies support Magliocca and Barker's concerns. Ross (1982) compared the maintenance or non-maintenance of skills for multiple handicapped students who did and did not attend a 6-week summer program. The findings revealed nonsignificant difference between treatment groups on pre- and post-measures, prompting the conclusion that both populations did not "regress" or "acquire" new skills or behaviors; rather they maintained their spring student progress record scores.

McMahon (1983) evaluated the progress of 26 students recommended for an extended school year. This select subgroup of students with handicaps (whom a multidisciplinary team judged the more severe to need an extended school year) displayed a roughly 70% maintenance of skill during measured intervals, regardless of instruction or non-instruction on skills. Though nonmaintenance of skills increased slightly during noninstructional periods, only a small proportion of these students displayed such "regression" of skills.

Turner (1981) studied more than 4,000 mildly, moderately, and severely handicapped students for nearly 3 years. He reported a low probability of substantial regression/recoupment problems for students with severe handicaps over the summer break.

Tilley, Cox, and Stayrook (1986) explored forgetting and recoupment in specific handicapped, severely handicapped, communication disordered, and hearing impaired students. The thoughtful design and thorough statistical treatment led to the following findings:

1. Mildly handicapped students regressed less than regular students and had complete recoupment by November.
2. Behaviorally disordered students performed similarly to regular students with the exception of reading, which was lower. Recoupment was not complete by December.
3. Moderately and severely handicapped students tended to forget more rapidly, and recoupment was slower than for other groups of students. Speech and language recoupment rates were similar to those of other students and generally were completed by November.
4. Communication disordered groups showed little regression and had complete recoupment by October.
5. Hearing impaired and deaf students tended to perform almost identically to regular students with regard to forgetting and recoupment.

Based on their data analysis, Tilley, Cox and Stayrook concluded and recommended the following:

1. Regular education students seem to regress in late summer on academic tasks, as measured by short forms of the California Achievement Test (CAT). It is

recommended that the administration give serious thought to providing regular summer school programs in late summer rather than the current practice of scheduling them right after school is out in spring.

2. Patterns of loss and recovery for students with handicaps are similar enough to those of regular students that the timing of summer program offerings could be the same for both groups as long as the service delivery structure contains provisions to accommodate exceptional needs of students with handicaps where necessary.
3. Given the unreliability of measuring handicapped students' performance, the .05 confidence interval is recommended for use in developing guidelines to determine which students require extended school year services.
4. Students with mild handicaps regress and recover at about the same rate as regular students, but their overall test scores are much lower than those of regular students.
5. Seriously behaviorally disabled, hearing impaired, and deaf students' patterns, rates, and performance levels on the California Achievement Test (CAT) were similar to those of students in the regular program.
6. Communication disordered students' patterns on a test of articulation were flat, and few students qualified for service. If they have more severe language acquisition problems, cutoff scores for language tests developed for moderately and severely handicapped students should be used.
7. Moderately and severely handicapped students' overall pattern of regression and recoupment looks like regular students; however, their rate of regression is much faster on all types of tests (e.g., cognitive, self-help, speech/language, occupational/physical therapy). Their recoupment is slower on cognitive test items, but on language, self-help, gross motor, and fine motor test items, their rate of recoupment is similar to that of students in the regular program.
8. Students who are deaf/blind or visually impaired were excluded from the study because the population sizes were too small for a separate statistical analysis. We recommend that the guidelines developed for the multihandicapped and mentally retarded-severe/profound be used.

YEAR-ROUND SCHOOLING

The rationale for including year-round schooling is logical. If mathematical language and processes require consistent maintenance over time and forgetting and recoupment studies show the significant summer losses in mathematics

skill, as well as a significant amount of time needed to recoup the lost skill, year-round schooling seems a most logical solution.

Although most school districts resort to year-round schooling for economic or space reasons, an even more important and substantive argument should be made based on achievement, specifically for mathematics. Newman (1990) reported 630 year-round schools enrolling some 524,000 students. All Los Angeles public schools had adopted a year-round schedule by July 1990. Initially, approximately 100 of the 600-plus schools were operating on a year-round schedule, accounting for about 20% of the students enrolled. The calendar is 90 days in school and 30 days off. Although the plan was adopted to relieve crowding, the most significant benefit may well be greater achievement. It is hoped that a sound research design will gather and analyze data from the Los Angeles district to shed light on the achievement question.

Newman cited a research study by Philadelphia-based public/private ventures that specifically documents "summer slippage" academically among children in at-risk populations. The cause cited is lack of home and community reinforcement over the long summer break. Newman also cited a research study by Adrian Van Mondfrans, Brigham Young University, showing that students on a year-round calendar make greater gains on test scores than those on traditional calendars. Utah, which has the fastest-growing school-age population in the nation, has the highest percentage of year-round schools in the nation. California has the greatest number of year-round schools.

Resistance to year-round schooling among teachers and patrons has been substantial. Newman cited school board president Jackie Goldberg: "One of the reasons we had so much resistance . . . is because we didn't talk enough about the instructional purposes."

Newman also cited results in Orange County, Florida, concerning teacher resistance. "Initially, the teachers were negative," said George Segna, Executive Director of the Orange County Classroom Teachers Association, "but the more they learned about it, the more positive they became. They found that year-round schooling doesn't add days to the calendar, and they enjoyed the pace."

Current reform movements have advocated a longer school year since inception. Newman cited U.S. Senator Jeff Bingham (D-NM), who introduced a bill to examine the idea of lengthening the school year: "All studies indicate that our students get less instruction than students in other countries. Students in West Germany, Japan, Great Britain, and South Korea attend schools as much as 243 days per year." The average U.S. school year ranges from 170 to 182 days. Most advocates of extended school years tend to see 200 as a minimum number of days.

The June-to-September school vacation is one of the few things about schooling that remains unchanged. Originally based on the needs of an agrarian society, there seems to be no economic reason for the June-to-September vacation to remain that way based on the needs of society today.

Christie (1989) noted reasons other than overcrowding for considering year-round schooling:

1. Buildings and equipment already exist.
2. Teachers might be given extended contracts.
3. Administrative staffs already operate year-round.
4. Many fixed costs are independent of the number of months the school operates.
5. Many young people have difficulty making worthwhile use of the long summer vacation.
6. Increasing numbers of students are becoming involved in summer school programs for remediation, enrichment, and acceleration.

Research on achievement as it relates to year-round schooling is limited and generally is conducted over such a short time period that determining the true effect of year-round schooling on achievement is difficult.

After surveying 32 Iowa elementary schools, Beggs (1969) concluded that students lost the equivalent of 5 months of education in basic language and mathematics skills during the 3-month summer vacation. Harlan's (1973) research indicated that the year-round plan was more beneficial to students with intelligence scores below 100.

Merino (1983) raised the issue of needed longitudinal research. In an evaluation of the elementary program in Hayward, California, the results of the year-round program did not become apparent until after 4 years of implementation, when students on year-round schedules showed greater gains than students enrolled in the traditional school schedule.

CONCLUSIONS AND RECOMMENDATIONS

From the preceding discussion, the learning of language and mathematics indeed seems to be closely related. Learning mathematics and specialized language also seem to be highly influenced by continual reinforcement without prolonged interruptions such as summer vacation. This is true for regular students and students in special education alike. Research on year-round schooling, which eliminates lengthy interruptions, shows favorable results toward greater achievement.

These three conclusions speak strongly for the argument that much could be accomplished toward better learning

and greater achievement, specifically in the areas of mathematics and language, by adopting year-round schooling. In spite of the resistance that might develop, those who do so have little or no solid research evidence that would defend retaining the June–September vacation pattern. Tradition and convenience constitute the argument the resistance advances.

What is needed above all else is well designed longitudinal research that will add to the existing research findings. Certainly, what is known at this point is that prolonged interruptions influence achievement negatively, whereas extended schooling and year-round schooling show a positive influence for greater achievement.

We suggest that year-round schooling offers a partial solution to raising achievement scores in mathematics. Further, we suggested that continual curriculum changes without some concomitant changes in other aspects of our schools cannot change the achievement picture. Certainly, national assessment studies do not support the notion that curriculum change alone can solve our problem of ranking near the bottom in the international studies comparing mathematics achievement.

In conclusion, various organizational patterns for the school calendar must be devised to eliminate prolonged interruptions in instruction, thus minimizing forgetting and minimizing the amount of instructional time needed for recoupment. As well, the frequent interruptions that occur daily must be diminished. No curricular change or change in methodology can hope to succeed when frequent and lengthy interruptions are tolerated as normal or acceptable. Acceptance of these interruptions in itself sends a signal to students concerning our view of the importance of instruction. It is time to return to the basics: uninterrupted instructional time.

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