E D M O N T O N P U B L I C S C H O O L S

June 19, 2001

TO: Board of Trustees

FROM: E. Dosdall, Superintendent of Schools

SUBJECT: Numeracy Initiative

ORIGINATOR: M. de Man, Department Head Designate

RESOURCE STAFF: Stephanie Busby, Sandra Carl Townsend, Judy Craig, Sandy Forster, Hans Van Ginhoven, Phyllis Levin, Maureen MacDonald, Anne Mulgrew, Colin Ross, Stuart Wachowicz, Lisa Wright, Stephen Wright, Lou Yaniw, Fran Yeske

INFORMATION

Background: An initiative was brought forward by trustees to examine the feasibility of supporting the enhancement of student numeracy in division I. Upon examination of this concept by the principals' curriculum committee and Resource Development Services, it was their conclusion that the need was greater than just for division I. Principals, many math teachers and high school department heads, all indicated a concern about the general ability of students to do basic arithmetic calculations with whole numbers, decimals and common fractions. Employers are also expressing concerns, indicating that students are weak in a number of arithmetic skills necessary for the work place.

The goal of this initiative is to promote and insure that Edmonton Public students have functional arithmetic skills and related mathematical reasoning, with a view to enabling them to perform higher mathematical tasks in the secondary and post-secondary years. The initiative will help insure that students become proficient in pencil and paper calculations, and procedural strategies, without depending on calculator use. While the use of calculators has a role in mathematics instruction, it will be the purpose of the initiative to facilitate all K-9 students to demonstrate their proficiency in arithmetic operations, realizing the desire to have students demonstrate competency with mental and paper and pencil calculations. This will be for the purpose of building a foundation for higher mathematical thinking, which is the goal of the Alberta mathematics curriculum.

The results of a recent study (Appendix I: "Cognitive Arithmetic Across Cultures"), which will appear in the *Journal of Experimental Psychology*, this month, makes some points which will help to focus the Numeracy Initiative. It suggests that procedural strategies constitute a major part of educated adults' repertoire of simple arithmetic skills. The study points out that complex arithmetic operations appear to enhance number sense and are related to the building of a better conceptual understanding of the structures that support mathematical reasoning.

Actions to be taken:

1. A steering committee drawn from district teachers, central services staff, principals' curriculum committee, and the curriculum unit will oversee the project and provide input and advice.
2. A working group drawn from district teachers from divisions I, II and III will be formed to assist the project manager, Sandy Forster* to:

    a) Establish a **set of expectations** for Edmonton Public Schools' students (kindergarten through grade 9) in terms of arithmetic procedural proficiency, within the context of the Alberta mathematics curriculum

    b) Facilitate:
        - the development of arithmetic assessment tools for teachers and students in kindergarten through grade 9
        - the development of student and teacher resources to enhance arithmetic achievement, with a view to improving student understanding of the conceptual structures that support arithmetic procedures, and to complement the Edmonton Public School elementary math resource **Math to the Max**.

    c) Develop an implementation strategy to enable students and teachers in classrooms to expedite the thorough learning of the arithmetic skills and procedures expected at each grade level.

*(The teacher working group will be brought in for 2-3 day periods of time throughout the 2001 – 2002 school year to work on the initiative.)

Each action, when completed, will be presented to the Board for information.

The implications of the Numeracy Initiative are far reaching. If an improvement in mathematical understanding, processing and proficiency in arithmetic procedures and numerical reasoning can be facilitated, this will impact student's learning of higher mathematics, as well as their efficiency and contribution to the work place.

Schools are currently considering the development of an instructional focus with a view to improving student achievement. For schools who wish to have a numeracy focus the initiative will provide support to this goal.

There is considerable public support for an initiative of this nature, making it an appropriate time to provide such support to schools.

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APPENDIX I: Synopsis of "Cognitive Arithmetic Across Cultures"
(full report available in the Trustee's Reading Room)

APPENDIX I

SYNOPSIS OF "COGNITIVE ARITHMETIC ACROSS CULTURES"

We examined arithmetic skills in three groups of students studying at the University of Saskatchewan in 1997: Asian Chinese students who learned their basic arithmetic skills in China, and two Canadian-educated groups; Canadian Chinese students whose ancestry was Asian and non-Asian Canadian students. We tested very simple arithmetic problems like 2 + 2, 3 x 6, 7 - 5, 56 / 8, etc., and also more complex arithmetic; e.g., adding three two-digit numbers, long division, etc. Finally, we asked our participants to indicate how much they used calculators during primary and secondary school. For simple arithmetic, the two Chinese groups performed equally well, but both were slightly faster than the non-Asian Canadians. This difference was due to the non-Asian Canadians' slower rote memory for arithmetic facts, and also greater use of slower solution strategies such as counting, transformation, etc. For complex arithmetic, the pattern across groups was different. Here, the Asian Chinese group substantially out performed both Canadian groups. The Asian Chinese students also reported much less calculator use during early math education. As less calculator use predicted better performance on the complex arithmetic, the Asian Chinese students' better performance on complex arithmetic could arise in part from less reliance on calculators. Reliance on calculators could restrict the level of expertise achieved both in long-term and short-term memory skills for mental arithmetic. The Asian Chinese advantage on complex arithmetic could also be related to better understanding of the conceptual structures that support arithmetic procedures.

Method overview

Canadian university students either of Chinese or non-Asian origin and Chinese university students educated in the People's Republic China solved all simple arithmetic problems in the four basic operations (e.g., 3 + 4, 7 - 3, 3 × 4, 12 ÷ 3) and reported their solution strategies (retrieving the answer from memory vs. use of a computational procedure such as counting or transformation). The simple arithmetic problems were displayed one at a time on a computer screen. Prior to this, participants completed a test of several hundred complex pencil and paper arithmetic problems (e.g., 84 + 57 + 32, 937 ÷ 8, 84- 47, 67 x 8). Finally, we asked participants to estimate their calculator use during elementary and secondary school (1-never, 2-rarely, 3-sometimes, 4-often, 5-always). There were 12 males and 12 females in each of the three groups, for a total of 72 participants. Testing occurred in the spring of 1997 at the University of Saskatchewan, Canada.

Findings

re: group differences in complex arithmetic...

For complex arithmetic, the Asian Chinese students correctly completed 58% more problems than the non-Asian Canadian students and 33% more than the Chinese Canadian students. Thus, the Asian Chinese students substantially outperformed both Canadian groups on the complex arithmetic task. The relatively smaller 19% advantage for Chinese Canadians compared to non-Asian Canadians was only marginally reliable statistically.

re: group differences in simple arithmetic...

In contrast, for simple arithmetic, the Asian Chinese and Chinese Canadians were practically equivalent and both performed better than non-Asian Canadians. Specifically, non-Asian Canadians were 24% slower than the Asian Chinese students and 21% slower than the Chinese Canadians. The advantage for the two Chinese groups was observed for all four basic arithmetic operations.

The average time in seconds to correctly answer simple arithmetic problems was 1.1, 0.9, and 0.9 seconds for the non-Asian Canadians, Chinese Canadians, and Asian Chinese respectively. Thus, whereas the simple arithmetic deficit presented by the non-Asian Canadian students appears quite large when expressed as a percentage difference (i.e., about 22% slower than the Chinese groups), in absolute terms all three groups were fast and did not differ greatly. There were no overall group differences in error rates.

Although memory retrieval is the dominant strategy for simple arithmetic, the results indicated that procedural strategies (e.g. counting, decomposition) played an important role in performance of simple arithmetic for all three groups. Chinese Canadians reported procedure use at rates very similar to the Asian Chinese (13% and 15%, respectively), whereas non-Asian Canadians reported substantially more procedure use (28%).

The non-Asian Canadians' relatively poor simple arithmetic performance resulted both from greater use of slow procedural strategies and also slower retrieval processes. The non-Asian Canadians, however, presented equivalent or perhaps slightly better efficiency when using procedural strategies for simple arithmetic, perhaps because they were more practiced at using such strategies. Nonetheless, the non-Asian Canadians' overall greater use of procedures, which are generally less efficient than retrieval, contributed to their slower performance of simple arithmetic.

re: group differences in calculator use...

Use of calculators was reportedly rare in elementary school for all groups, but especially for the Asian Chinese students; 83% reported never using a calculator in elementary school compared to 44% for the Canadian students. Eighty-one percent of the Canadian students reported using a calculator at least sometimes in secondary school; 48% reported using a calculator often or always. In contrast, only 25% of the Asian Chinese sample reported using a calculator at least sometimes in secondary school, and 46% reported never using a calculator in secondary school. In summary, calculator use was relatively rare for the Asian Chinese students prior to university, but Chinese Canadians and non-Asian Canadians were more likely to begin using a calculator in elementary school and reliance on calculators was substantial by the time they were in secondary school.

Less use of calculators was associated with better performance of the complex arithmetic task. As the Asian Chinese students reported less calculator use prior to university relative to both Canadian groups it is likely that the Asian Chinese students had more practice performing relatively complex arithmetic without the aid of a calculator. This would promote better working memory skills for complex arithmetic procedures such as carrying, borrowing, and place keeping. The Asian Chinese advantage on complex arithmetic could also be related to better understanding of the conceptual structures that support arithmetic procedures.

As the two Canadian groups reported equivalent calculator use, the simple arithmetic advantage for the Chinese Canadians relative to non-Asian Canadians apparently is unrelated to calculator use. More generally, calculator use was not predictive of simple arithmetic performance, indicating that greater calculator use is not necessarily associated with weaker elementary arithmetic skills.

Conclusions

The experiment suggests that cross-cultural differences in young adults' simple arithmetic skill are not necessarily attributable to cross-national differences in formal education. Asian Chinese and Chinese Canadians, despite receiving their formal math education in China and Canada, respectively, were practically equivalent in all aspects of simple arithmetic.

In contrast, Chinese Canadians and non-Asian Canadians, who both received formal mathematics education in Canada, presented different levels of performance. The better simple arithmetic performance of Chinese Canadians relative to non-Asian Canadians suggests that extracurricular cultural-specific factors, rather than cross-national differences in formal education, underlie differences in simple arithmetic performance observed between Chinese and North American adults.

The Asian Chinese outperformed both Canadian groups on the complex arithmetic, possibly because they relied less on calculators in elementary and secondary school than the Canadian students.

Previous research (e.g., by Prof. Harold Stevenson and his colleagues) has also identified a variety of extracurricular cultural differences between North Americans and East Asians that likely contribute to differences in mathematical development and achievement (e.g., parents and peers holding high academic standards, believing that effort mediates success, pursuing extracurricular instruction or practice, having positive attitudes about achievement).

Other research (e.g., by Prof. David Geary and his colleagues) has found that differences between East Asian and North American samples are still found when IQ is controlled, and are observed for arithmetic but not necessarily for non-mathematical measures of cognitive or academic performance. This research has also found that the arithmetic competencies of older Chinese and American adults (60 to 80 years old) do not differ. These findings suggest that the cross-cultural differences in simple arithmetic performance observed in children and young adults is a recent development, and reinforces the conclusion that the achievement gap is to due cultural (i.e., educational and other social influences) rather than biological or linguistic factors.

Finally, the results indicate that procedural strategies constitute a major part of educated adults' repertoire of simple arithmetic skills. Indeed, exclusive reliance on retrieval for simple arithmetic probably is a rare achievement. Even the Asian Chinese, whose educational and cultural experiences apparently provide an especially strong foundation for simple arithmetic, did not report having memorized all the basic number facts. The findings confirm the central importance of procedural knowledge in skilled adults' performance of elementary mathematics.

By Jamie Campbell and Qilin Xue, University of Saskatchewan
to appear in the Journal of Experimental Psychology: General, June, 2001.