Numeracy / Mathematics Education
Numératie / Éducation mathématique

(Org: **Sherry Mantyka** (Memorial) and/et **Canadian Language and Literacy Research Network** (CLLRNet))

DANIEL ANSARI, University of Western Ontario, Westminster Hall, London, ON, N6G 2K3

Numeracy and Arithmetic in the brain: the roles of development and individual differences

Modern Cognitive Neuroscience methods, such as functional Magnetic Resonance Imaging (fMRI) have provided researchers with unprecedented insights into the neural correlates of cognitive functions, such as the representation of numbers and the brain processes that enable adults to calculate. While the brain mechanisms underlying adult number and arithmetic processing have been the subject of significant research, comparatively less is known about how mature brain circuits underlying number processing and mental arithmetic emerge over developmental time and how individual differences in numerical and mathematical competence modulate the activity of brain regions. Furthermore, despite the fact that a large number of children suffer from difficulties with even the most basic aspects of numerical magnitude processing, we currently lack detailed insights into the neurocognitive basis of atypical number development. In this talk, I will present data from behavioral and brain imaging investigations into the developmental trajectories of both symbolic and non-symbolic numerical magnitude representation and calculation abilities. I will discuss data from both typically developing children and those who have mathematical difficulties. These data will illustrate the importance of considering developmental changes and individual differences in the neurocognitive mechanisms underlying numerical magnitude representation and arithmetic in order to gain greater insights into how children develop mathematical skills and how these processes break down in children who have mathematical difficulties.

JEFF BISANZ, University of Alberta

Detours in the Development of Mathematical Thinking

The study of children's mathematical thinking provides a valuable window on cognitive development during childhood, as well as insights into how to optimize the ways in which children learn mathematics. The common view is that learning mathematics is an incremental process in which older children develop new and more powerful concepts that incorporate or replace previous concepts. We have studied the development of two mathematical concepts in some detail: inversion, the principle that $a+b-b$ must equal a; and equivalence, the concept that two sides of an equation must represent the same quantity. Contrary to the common view, many older children have considerable difficulty understanding or using these concepts in arithmetic despite the fact that preschool and early elementary school children appear to use these very concepts under certain conditions. These detours in development appear to be due to difficulties that children experience—and that we create—when we impose the symbol-based mathematical tools of our culture onto the informally acquired, intuitive mathematical knowledge of young children.

PETER BRYANT, Department of Education, University of Oxford

The importance of understanding the inverse relation between addition and subtraction

My presentation will be about a series of studies on children's understanding of inversion and their use of this understanding to solve arithmetical problems. I will deal with the origins of understanding quantitative inversion and with children's ability to combine their knowledge of inversion with decomposition. I shall also show that children are sometimes able to transform complex problems into easier ones that can be solved with the help of inversion. My presentation will include some data on individual differences in the use of inversion and also on the possibility of improving children's understanding of inverse relations. I shall argue that inversion plays a crucial role in children's mathematical reasoning.

SITE VISIT TO MATH LEARNING CENTRE,

GARRY DAVIS, Evan Hardy Collegiate, 605 Acadia Dr., Saskatoon
Avoiding Hangdog Mathematics

In this session I will share the challenges and successes that we have experienced at Evan Hardy Collegiate this year as we have piloted a program for assisting students entering high school who have struggled with mathematics in elementary school. The goal of the program is to address the learning gaps that students have and to prepare them to study high school mathematics. This program was developed using an approach similar to the program developed by the Mathematics Learning Center in Memorial University. I will share the advantages and disadvantages of the program and how it has changed me as a teacher. I will also share the perspective of parents, students and others involved in the program as well as the response of my colleagues throughout the school division.

DARCY HALLETT, Memorial University of Newfoundland
The implications of symbolic systems and non-symbolic systems in fraction understanding

Recent advances in the field of mathematics cognition have suggested that there are two cognitive systems that deal directly with knowledge of number and mathematics. The first is known as the "symbolic" system. At its basic level, this system underlies the understanding of how a symbol (e.g., the symbol "2") can refer to a numerosity (e.g., the quantity of 2) and also how to manipulate these symbols to generate exact answers to questions (e.g., $2 + 3 = 5$). The non-symbolic system, found in both humans and animals, is not exact and instead allows for quick and approximate estimates of quantity that are almost done unconsciously. To date, the research that has explored how these two systems interact has largely investigated simple operations with whole numbers. This paper will instead consider how these systems might interact in the more complicated topic of fraction understanding. More specifically, I will explore how conceptual and procedural knowledge of fractions are related to subitizing, quantity estimation, and working memory and the possible implications of these data for the teaching of fractions.

JOHN MIGHTON, The Fields Institute, 222 College Street, Toronto
The Importance of Teaching Math to Children

I will argue that society is harmed in many ways because we fail to teach children according to their true potential in mathematics. I will present evidence from psychological and educational research, as well as evidence gathered by the JUMP program, that ability in mathematics can be nurtured in even the weakest students. I will examine which of the approaches to math education presently used in our school are working and which, in my opinion, need to be modified or re-evaluated.

TEREZINHA NUNES, University of Oxford, Department of Education, 15 Norham Gardens, Oxford, OX2 6PY
The scheme of correspondence and its role in understanding relations

Numbers are used in primary school to represent quantities and relations. Most of the research about children's learning and of the teaching efforts focus on children's use of number to represent quantities. This paper analyses the role that the scheme of correspondence plays in children's understanding of relations between quantities. One-to-one correspondence is a sine qua non for counting but also for understanding equivalences between sets even in the absence of counting. One-to-many correspondence provides a natural and effective foundation for children's understanding of multiplication, division, and fractions, and also provides a foundation for children's understanding of multiplicative relations. Children and adults who use of mathematics outside school rely on the scheme of one-to-many correspondences to solve proportions problems; this finding supports the idea that this scheme is a natural foundation for understanding relations. New longitudinal and intervention studies will be reported, which show that children's knowledge of how to use one-to-many correspondences plays a critical role in their mathematics development.

Implications for teaching will be discussed and a programme that helps students become aware of relations that they understand only implicitly will be presented.

HELENA OSANA, Concordia University
Understanding Mathematical Knowledge for Teaching: An Examination of the Content Knowledge of First-Grade Teachers

The ultimate goal of teaching mathematics is to assist children to develop a genuine understanding of the discipline. It is becoming increasingly clear, however, that a teacher's knowledge of mathematics alone is not sufficient for achieving this educational objective. Rather, elementary teachers need a specialized type of professional knowledge of mathematics to be effective in the classroom. For example, teachers must know how children think about mathematics and the types of misconceptions they generally hold, as well as how to identify and interpret students' work and ways to design classroom activities to mobilize specific concepts in the school curriculum. Dr. Osana will present data from a larger study that explores the relationship between teachers' specialized mathematics knowledge, their classroom practices, and the development of their students' mathematical proficiency. In this talk, Dr. Osana will focus on an instrument she developed to measure teachers' knowledge in the context of this larger project. She will present items from the instrument as well as report on data that have been collected using the measure with a sample of first-grade teachers. The findings will illustrate the complex forms of knowledge even elementary-level mathematics teachers appear to require to assist their students to think about mathematics with meaning. Connections to the teachers' classroom practices will also be addressed.

PANEL DISCUSSION,

MICHAEL RABINOWITZ, Psychology, Memorial University, St. John's, NL, A1B 3X9
Nim, Human Learning, and Teaching Mathematics

About 25 years ago, psychologists began to seriously discuss the possibility that there are two basic forms of learning. The first, associative learning, is context specific and implicit. People often can not describe what they have learned. The second, rule-based or cognitive learning, generalizes across contexts and can be explained by the learner. These two forms of learning were embedded in a computational model in an attempt to account for individual differences in the manner people learn to play Nim, a token game. The version studied involved five rows of counters. None of the participants were able to solve this highly structured problem in 60 games. Most, however, played better as a function of practice. The fit of the computational model was improved by adding rules that people might use to conceptualize or structure the problem before they acquired information about specific moves. To the extent that imposing structure, associative learning and rule-based learning characterize human problem solving, they are relevant to the learning of mathematics. The relationships between learning to play Nim, problem solving, and teaching mathematics are explored.