

### Math and the brain: Insights for early childhood educators

#### **Orit Elgavi-Hershler and Pircha Hamo**

#### Abstract

This paper presents basic neuropedagogical content knowledge (N-PCK) on the development of mathematical understanding in early childhood, in order to enable early childhood educators to understand neurological findings on mathematical development in the brain in an informed way and apply these findings to educational practice. The paper presents seven neuropedagogical principles surrounding mathematical development in early childhood, together with insights and practical examples that can be used to impact early childhood education. This review might also be used by teacher educators teaching courses on early numeracy, and as a basis for future research in this field.

**Keywords:** brain; neuropedagogy; early childhood education; mathematics; ENC (early numeracy curriculum).



# Effect of mathematical activity of the pregnant woman on the fetal brain

#### Dina Hassidov, Uzi A. Asher, Moshe Ben-Ami, Leandro Keselman, Ruba Sabri Al Abed and Sami Haddad

#### Abstract

In recent years, there has been growing interest in the effect of maternal exposure to physiological, environmental, and also psychological factors during gestation on child development. Several independent studies link maternal stress during pregnancy to emotional and behavioral problems in the child.

This study aimed to observe the effect of maternal cognitive activity on fetal brain blood flow to determine whether systematic maternal mathematical activity during pregnancy might influence child brain development.

Thirty-five women in the 28th to 40th week of pregnancy engaged in mathematical activities. Fetal middle cerebral artery (MCA), pulsatility index (PI) and peak systolic velocity (PSV) were monitored before, during, and after the activity.

Brain activity and blood flow were shown to be intimately linked. We observed a significant decrease in fetal brain MCA resistance, as evidenced by decreased MCA PI, towards the end of the mathematical activity. This may result in increased blood flow in the arteries supplying most brain regions and, possibly, increased brain activity.

A correlation between the mother's engagement in mathematical activities and fetal brain blood flow may lead to enhancement of the fetus's brain function and a cognitive advantage for the child.

Key words: fetal brain; maternal mathematical activities; blood flow; fetal programming.

# Brain activity associated with logical inference in geometry in students with different ability levels

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#### Abstract

Mathematical processing related to solving short geometric problems that require logical reasoning was examined among students who differ in levels of general giftedness (G) and excellence in mathematics (EM) using Event-related potentials (ERP) methodology. Sixty-seven high school male students participated in this study. The study participants were divided into four major study groups designed according to various combinations of G and EM factors. The G and EM factors had a similar effect on accuracy and reaction time: students who excel in mathematics (EM) and students who are generally gifted (G) were more accurate compared to their peers who are not excellent in mathematics (NEM) and non-gifted (NG), respectively. At the same time, G and EM factors related to ERP absolute amplitudes in some problem-solving stages. Based on the differences found, we suggest that our study demonstrated that G and EM factors are interrelated but are different in nature. We recommend that ability grouping in school mathematics must consider both excellence in mathematics and general giftedness, that is, the EM and G factors.

**Keywords:** problem-solving in geometry; logical inference; giftedness; excellence in mathematics; Neurocognition; ERP – Event Related Potentials..

## Retrieval practice, spaced practice and interleaved practice in the teaching of Mathematics

**Dorit Neria** 

#### Abstract

Research in neuroscience has great potential for advancing the understanding of learning and for the understanding of optimal teaching and learning approaches. One of the most important neurological principles that can be applied in teaching is neuroplasticity – assimilating new information or retrieving knowledge from memory leads to the creation of new connections (synapses) between neurons and strengthens existing connections. This article discusses three major strategies in learning in general and in learning mathematics in particular, that can be applied from the conclusions of neurological studies: retrieval practice (retrieving knowledge from memory), spaced practice (encountering content at brief periods spread out over time), and interleaved practice (practicing a mixture of topics and contexts). The three strategies focus on dividing the content into small portions, repeating and spacing sessions over time and mixing up topics. These strategies can promote meaningful learning and a deeper understanding of the topics being studied.

Keywords: retrieval practice; spaced practice; interleaved practice.



## Professional well-being of mathematics and science expert teachers in effective professional development programs

Mirela Widder and Anat Even-Zahav

#### Abstract

Examining psychological and neurological aspects of the Self-Determination Theory led scholars to theorize that professional well-being is essential for teachers' satisfaction and personal-professional growth. However, teacher professional development programs primarily focus on promoting student achievement and only partially and indirectly address teachers' professional well-being. In particular, the absence of teachers' voices in this discrepancy is noticeable. This study aimed at confronting teachers' perceptions about their professional well-being needs with how actual practices in effective teacher professional development programs address these needs. Well-being components (competence, relatedness, autonomy, and aspirations) were implicitly identified within 20 interviews with expert STEM teachers. The findings show that teachers attribute importance to their professional well-being in all components. In particular, aspirations for personal-professional growth, indicated by all teachers as most important, were not evident at all in effective teacher professional development programs. This additional characteristic may provide an answer to psychological and neurological needs in the context of teachers' learning processes and therefore may have practical and theoretical implications for planning and evaluating the effectiveness of professional development programs.

**Keywords:**self-determination theory; neurobiology and learning; professional well-being of teachers; effective teacher professional development programs; expert STEM teachers.

# Teaching for mathematical literacy: Why does the traditional mathematics instruction fail to do the trick?

Anna Sfard

#### Abstract

Today, diverse literacies, and mathracy (mathematical literacy) among them, are considered "21st-century skills", indispensable for those who live in the ever-changing reality rife with increasingly sophisticated technology. Findings of research conducted in recent decades in many places around the globe has consistently shown that mathracy is not an automatic result of school learning: even those who manage to master school mathematical discourse do not tend to use this discourse in life. This fact leads to several questions: If we agree that mathracy is a combination of two abilities, the ability to participate in mathematical discourse and the ability to apply this discourse in life activities, why is the first ability not enough to develop the second? What makes school graduates unwilling to resort to mathematical discourse in everyday life? Finally, what are the ways in which it is possible to overcome the obstacles and thereby promote the development of mathracy? The answers to these questions offered in this article are based on a theory, according to which all our moves – everything we do in various life situations – is built from routines we have developed over the course of our lives. This claim is reinforced by what can be deduced from what the new neuroscience tells us about our responses to diverse needs and requirements. The article ends with a number of practical tips for teachers who aspire to develop mathracy in their students.

Keywords: mathematical literacy (mathracy); discourse; routine; simulation; situativity.

## Extending the trail and pushing back the boundary:

Attempts to apply theoretical ideas from educational and cognitive psychology in teacher training and M.Ed. mathematics education programs

Tikva Ovadiya

#### Abstract

The attached article describes three examples taken from three different studies in which attempts were made to design learning environments and teaching methods in accordance with concepts used in studies dealing with cognitive or other types of psychology in order to maximize the learning processes of the individual and the group. The analysis of the events presented seek to focus on the interpretation of the learning situations based on theoretical ideas from the fields of neuroscience and psychology. In the three examples presented in this article, the researcher focuses on the participants' attention so as to understand what attracted their attention and what actions they took as a result.

In the first example, the researcher observes the attention of a teacher who altered the learning environment for her students so that they would act independently for a large part of the lesson; in this case, the teacher tried to focus her attention on her new role in the classroom. In the second example, the researcher observed the focus of an individual who had to solve a non-routine mathematical problem in a work group. In the third example, the researcher observed the attention of a teacher who was documenting her teaching processes, focusing on the teacher's interpretation of those events that drew her attention and events that she overlooked.

Observing the attention of the learner undergoing a learning process or of a teacher while teaching promotes understanding of the practices taken by learners and teachers during teacher education processes that are a result of their attention. It also imparts awareness of the necessity of characterizing those events that were overlooked. This awareness can stimulate the design of teaching learning processes and environments that will increase teachers' and learners' attention to important events that might be overlooked. Observing the examples presented in the article through lenses borrowed from theories from fields other than mathematics education promotes in-depth understanding of the processes that took place in them.

**Keywords:** noticing; neuro-pedagogy; cognitive load; episodic memory; collaboration; geometry; foolproof environment; problem solving; cooperative working memory.