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Pre-service teachers' perceptions of Mathematics as a language[1]

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The article deals with the perceptions of Mathematics as a language of pre-service teachers of Mathematics in a College of Education in Israel. The formal language of studying in the College of Education is Hebrew. The goals of the study were to examine the perceptions of pre-service teachers on the following issues: the language components involved in learning Mathematics, the basic cognitive skills required for learning Mathematics, and the perception of Mathematics as a language (PML). Findings indicated that due to new attitudes in mathematical training, pre-service teachers of Mathematics perceived Mathematics as a language regarding all language components.

Keywords: basic cognitive skills, language acquisition, language components, language features, the language of Mathematics
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INTRODUCTION

Webster Dictionary (1997) provides a number of definitions for the term 'language'. The first definition is "a body of words and the systems for their use common to a people of the same community and nation, the same geographical area, or the same cultural tradition". The second definition is "communication using a system of arbitrary vocal sounds, written symbols, signs or gestures in conventional ways with conventional

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meanings." The third definition is "any set or system of formalized symbols, signs, sounds or gestures used or conceived as a means of communicating."

The first definition seems to relate to language as a unique feature which is common to people of the same nation, location or culture, and emphasizes a sense of belonging (such as Hebrew or Arabic for people living in Israel or English for people living in the US). The second and third definitions address the concept of language as a formalized or arbitrary means for communication.

It seems that the definition of Mathematics as a language is related to the second and third definitions, as it comprises specific terminology such as signs, graphic representations, numbers and icons. The examination of Mathematics as a language will be conducted in conjunction with these definitions and existing literature. The prevailing attitude among Mathematics educationalists in the last decade is that Mathematics is a language and therefore all language components must be taken into consideration in Mathematics teaching.

THEORETICAL BACKGROUND

A. Cognitive Skills involved in Learning Mathematics

Processing speed: the rate at which individuals perform basic cognitive processes, such as searching, retrieving and comparing, is essential for basic cognitive development (McBride-Chang & Kail, 2002). Decoding ability in reading tasks is influenced by the processing speed and by rapid naming (Kail *et al.*, 1999).

In conclusion, the cognitive components which underpin language acquisition comprise auditory and visual processing skills and relate to the four components of language: reading, writing, speaking and listening. The individual learner must be able to analyze and synthesize phonemes while speaking and listening, and rely on visual processing in order to recognize letters and words while reading and writing. Naming speed requires visual recognition of stimuli and at the same time it requires the phonological decoding ability in order to articulate words. This ability is necessary in speaking, reading and writing. Speed of processing relates on the ability to carry out cognitive tasks and is demonstrated in oral and in written abilities. The use of memory enables the access to the phonological, semantic and syntactic memory in encoding, storage and retrieval processes while reading and writing.

Visual processing is the perception and interpretation of visual forms (Gardner, 1996). Word and character recognition involve matching a visual symbol (such as letters or words) with a spoken stimulus (the corresponding phonemes). Therefore, learning to read requires visual processing skills. Despite the significance of visual processing for word

recognition at higher levels (Jorm & Share, 1983), the role of visual processing in initial alphabetic reading has been downplayed considerably in recent years (McBride-Chang & Kail, 2002).

The language of Mathematics comprises symbols and signs and failing to distinguish between them on visual grounds may impede learning. For example, confusion between 2 and 5, between the signs > and <, or between + and -.

Hoover and Nolan (1993) claim that learning Mathematics requires spatial orientation abilities, in particular directionality, because arithmetic algorithms and other geometric shapes might require specific reading abilities, such as reading from right to left, from top to bottom, from bottom to top, diagonally, in a circle, tracing errors. Furthermore, Olivares (1996) argues that learning Mathematics in a foreign language might require reading a text which can be written from top to bottom or from right to left.

Verbal-linguistic processing: the prevailing attitude in the past decade is that difficulties in learning Mathematics do not stem merely from lack of mathematical knowledge, but also from difficulties in language processing, and more specifically in understanding the abstract nature of Mathematics (NCTM, 2000). Baddeley *et al.* (1998) argue that there is a link between the phonological system and Mathematics. For example, verbal problems in Mathematics make a specific type of text, whose decoding and understanding rely on the phonological system. Mathematics is used to get access to information, to gain meaning, to organize ideas, to express generalizations orally and in writing. Difficulties in mathematical education also derive from the ambiguity of words in different languages or in different contexts in the same language, or because some words have a double meaning (Olivares, 1996).

Memory systems

1. Working memory (WM): According to Baddeley & Logie (1999) and Miyake (2001) WM may be defined as the capacity to manipulate and transform material while maintaining information. A large body of research supports the view that resources from the WM system and phonological storage (especially naming speed) play a critical role in integrating information during mathematical performance (Swanson and Kim, 2007; Swanson, 2004; Ackerman *et al.*, 2002). Swanson & Sache-Lee (2001) assume that because understanding mathematical word problems involves a complex interaction of text comprehension and mathematical processes, proficiency of the WM system is associated with solution accuracy.
2. Short-term memory (STM): Research indicates that children who are less proficient in math perform more poorly on tasks which require short-term retention, especially on measures of digits (McLean & Hitch, 1999). STM is often related to situations in which small amounts of material (digits or words) are held passively

and then reproduced. The majority of studies that focus on individual differences in children assume that STM measures are a subset of WM performance as it involves two major components discussed in the WM literature: speech-based phonological store and articulatory (rehearsal) control system (Baddeley, 1986).

3. Retrieval: A number of studies demonstrate that poor retrieval abilities play a causal role in difficulties in learning Mathematics. For example, retrieval of facts regarding multiplication and division. Indeed, explanations provided by teachers and books assume that students possess automatic retrieval abilities (Hasselbring *et al.*, 1988).

Problem-solving and logical reasoning: The Principles and Standards for School Mathematics (NCTM, 2000) emphasize the abilities which are required for efficient mathematical performance. These include problem solving and reasoning abilities, which enable the learner to build confidence in unfamiliar situations and produce mathematical proofs. According to Swanson (2004), the critical ability for mathematical problem-solving comprises two specific abilities: an ability to understand what the problem is and to assign the correct numerical representation; an ability to place numbers from the word problem into an equation format. The problem-solving ability equally includes the psychological component of meta-cognitive ability which enables the learner to plan and monitor the products of his work (Hoover & Nolan, 1993).

Creating mental images: Research indicates that students with difficulties in Mathematics bear a difficulty to develop and maintain mental images of mathematical concepts or representations of basic concepts, such as the ability to create a mental picture of the decimal system (Geary, 2005).

B. Language Components Involved in Learning Mathematics

Current literature supports the existence of the four language components in learning Mathematics: reading, writing, speaking and listening.

Reading: Siegel *et al.* (1996) argue that reading is central to teaching and learning Mathematics. Indeed, reading enhances understanding of mathematical ideas, but at the same time it improves understanding the link between Mathematics and everyday life, develops data-sharing strategies and exposes the learner to different attitudes and to a variety of concepts and ideas. This is made possible via the use of meta-cognitive orientation, and strategies such as summarising, asking questions, predicting and making clarifications (NCTM, 2000).

Writing: Writing with relation to learning Mathematics involves the ability to deliver ideas and develop concepts. Writing is an essential tool in learning Mathematics (NCTM, 2000). Usiskin (1996) argues that writing in Mathematics is a primary rather than a

secondary tool and delivers mathematical ideas more clearly. Kazemi (1998) postulates that writing encourages the enhancement of mathematical reasoning.

Masingila & Prus-Wisniowska (1996) contend that writing is a way of transforming implicit mathematical knowledge to explicit knowledge via reflection. In the process of writing the learner develops critical thinking, communicates his ideas and creates a network of knowledge.

Speaking: Despite the fact that Mathematics is not perceived as a spoken language, the new standards for teaching Mathematics indicate the necessity for verbalization ("Mathematical discourse") (Huinker & Laughlin, 1996). They argue that while delivering a mathematical idea the learner selects terminology in order to negotiate his ideas. He makes sure that he has been understood by others and that he understands the idea fully himself. Thus, the learner validates his ideas and sharpens his oral skills. Furthermore, speaking encourages the existence of a "learning community" which fosters a dialogue in class with minimal intervention by teachers.

Listening: Pirie (1996) contends that both teacher and learner need to undertake the role of speaking and active listening while communicating mathematical ideas. The active listening of Mathematics teachers in class contributes to active participation of learners, and enhances a dialogue among the learners themselves. It also creates a change in the perception of teachers as being the sole resource of knowledge and of the learner as being the recipient of knowledge. According to Smith (1996), the two oral components of language, speaking and listening, contribute to students' mathematical performance. This depends on the teacher's ability to create an atmosphere in which students can express their ideas safely. By listening to others, they learn to see things from other people's perspectives. By expressing their ideas, they learn to present clear and complete arguments. Children in their early school years, who cannot express themselves in writing, learn to explain their strategies and think out loud as a means of re-examination of their mathematical reasoning.

In conclusion, the idea of communication in Mathematics is expressed clearly in the Principles and Standards for School Mathematics (NCTM, 2000, p. 60) "They communicate to learn Mathematics and they learn to communicate mathematically."

C. Perceptions of Mathematics a Language

If we re-examine the definition of language in the introduction to this article (Webster, 1997), it seems that the language of Mathematics is a formalized set of conventions that are used for the specific purpose of problem-solving.

Existing literature supports this view. While Weinzweig (1982), called it "a sub-language," Usiskin (1996) argues that Mathematics has a lot in common with other

languages because of the following reasons:

1. Mathematics does not only describe ideas, but also fosters the organization of these ideas within the learner;
2. The number of symbols and signs in Mathematics is similar to the number of letters in other languages (*e.g.*, $\perp = \cong$);
3. Mathematics has its own syntactic rules, expressions such as "3+4", and verbs (*e.g.*, substract);
4. Mathematics has a "private property" of vocabulary like any other language as well as its unique features;
5. Mathematics lends and borrows words like any other language. It makes use of the Latin alphabet in Algebra, the Greek alphabet in Geometry (*e.g.*, ellipse, parabola), the word 'radius' from Latin, etc. It also lends words. For example, the word 'triangle' in Mathematics refers to a two-dimensional shape whereas in everyday English it is also used to describe a romantic loop with 3 people involved.

According to Usiskin (1996) the reasons for experiencing problems in learning Mathematics are related to its language aspects. The fact that students are not exposed to the "Language of Mathematics" at home or in their close environment makes teaching harder. It is important to start teaching Mathematics at an early stage, so that it can become a mother tongue or a second language for the learners. Moreover, Mathematics is often taught out of context. This makes learning meaningless and inapplicable to the learners' lives. As a result, the learners learn a "dead," useless language. In addition, teaching Mathematics comprises the use of abstract concepts, which are not always clear and meaningful to the learner.

We have decided to summarize the main points from the Literature in Tables that address three aspects: Table 1 introduces the involvement of language components in Mathematics; Table 2 introduces the features of Mathematics as a language; Table 3 introduces the basic cognitive skills required for Mathematics.

Table 1. Language components of Mathematics

	Mathematics
Reading	+
Writing	+
Speaking	+
Listening	+

Table 2. Features of Mathematics as a language

	Mathematics
Vocabulary	+
Set of rules	+
"Borrowed words"	+
Learning in context	Not always
Exposure	Mostly at school

Table 3. Basic cognitive skills required for Mathematics

	Mathematics
Thinking Abilities	+
Visual Processing	+
Auditory Processing	+
Integration of ...	Visual & verbal
Processing Speed	+
Phonological Processing	Memory, Verbal Skills

Research Goals

The goals of the study were to examine the perceptions of pre-service teachers of Mathematics on the following topics: features of Mathematics as a language, the basic cognitive skills which underpin learning Mathematics, and perceptions of Mathematics as a language (PML).

Research Questions

1. What are the language components involved in learning Mathematics?
2. What basic cognitive skills are necessary for learning Mathematics?
3. Is Mathematics perceived as a language?

Methodology

Research Approach

The approach that has been chosen for this study is the interpretive approach. The data analysis relied on the participants' subjective understanding as well as on how the re-

searchers have interpreted the participants' perceptions. This means that the 'reality' of the two languages and their acquisition has been elaborated on two levels: that of participants and that of the researchers on the basis of pre-service teachers' perceptions. This idea gains support by LeCompte and Preissle (1993, p. 45) who introduce two terms: 'emic', "where the concern is to catch the subjective meanings placed on situations by participants" and 'etic', "where the intention is to identify and understand the objective or researcher's meaning and constructions of a situation". Similarly, Cohen *et al.* (2000, p. 20) maintain that "understanding of individuals' interpretations of the world around them has to come from the inside, not the outside."

Research Population

The population of this study included 20 pre-service teachers of Mathematics, ages 22–25, all of whom are females: all of them specialize in teaching Mathematics for Elementary Schools. The formal language of studying in the College of Education is Hebrew.

The reason for choosing pre-service students of Mathematics was to examine whether they have internalized the new attitude which perceives Mathematics as a language.

Procedures

The pre-service teachers were not selected for the study by definite criteria. They were given the questionnaires randomly. The 20 pre-service teachers who came in early were asked to answer the questionnaires (in Hebrew). It took them 30 minutes approximately to complete the questionnaire.

Research Tools

The research tool that has been chosen for this study was a questionnaire for the pre-service teachers. The questionnaire was administered in Hebrew and included 6 questions that relate to three main topics:

1. The language components of Mathematics (questions 1– 4).
2. The basic cognitive skills that are necessary for learning Mathematics (question 5).
3. Perceptions of Mathematics as a language (PML- question 6)

Below are the questions that appeared in the questionnaire:

1: Are reading skills related to learning Mathematics? Yes/No

Explanation/Argument_____

2: "Are writing skills related to learning Mathematics"? Yes/No

Explanation/Argument_____

3: "Are discourse skills (speaking) related to learning Mathematics"? Yes/No

Explanation/Argument_____

4: "Are listening skills related to learning Mathematics"? Yes/No

Explanation/Argument_____

5: "What are the important cognitive skills for learning Mathematics"?

6: "Is Mathematics a language"?

Analysis of Data

The data were analyzed in a qualitative method by content categories that were gathered from the answers of the participants. The categories by which the data were analyzed were: language components (reading, writing, speaking, listening), and basic cognitive skills. The two researchers have validated the analysis by a procedure of Experts Evaluation, in which each of them conducted the analysis individually according to the categories that had been decided upon. Then data were compared and the percentage of consent was calculated. The percentage was found to be above 91%.

FINDINGS

Research question 1: The language components that are necessary for learning Mathematics.

Questions 1–4 of the questionnaire refer to the language components which are required for learning Mathematics, and are introduced in Table 4 below.

Table 4. Perceptions of Language Components involved in Mathematics

Perceptions/participants	Pre-service teachers of Mathematics N=20 Yes
Q 1 -Reading skills	18
Q 2 - Writing skills	14
Q 3 - Discourse skills	18*
Q 4 - Listening skills	20
Average percentage of participants who perceive language components as involved in learning Mathematics	**87.5 %**

* The number of respondents to this question was 9

Q1 : Are reading skills involved in learning Mathematics?

Findings indicate that most pre-service teachers of Mathematics perceive reading skills as part of learning Mathematics (18 out of 20). Below are the statements of the pre-service teachers of Mathematics:

1. Eight out of ten pre-service teachers of Mathematics teaching explained that "in Mathematics to read verbal problems."
2. "One needs to be able to read different graphic symbols";
3. "One needs to read the instructions of an exercise."
4. The only student who perceived reading skills as unrelated to learning Mathematics explained: "the question can be recorded and read out loud to the student. Therefore, comprehension skills is what counts."

Q 2: Are writing skills involved in learning Mathematics?

Findings indicate that pre-service teachers of Mathematics teaching perceive writing skills as part of learning Mathematics (14 out of 20). Below are the statements of the pre-service teachers of Mathematics teaching:

1. "In Mathematics there are conventions of writing and graphic symbols."
2. "One needs to express oneself in writing."
3. "One has to be accurate in writing – 25 is not 52".
4. "It is crucial to discriminate between shapes and to be able to write a proof".
5. "One needs to write full answers" (4 pre-service teachers).

Q 3: Are discourse skills (speaking) involved in learning Mathematics?

Nine pre-service teachers of Mathematics noted that discourse skills are involved in learning Mathematics (one student did not answer this question). Below are the statements used by the nine pre-service teachers:

1. Three pre-service teachers stated "the need for discussion and communication with pupils."
2. Two pre-service teachers referred to "the need for oral explanation in class."
3. Two pre-service teachers stated "the need for oral responses" and the fact that "difficulty in pronounciation leads to difficulty in comprehension, and in providing arguments and explanations properly."

Q 4: Are listening skills involved in learning Mathematics?

Findings indicate that all ten pre-service teachers of Mathematics perceived listening skills as necessary for learning Mathematics. Eight pre-service teachers explained that

"listening skills are necessary because pupils are exposed to oral discussions in class as well as to instructions and tasks".

In sum, findings from questions 1-4 which refer to the language components involved in learning Mathematics indicate that pre-service teachers of Mathematics perceive all language components as crucial for learning Mathematics (87.5 %).

Research question 2. Basic cognitive skills necessary for learning Mathematics.

Question 5 in the questionnaire deals with the basic skills required for learning Mathematics as perceived by the pre-service teachers. Findings are introduced in Table 5 below.

Table 5. Participants' Perceptions of the Cognitive Skills Necessary for Mathematics

Perceptions/participants		Pre-service teachers of Mathematics *N*=20
Basic cognitive skills	Listening and attention	12
	Spatial processing	2
	Visual discrimination	4
	Memory	10
	Reasoning abilities	12
Language components	Listening and reading comprehension	2
	Oral and written proficiency	2
	Reading skills	0
Strategies	Learning habits	2
Others	Motivation	0
	Mental maturity	4
	knowledge	6

Findings show that the basic cognitive skills perceived by pre-service teachers of Mathematics as the most important skills for learning Mathematics are: 1. listening ability and attention; 2.reasoning skills; 3. memory; Regarding "language components", the two groups did not perceive reading and writing abilities as important for Mathematics. It might be claimed that pre-service teachers could not distinguish between language components and basic cognitive skills.

Research question 3

The question whether Mathematics is a Language (question 6 in pre-service teachers'

questionnaire) is introduced in Table 6 and 7 below.

Table 6. Perceptions of Mathematics as a language

Perceptions/Participants	Pre-service teachers of Mathematics *N*=20	
	Yes	No
	20	0

All pre-service teachers of Mathematics seem to perceive Mathematics as a language. The statements in Table 7 contributed to our understanding of the participants' perceptions of language components in general, and not only of Maths as a language. Indeed, they perceive a language as comprising messages for purposes of communication, conventions and rules, concepts and layers of knowledge. The main argument was that Mathematics is a language because it has a set of conventions such as graphic symbols, similarly to other languages that rely on letters and punctuation. It seems that pre-service teachers of Mathematics are aware of the fact that Mathematics has language features such as graphic conventions and rules, and that there are concepts which are used differently in everyday language and in Mathematics.

DISCUSSION AND CONCLUSION

The present study examines perceptions of pre-service teachers regarding Mathematics as a compulsory subject in Elementary School and in High School. Two elements that pertain to language acquisition were examined in this study: language components and basic cognitive skills which underpin language acquisition.

An examination of the literature supports the existence of the four language components in learning Mathematics (Usiskin, 1996; Uso-Juan & Martinez-Flor, 2006) as well as of basic cognitive skills which are involved in Mathematics (*e.g.*, Shaywitz, 1996; Swanson, 2004).

The research involved a group of pre-service teachers of Mathematics which was exposed to the new attitude in mathematical pedagogy that emphasizes mathematical discourse and communication, and views Mathematics as a universal language which requires the use of oral and written language components.

The first and third research questions referred to pre-service teachers' perceptions of Mathematics as a language and of the language components involved in learning Mathematics. Our assumption was that if the answer to the first question did not include any language components, the answer to question 3 would be negative. However, findings

indicate that pre-service teachers of Mathematics perceive Mathematics as a language. This perception matches Gazit's claim (2008) by which Mathematics is basically a universal language which consists of graphics, symbols, digits, all of which are necessary for Mathematical and geometric operations. Gazit also states that Mathematics has grammar and rules of its own.

Indeed, pre-service teachers of Mathematics perceived all 4 language components as crucial for learning Mathematics. The fact that they perceive discourse skills as important can be explained by the new attitudes and beliefs in mathematical pedagogy that prevail in recent years. Whereas in previous decades teaching Mathematics was mainly based on reading and writing, without referring to the element of "mathematical discourse" and communication, at present emphasis is placed on the dialogue between teachers and learners and among learners themselves in class.

The second research question focused on pre-service teachers' perceptions of the basic cognitive skills which are necessary for learning Mathematics. Findings indicate that pre-service teachers of Mathematics perceive attention and listening abilities as well as memory as the two most necessary skills for language acquisition. They also focused on reasoning skills, such as generalization and deductive abilities, planning and problem-solving. This might be explained by the fact that they seem to dwell on an element which was dominant in Mathematics, namely logic and reasoning. In their responses they referred to aspects other than cognitive components as important for Mathematics, such as knowledge and motivation, probably because they are aware of their role in learning Mathematics.

CONCLUSION

This study attempted to examine the perceptions of Mathematics as a language among pre-service teachers in a College of Education in Israel.

It is recommended that teacher training should include the enhancement of awareness of the basic cognitive skills and language components involved in different subjects at school, in order to enhance disciplinary and interdisciplinary understanding of difficulties students might tackle, such as verbal problems in Mathematics, working in a Biology Lab, or reading comprehension. In addition, it is recommended to conduct a research of a wider scope (including quantitative data) to validate the results of the present study.

REFERENCES

Ackerman, P. L.; Beier, M. E. & Boyle, M. O. (2002). Individual difference in WM within a

nomological network of cognitive and perceptual speed abilities. *Journal of Experimental Psychology: General* **131**, 567–589.

Baddeley, A. D. (1986). *Working memory.* Oxford: Oxford University Press.

Baddeley, A. D.; Gathercole, S. E. & Papagno, C. (1998). The phonological loop as a language learning device. *Psychology Review* **105(1)**, 158–173. ERIC EJ562060

Baddeley, A. D. & Logie, R. H. (1999). The multiple-component model. In: A. Miyake & P. Shah (Eds.), *Models of working memory: Mechanisms of active maintenance and executive control* (pp. 28–61). Cambridge: Cambridge University Press.

Cohen, L.; Manion, L. & Morrison, K. (2000). *Research Methods in Education* (5th ed.) London, USA, Canada: Routeledge Falmer.

Gardner, M. F. (1996). *Test of Visual-Perceptual Skills (n-m)revised manual.* New-York: Psychological and Educational Publications.

Gazit, A. (2008). Mathematics, language, poetry: on mathematicians, poets and mathematical poets. *The Concept of Poetry: On-line journal for poetry pertaining to the circle of poetry fans* **(14)**, 21–31 (translated from Hebrew).

Geary, D. C. (2005). Role of cognitive theory in the study of learning disability in Mathematics, *Journal of Learning Disabilities* **38(4)**, p. 305. ERIC EJ695629

Haselbring, T. S.; Bransford, J. D. & Goin, L. I. (1988). Developing Math automaticity in learning-handicapped children: the role of computerized drill and practice. *Focus on Exceptional Children* **20**, 1–7.

Hoover, L. A.; Nolan, J. F. (1993). Reading in Math. In: M. Dupnis, L. Merchant (Eds.), Reading across the curriculum: Areasearch Report for Teachers. 64-76.edited, Ind: ERIC Clearinghouse on Reading and Communication.

Huinker, D. & Laughlin, C. (1996). Talk your way into writing. In: P. C Elliott & M. J. Kenney (Eds.) *Communication in Mathematics, K-12 and Beyond* (pp. 81–88) Reston, VA: NCTM.

Jorm, A. F. & Share, D. L. (1983). Phonological recoding and reading acquisition. *Applied Psycholinguistics* **4**, 103–147.

Kail, R.; Hall, L. K. & Caskey, B. J. (1999). Processing speed, exposure to print, and naming speed. *Applied Psycholinguistics,* **20**, 303–314. ERIC EJ589655

Kazemi, E. (1998). Discourse that promotes conceptual understanding. *Teaching Children Mathematics* **4(7)**, 410 –414. ME **1999b**.00786 ERIC EJ561776

LeCompte, M. & Preissle, J. (1993). *Ethnography and Qualitative Design in Educational Research* (2nd edition). London: Academic Press Ltd.

Masingila, J. O. & Prus-Wisniowska, E. (1996). Developing and assessing mathematical understanding in calculus through writing. In: P. C Elliott, M. J. Kenney (Eds.) *Communication in Mathematics, K-12 and Beyond* (pp. 95–104). Reston, VA: NCTM.

McBride-Chang, C. & Kail, R. V. (2002). Cross-cultural similarities in the predictors of reading acquisition, *Child Development* **73(5)**, 1392–1407. ERIC EJ666690

McLean, J. F. & Hitch, G. (1999). Working memory impairments in children with specific arithmetic learning difficulties. *Journal of Experimental Child Psychology* **74(3)**, 240–260. ME **2000d.**02653 ERIC EJ597717

Miyake, A. (2001). Individual differences in working memory: Introduction to the special section. *Journal of Experimental Psychology: General* **130**, 163–168.

National Council of Teachers of Mathematics (2000). *Principles and Standards for Teaching Mathematics.* Reston, VA: NCTM.

Olivares, R. A. (1996). Communication in mathematics for pre-service teachers with limited English proficiency. In: P. C Elliott, M. J. Kenney (Eds.) *Communication in Mathematics, K-12 and Beyond* (pp. 219–230). Reston, VA: NCTM.

Pirie, S. E. B. (1996). Is anybody listening? In: P. C Elliott, M. J. Kenney (Eds.) *Communication in Mathematics, K-12 and Beyond* (pp. 105–115). Reston, VA: NCTM.

Siegel, M.; Borasi, R.; Fonzi, J. M.; Sanridge, L. G. & Smith, C. (1996). Using reading to construct mathematical meaning. In: P. C Elliott, M. J. Kenney (Eds.) *Communication in Mathematics, K-12 and Beyond* (pp. 66–75). Reston, VA: NCTM.

Shaywitz, S. (1996). *Dyslexia, Scientific American,* 98–104.

Smith III. J. P. (1996). Efficacy and teaching mathematics by telling: A challenge for reform. *Journal for Research in Mathematics Education* **27(4)**, 387–402. ME **1997f.**03697

Swanson, H. L. & Sachse-Lee, C. (2001). Mathematics problem solving and working memory in children with learning disabilities: Both executive and phonological processes are important. *Journal of Experimental ChildPsychology* **79**, 294–321.

Swanson, H. L. (2004). Working memory and phonological processing as predictors of children's mathematical problem solving at different ages. *Memory and cognition* **32(4)**, 648–661.

Swanson, H. L & Kim, K. (2007). Working memory, short-term memory, and naming speed as predictors of children's mathematical performance. *Intelligence,* **35**, 151–158.

Usiskin, Z. (1996). Mathematics as a language. In: P. C Elliott, M. J. Kenney (Eds.) *Communication in Mathematics, K-12 and Beyond* (pp. 231–243). Reston, VA: NCTM.

Uso-Juan, E. & Martinez-Flor, A. (2006). Current Trends in the Development and Teaching of the Four Language Skills, The Hague: Mouton de Gruyter.

Webster's Universal College Dictionary (1997). Gramercy Books: New-York.

Weinzweig, A. I. (1982). Mathematics as an extension of language. In *Language and Language Acquisition,* New-York: Plenum Press. ME **1984d.**10213