GIRLS AND BOYS IN "THE LAND OF MATHEMATICS" 6 TO 8 YEARS OLD CHILDREN'S RELATIONSHIP TO MATHEMATICS INTERPRETED FROM THEIR DRAWINGS

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In this paper we highlight 6 to 8 years old children's relationship to mathematics. For this task we use children's drawings. Children were asked to imagine themselves in math land. We describe, reduce, and interpret to organize our analyses of gender differences. Theoretical basis lies on theoretical knowledge of math learning, and interpretation of children's drawings. We found that there are meaningful connections between gender, children's developmental level, emotions, and math productions.

METHODOLOGICAL INTRODUCTION

This paper is based on our multidisciplinary research project "Children and Mathematics". We have gathered data from 6 to 8-year-old children (n = 300) by our pictorial test (Perkkilä & Aarnos, 2007a). Pictorial test has two parts: a picture collection presented to children and children's drawings of themselves in the math land. In this paper we concentrate on children's drawings. Drawings give children another language with which to share feelings and ideas. Our goal is to reach the usefulness of multidimensional approaches for understanding children's drawings. The main aims are:

1. To describe math contents and impressions girls and boys produced in their drawings.
2. To reduce results towards the core meaning of math and contextual basis for math learning.
3. To interpret girls' and boys' mathematical and psychological needs for math learning environment.

The interpretative framework we use to organize our analyses of gender differences in children's drawings "Me in the Math Land" is shown in Figure 1.

	Mathematical Perspective	**Psychological Perspective**
Description	Children's productions	Impressions
Reduction	Meaning of Math	Contextual basis for math learning
Interpretation	Math needs	Psychological needs

Figure 1: Framework for analysing girls' and boys' drawings

As the column headings "Mathematical Perspective" and "Psychological Perspective" indicate, the analytical approach involves coordination two distinct theoretical viewpoints on mathematical activity. In our analysis we'll take three steps: description, reduction and interpretation. The entries in the column under mathematical perspective indicate three aspects of children's relationship to mathematics, and the entries in the column under psychological perspective indicate three related aspects of individual basis for children's math learning.

The drawings were analysed by an open method; all the contents, colours, and impressions were classified. We found from the data following categories:

1. "Me" (person in the picture) with two subcategories: a) activities, and b) social situations,
2. Real life contents with four subcategories: a) wild nature, b) animals, c) buildings, and d) vehicles,
3. Mathematical contents with five subcategories: a) amounts of numbers, b) quantity of numbers, c) arithmetical problems, d) geometrical forms, and e) mathematical talk, and
4. Impressions with five subcategories: a) human expressions, b) colours, c) emotional expressions, d) creativity, and e) maturity.

The background variables were gender and grade.

PERSPECTIVES ON MATHEMATICS LEARNING

Hersh (1986) has answered to the question "What is mathematics?" as follows: "It would be that mathematics deals with ideas. Not pencil marks or chalk marks, not physical triangles or physical sets, but ideas (which may be presented or suggested by physical objects). The main properties of mathematical knowledge, as known to all of us from daily experience, are:

1) Mathematical objects are invented or created by humans.

2) They are created, not arbitrarily, but arise from activity with existing mathematical objects, and from the needs of science and daily life.

3) Once created, mathematical objects have properties which are well-determined, which we may have great difficulty in discovering, but which are possessed independently of our knowledge of them." (Hersh, 1986, 22.)

The nature of mathematics comes up especially then when you try to develop mathematical model from every day situation, and to apply mathematical system for example in the problem situation to another new every day situation (Ahtee & Pehkonen, 2000, 33-34). The daily life problems are increasingly emphasized in recent mathematics curricula in various countries. For example an illustration of the daily life problems in arithmetic could begin by having children use their own words, hands-on-materials, pictures, or diagrams to describe mathematical situations, to organize their own knowledge and work, and to explain their strategies. Children gradually begin to use symbols to describe situations, to organize their mathematical work, or express their strategies. (Singer & Moscovici, 2007, 1616.)

Mathematical knowledge cannot be revealed by a mere reading of mathematical signs, symbols, and principles. The signs have to be interpreted, and this interpretation requires experiences and implicit knowledge – one cannot understand these signs without any presuppositions. Such implicit knowledge, as well as attitudes and ways of using mathematical knowledge, are essential within a culture. Therefore, the learning and understanding of mathematics requires a cultural environment. (Steinbring 2006, 136.) According to Berry and Sahlberg (1995, 54) many children have preconceptions about modelling which are based on interpretations of real models. They argue that it is worth to utilize these preconceptions in school mathematics. According to Presmeg (1998) there is strong evidence that traditional mathematics teaching does not facilitate a view of mathematics that encourages students to see the potential of mathematics outside the classroom. Although some reports indicate that children are involved in many life activities with mathematical aspects, they continue to see mathematics as an isolated subject without much relevance to their lives.

EARLY MATHEMATICS LEARNING AND GENDER ASPECTS

According to Aunio's (2006, 10) research review there are contradictory research results in children's mathematical performance and gender. For example Dehaene's (1997), Nunes & Bryant's (1996) research results show that girls and boys possess identical primary numerical abilities. Carr and Jessup (1997) have reported that during the first school year, boys and girls may use different strategies for solving mathematical problems, but there is no difference in the level of performance. Whereas Jordan, Kaplan et al. (2006) found in their research small but reliable gender effects favouring boys on overall number sense performance as well as on nonverbal calculation.

According to Ojala and Talts (2007), we can better understand why girls in school and afterward usually achieve their learning goals better. Their study shows that gender differences in learning are probably emerging early before school starts. The gender differences were present in most areas of learning expect language, mathematics, and science. (Ojala & Talts, 2007, 218.)

According to Geist and King (2008) to support excellence in both boys and girls we must design experiences and curriculum that meet the needs of both boys and girls by understanding their uniqueness. Most teachers would never consciously treat boys and girls differently; however assumptions about gender roles and myths about learning mathematics can sometimes lead to us treating boys and girls differently without even realizing it. This is what is know as the "self-fulfilling prophesy." (Geist & King, 2008, 44-50.)

According to Muzzatti and Agnoli (2007), gender differences exist also in gender stereotyping of mathematics. Despite the lack of gender differences in actual mathematics performance, girls evaluate themselves as being less competent, and as they grow older, both boys and girls lose confidence in their ability and perceive this subject matter as more difficult and as less likeable. (Muzzatti & Agnoli, 2007, 757.)

Interpreting and understanding children's drawings

The children are telling us in pictorial language how they feel about themselves and the determining influences in their lives. They are also telling us how they need other persons. An attempt to interpret child art within a single theoretical framework can only result in frustrating oversimplification. More productive than a single-minded approach is an eclectic one that draws upon disciplines that have contributed significantly to our understanding of the infinite variety of human behaviour. (DiLeo, 1983, 214-216.) In this paper such an eclectic approach will draw upon mathematics learning and teaching, educational and developmental psychology.

The first representation of the human form has been observed wherever children's drawings have been studied. During the preschool years, spontaneous drawings tend to be more elaborate with the inclusion of other items of significance, notably houses, trees, sun, and other aspects of nature. Human figures in particular are regarded as valuable indicators of cognitive growth. A qualitative as well as a quantitative change occurs at about seven or eight years when "intellectual realism" gives way to "visual Realism", a change that finds its correspondence in the Piagetian concept of a shift from the preconceptual (preoperational) to the concrete operational stage. These terms express, in substance, a metamorphosis in thinking from egocentricity to an increasingly objective view of the world. (DiLeo, 1983, 37.)

Two developmental stages of drawing are especially relevant to our research: intellectual and visual realism (see fig. 2). According to Malchiodi (1998, 1) drawing has been undeniably recognised as one of the most important ways that children express themselves and has been repeatedly linked to the expression of personality and emotions. Children's drawings are thought to reflect their inner world. Although children may use drawing to explore, to problem solve, or simply to give visual form to ideas and observations, the overall consensus is that art expressions are uniquely personal statements that have elements of both conscious and unconscious meaning in them and can be representative of many different aspects of the children who create them. (cf. fig. 2)

Age	Drawing	Cognition
4-7	*Intellectual realism* Draws an internal model, not what is actually seen. Draws what is known to be there. Expressionistic. Subjective.	*Preoperational stage (intuitive phase)* Egocentric. Views the world subjectively. Vivid imagination. Fantasy. Curiosity. Creativity. Functions intuitively, not logically.
7-12	*Visual realism* Subjectivity diminishes. Draws what is actually visible. Human figures are more realistic. Colours are more conventional.	*Concrete operations stage* Thinks logically about things. No longer dominated by immediate perceptions. Concept of reversibility.

Figure 2: Intellectual and visual stages related to Piaget's stages of cognitive development according to DiLeo (1983, 37-38.)

According to Malchiodi (1998) phenomenological approach is a way to understand children and their drawings. Understanding children's creative work is attractive because it entails looking at drawings from a variety of perspectives, including among others developmental and emotional influences. (Malchiodi, 1998, 35-40.)

Themes of children's drawings may also be gender-related. General differences in the themes of boys´ and girls´ drawings, observing that "the spontaneous production of boys reveal an intense concern with war fare, acts of violence and destruction, machinery, and sports contents, where as girls depict more tranquil scenes of romance, family life, landscapes, and children at play". Girls use fairy tails images such as kings and queens and animals such as horses as the subjects of their drawings. Whether this, tendency to portray specific subjects by boys and girls is developmental or the result of parental or societal influences or both remains as an unsolved question. (Malchiodi, 1998, 186-187.)

Vygotsky (1978) viewed drawing as a way of knowing, as a particular kind of speech, and emphasized the critical role of drawing in young children's concept development; particularly because the drawing event engages children in language use and provide an opportunity for children to create stories.

RESULTS

Descriptions

Children drew themselves in rich forms, produced math contents and informal contents (e.g. nature and buildings). Most children were standing alone in the math land. Most girls were smiling and some of the boys seemed to be involved in action. Girls and boys equally expressed numbers and arithmetical problems. Besides children themselves wild nature was the main content of the pictures.

Mathematical productions

	Girls (%)	Boys (%)
None	23,2	28,3
Numbers	76,8	71,7

Table 1: Number expressions

	Girls (%)	Boys (%)
Numbers (≤10)	44,5	40,0
Numbers (>10)	32,3	31,7

Table 2: Number quantities

	Girls (%)	Boys (%)
None	65,8	65,5
Arithmetical problems	34,2	34,5

Table 3: Arithmetical problems

	Girls (%)	Boys (%)
None	12,9	15,2
Numbers with forms	29,0	29,7
Other forms	58,1	55,2

Table 4: Forms

There were no differences in girls' and boys' math expressions (Tables 1- 4). These results have similarities with some other researches e. g., Nunes and Bryant (1996), Carr and Jessup (1997), Perkkilä and Aarnos (2007a).

In figure 3 drawers are practicing their number sense which is essential part of early math curriculum. Still there is a worry that this kind of number practicing is not enough in children's early math learning.

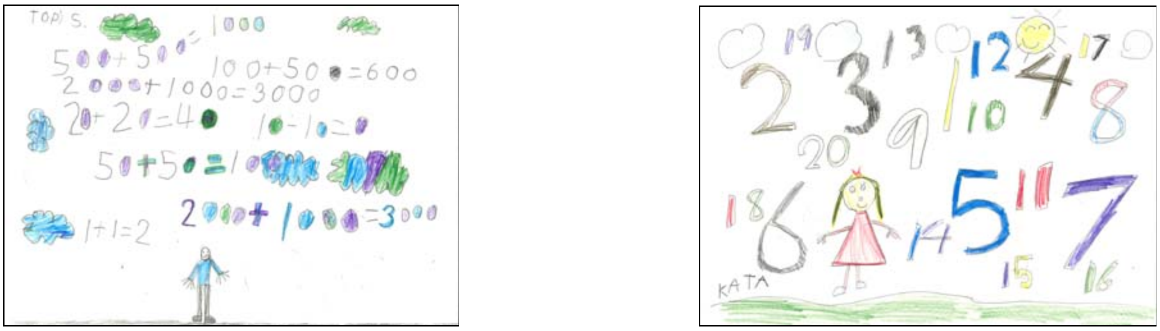

Figure 3: First-grader boy's and first-grader girl's drawings demonstrating huge number productions

Figure 4: Second-grader boy's and second-grader girl's drawings demonstrating creative use of numbers

These children also are practicing their number sense but in a more creative way than children in figure 3. However, we have to accept that it is difficult to conclude any differences only by the pictures. Concerning to this challenge, we sustained trustworthiness by comparing these differences to children's other responses in our pictorial test, and by finding parallel results.

Emotional expressions

	Girls (%)	Boys (%)
Sad	4,5	19,3
Neutral	42,6	60,0
Joy	52,9	20,7

Table 5: Emotional impressions (χ^2=41.8***)

Statistically significant gender effect can be seen in girls' and boys' emotions (Table 5). Most girls express in their drawings joyful attachment for mathematics whereas it was hard to see clear emotional expressions in most boys' drawings, and so they were interpreted to have neutral attachment for mathematics. We wonder if results have basis in either the differences in girls' and boys' development (e.g. Bornstein et al. 2006) or early gender stereotypes (e. g. Steele 2003; Golombok et al. 2008).

Reduction

	Girls (%)	Boys (%)
Alone	73,5	63,4
With others	7,7	9,7
With fairy	15,4	14,5
None	3,2	12,4

Table 6: “Me” in Math Land

	Girls (%)	Boys (%)
Standing	67,1	62,1
Moving	22,0	18,0
Housing	3,2	1,4
None	7,7	18,5

Table 7: “My Action” in Math Land

The meaning of math for these children seems to be “being alone, silent, producing numbers and arithmetical problems”. Most children seem to be at level of intellectual realism (see Fig. 2). Contextual basis for math learning is for most children in this research outside school buildings, mostly in wild nature (Table 8).

	Girls (%)	Boys (%)
Wild nature	80,6	62,1
Animals	36,1	23,4
Buildings	36,1	44,8
Vehicles	3,2	13,1

Table 8: Contents of Math Land

Typically, in boys’ drawings there were few more buildings and vehicles whereas girls produced few more animals and wild nature (e.g. Malchiodi 1998, 186-187). The buildings in the drawings were towers, cottages, castles, home houses etc.

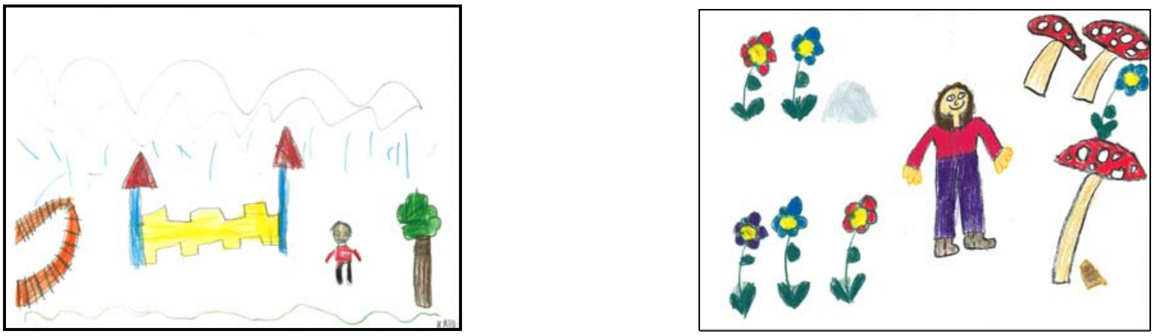

Figure 5: First-grader boy’s and first-grader girl’s drawings demonstrating no numeric content

In these drawings (Fig. 5) children seem to practise early mathematical skills e.g. classifying, grouping, and making series. In general, these skills develop in early years.

Interpretation

Different kinds of needs can be interpreted from children’s drawings “Me in the math land”. Children have both mathematical and psychological needs. Concerning the math learning we could find three different groups of children: “traditional school mathematicians” (Fig. 3), “wild and creative mathematicians” (Fig. 4), and beginning mathematicians” (Fig. 5). These groups need differentiations in math teaching (cf. Geist & King, 2008). In order to collect the main gender effects, three main scales were counted of the categories presented earlier: emotions, developmental level, and math productions. The connections were analysed by t-test (gender differences), and by correlations (dependences between scales). Concerning the psychological needs there are great discrepancies in children's developmental level and emotional basis. Still there can be seen gender views (Fig. 6).

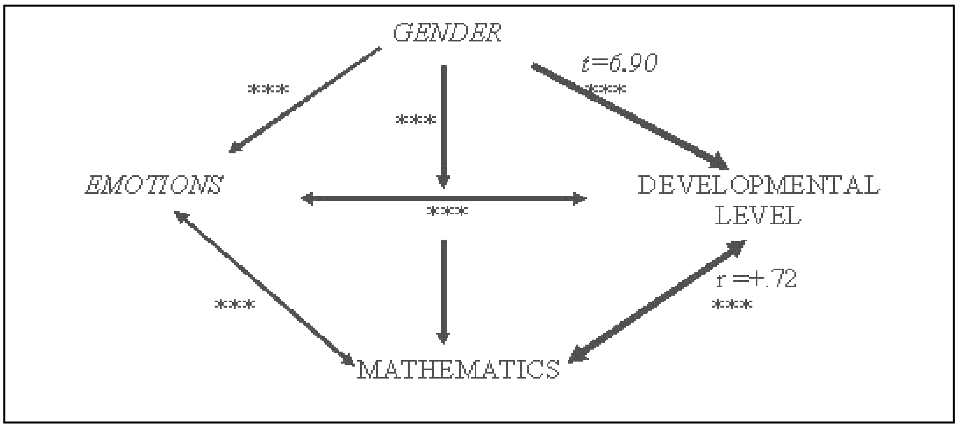

Figure 6: Statistically meaningful connections between gender and basic scales interpreted and counted in children's drawings

All connections between gender and three scales (emotions, developmental level, and math productions) are statistically significant, favouring girls. The most powerful connection is between gender, children's developmental level, and math productions. Furthermore, children's mathematical skills have strong effect in their mental development. Therefore children need mathematical inspirations in their growing environments.

We found a strong cumulative circle between children's developmental level, mathematics productions, and emotions (fig. 6). Aunola et al. (2004) have shown that children's mathematical skills develop in a cumulative manner from the preschool to the first years of school, even to the extent that the initial mathematical skills in beginning of preschool were positively associated with their later growth rate: the growth of mathematical skills was faster among those who entered preschool with already higher mathematical skills. Aunola et al. (2004) also showed that by the end of grade 2 children have problems both in attachment for mathematics and in math learning.

According to Geist and King (2008), when boys enter school they are often less able than girls to write numbers correctly or align numbers for tasks such as adding and subtracting on paper. Girls, on the other hand, find writing and completing worksheets much easier. (Geist & King 2008, 45-46.) Boys' weaker fine motor skills were also seen in children's drawings. As shown in tables 1 to 4 there were no gender differences in math expressions themselves. While interpreting profoundly the data we have looked at the issues behind math expressions e.g. emotions and developmental level.

Many teachers believe that girls achieve in mathematics due to their hard work, while boy's achievement is attributed to talent. These differing expectations by teachers and parents may lead to boys often receiving preferential treatment when it comes to mathematics. Children may internalize these attitudes and begin to believe what their teachers and parents believe. As a result girls' assessment of their enjoyment of mathematics falls much more drastically than boys' assessment as they move through the grades. These attitudes may shape the experiences that children have as they are learning mathematics. (Geist & King 2008, 44-45.)

Concerning the need for learning environments, children's math land is mostly in the nature. They spontaneously combine the informal and formal mathematics. Boys seem to need more lively actions and constructions in their learning environments. Girls' expectations towards mathematics learning environments are more positive than boys'. Teachers and other educators should recognize how powerful out-of-school learning experiences could be in math learning. Mathematical experiences are essential parts in children's world from very early of life. The child's focusing on numerosity produces practice in recognizing and utilizing numerosity in the meaningful everyday context of the child.

CONCLUSIONS

The description and interpretation of children's drawings gave us insights into children's math experiences and needs. Children's drawings can be an effective of evaluating important basis of math learning, e.g. their relationship towards mathematics. This method also allowed children, who found written reporting and recording difficult, a better opportunity to reveal their understanding the nature of mathematics and their inside needs for the learning situations. (cf. DiLeo, 1983; Malchiodi, 1998; Vygotsky, 1978)

The Finnish curriculum (2004, 17) is giving more attention to the following aspects: Special needs of girls and boys; Equal opportunities for children to learn and to start school; Strengthening children's positive self-concept and their ability to learn skills; Having children learn to understand the significance of a peer group in learning; and Having children learn to join learning and to face new learning challenges with courage and creativity.

According to Perkkilä and Aarnos (2007b, 3), in school children have to learn formulas, exact proofs, or formalized definitions. Without real life connections this kind of math learning may restrict the talk about math in to formal mathematics. In present research children drew themselves mostly in real life situations. Daily life problems and narratives in learning situations could promote early math learning (cf. Singer & Moscovici, 2007; Presmeg, 1998).

The gender variations found in children's drawings are important to think about. We suggest that early math learning environments should be child centred and gender sensitive.

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