ON PUPILS' SELF-CONFIDENCE IN MATHEMATICS: GENDER COMPARISONS

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In this paper we will concentrate on pupils' self-confidence in mathematics, which belongs to pupils' mathematical beliefs on themselves, and beliefs on achievement in mathematics. Research described consists of a survey of more than 3000 fifth-graders and seventh-graders. Furthermore, 40 pupils participated a qualitative follow-up study (interviews and observations). Results showed that mathematical beliefs on oneself could be divided, based on the indicator used, into three factors: self-confidence, success orientation, and defense orientation. The fifth-graders had higher self-confidence than the seventh-graders. Additionally, boys in both grades had remarkably higher self-confidence in mathematics than girls.

INTRODUCTION

Pupils' conceptions on themselves as a learner are strongly connected with what kind of general attitudes they have toward the discipline in question. Mathematics has been since centuries a highly valued discipline in school, and therefore, pupils experience success in mathematics important. It has been observed that pupils' beliefs on mathematics and on themselves as mathematics learners have a central role in pupils' learning and success in mathematics (e.g. Schoenfeld 1992).

The importance of beliefs is earning more and more recognition in mathematics education; this is concordance with the constructivist understanding of teaching and learning. For the term "belief", there is no single, exact definition. Furinghetti & Pehkonen (2002) have tried to clarify the problems of the concept belief, and they conclude that it seems to be impossible to find a universally accepted characterization for beliefs. For example, Schoenfeld (1992, 358) describes beliefs as "*an individual's understandings and feelings that shape the ways that the individual conceptualizes and engages in mathematical behavior*". Our understanding of what a belief is may be is further characterized by the following specification of its function in a system. Pehkonen & Törner (1996) describes four kind of functions: (a) beliefs form a background regulating system of our perceptions, thinking, and actions, and therefore, (b) beliefs act as indicators for teaching and learning. Moreover, (c) beliefs can be seen as an inertia force that may work against change, and as a consequence (d) beliefs have a forecasting character.

Beliefs have their principal origin in social interaction. An individual's mathematical beliefs originate from his personal experiences in school and outside of school. These, in turn, consist of perceptions that originate from mathematics teachers, other teachers, schoolmates, learning materials, achievements in mathematics, etc. Especially, mathematics teachers have an influence, among other things, through their curricular decisions. decisions. The prevailing image of mathematics in society influences students' beliefs through their parents, relatives, friends, different kinds of media, job opportunities, etc.

Mathematical beliefs and mathematics learning form a circular process. I.e. on one hand how mathematics is taught in class influence little by little on pupils' beliefs in mathematics. On the other hand, beliefs influence how pupils can receive mathematics teaching in class. A pupil's mathematical beliefs act as a filter influencing all his thoughts and actions concerning mathematics. Mathematical beliefs can be divided into four main components: beliefs on mathematics, beliefs on oneself as a mathematics learner/applier, beliefs on teaching mathematics, and beliefs on learning mathematics (e.g. Lester & al. 1989).

Of mathematical beliefs on oneself, the most studied ones are, among others, self-confidence, self-efficiency and success expectations and their connections with success. Several studies have shown that beliefs on oneself have a remarkable connection with success in mathematics (e.g. Hannula & Malmivuori 1996, House 2000). For example, in the study of Hannula and Malmivuori (1996) the observation was made that of ninth-graders' mathematical beliefs, self-confidence correlated statistically significantly with success in the mathematics test they used.

Often one tries to approach mathematical beliefs using comparisons of girls' and boys' results. Among others, in the test of Pehkonen (1997) boys in grade 9 were more interested in mathematics and have more confidence in themselves than girls. According to results of the same study, girls were, however, more ready to cooperate with other pupils and to practice with more tasks than boys. Similar results were found also in other studies (e.g. Stipek & Gralinski 1991). These results are supported also by the study of Vanayan & al. (1997) that showed that already in grade 3 and 5 boys estimated them selves to be better in mathematics than girls. That in teenage girls' have weaker self-confidence in mathematics than boys has also been reported in several publications, e.g. in Leder (1995) and Bohlin (1994). Also mathematics anxiety seems to be more general in girls than in boys (Frost, Hyde &Fennema 1994).

The focus of this paper is to describe pupils' mathematical beliefs on themselves, and to consider them in relation to their mathematical achievement. Especially, we concentrate us on comparison of girls' and boys' beliefs and achievement.

METHOD

The study is a part of a research project "Understanding and Self-Confidence in Mathematics" financed by the Academy of Finland (project #51019). The project is targeted grades 5–8, and contains in the beginning a large survey with a statiscal sample from the Finnish pupil population of grade 5 and grade 7 with 150 school classes and altogether 3057 pupils. In the sample, the share of girls and boys is about the same, as well as the share of pupils in two grade levels (grade 5 and 7). The survey was implemented at the end of the year 2001, and the information gathered was deepened with interviews in spring 2002. The development of pupils' understanding and self-confidence were tried to track with follow-up interviews that are planned to run during winter 2002-03. For the interviews 10 classes are selected, and from each of them four pupils. Thus, altogether 40 pupils will be interviewed and observed.

The questionnaire was planned especially for the project, but some ideas were collected from the existing literature. Its aim was to measure both pupils' calculation skills in fractions and decimals, and their understanding in the case of the concepts "density of fractions" and "infinity"; additionally pupils' self-confidence in mathematics was measured. The questionnaire is a compound of five areas: a pupil's background knowledge, 19 mathematical tasks, a pupil's expectation of success before doing the task, a pupil's evaluation of success after doing the task, and an indicator for his mathematical beliefs. The questionnaire was administered within a normal mathematics lesson (45 minutes) by the teacher. Some examples of the mathematical tasks used in the questionnaire were the following:

Task 5. Write the largest number that exists. How do you know that it is the largest?

Task 6c. Calculate 2*0.8.

Task 7. How many numbers are there between numbers 0.8 and 1.1?

Some results connected to the concept "infinity" have been reported in an earlier paper (cf. Hannula & al. 2002). Here we will concentrate on the results of the self-confidence in mathematics. Furthermore, connections of the pupils' beliefs are studied with their (self reported) latest marks in mathematics and with their achievement in mathematical tasks of the questionnaire. Grade and gender were used as background variables. The questionnaire and interview structure were tested in autumn 2001, and some small changes were made.

The indicator used (belief scale) contained 25 statements of beliefs on oneself in mathematics. Of these items, ten were taken from the self-confidence part of the Fennema-Sherman scale (cf. Fennema & Sherman 1976), and the other 15 items measured pupils' beliefs on themselves as mathematics learners, and beliefs on success. The wording of the statements is given in Table 1 describing the factor solution. The students answered on a 5-point Likert-scale (from totally disagree to totally agree).

The sum variables made from beliefs have been considered mainly without classifications, but, if needed, three groups (weak, average, good) were formed. According to school marks in mathematics, pupils were divided into three equal groups in the way that the following division was used: about a quarter of the pupils from the weakest part, about a quarter of the pupils from the best part, and about half of the pupils between these. The same was done with the sum scores of the mathematics tasks in the test: a quarter from the weakest part, a quarter from the best part, and half of the pupils between these. The data of the fifth-graders and the seventh-graders was dealt with both together and separated. The results are reported mainly with all pupils together, but if there are significant differences between the grades, they are mentioned separately.

Data analysis concerning beliefs began with factor analysis. Next the connections of the sum variables, made from the factors obtained, with gender, grade level, mathematics mark and the test score were considered. Parametric tests, such as t-test, were used, and the results were checked, if needed, with corresponding nonparametric tests.

The questionnaire used in research was tested with some pupils from grade 5 and 6 in autumn 2001, and some small changes were made. Since the mathematical tasks in the questionnaire are same for both grades (grade 5 and 7), it is clear that the task scores of the seventh-graders were remarkably higher than those of the fifth-graders. In the case of self-confidence, the belief scale seemed to form a very unified, and therefore, reliable part, since its statements were factorized in several different solutions on the same factor.

The research participants formed a large and covering sample of fifth-graders and seventh-graders in Finland. Therefore, results can be generalized to the whole Finland. Also gender differences in results are possible to generalize in Finland, since the amount of girls and boys in the sample was about the same.

ON RESULTS

Factorized mathematics beliefs

Factor analysis resulted in the case of both grades a very similar structure. The program suggested five factors, when using the criteria "eigen value > 1", whereas according to the Cattell scree-test the proper number of factors seemed to be 3…5. Therefore, several different factor solutions were experimented, and finally decided to use three factors.

For a three factor solution, there were the following facts: In all factor solutions, the 10 Fennema-Sherman statements were loaded in the first factor. Therefore in the four and five factor solutions, there were left only two or three statements for the last factors. Additionally, the Cronbach alphas for the last factors in question were very low. Furthermore, the three-factor solution explained from the variance almost as much as e.g. the five-factor solution.

The three-factor solution was further elaborated. Because of their low communalities (< 0.30), five statements were compelled to remove from the combined data and from the seventh-graders' data. In the case of fifth-graders, two additional statements were removed. In other points the structures were very similar, and therefore, we concentrate here to consider only the factorization made from the combined data.

In Table 1, one can see the three-factor structure with loadings and communalities. The explanation level of this factor solution is 48 %. In the first factor, the central point is clearly self-confidence in mathematics, and therefore, we name the factor "self-confidence"; it explains 26 % of the variance.

The second factor contains, among others, preparation for tests, importance of getting a good mark, and importance of understanding topics. The name of the factor will thus be "Success orientation", and it explains 12 % of the variance. One should note that the factor contains many types of willingness to success – on one hand desire to understand topics, and on the other hand, desire to success in tests.

The third factor contains statements that are combined with the fear of embarrassing and avoiding behavior in mathematics class. The factor was named "Defense orientation", and it explains 10 % of the variance.

There is a statistically very signiticant difference between grades in self-confidence and in success orientation in the way that the fifth-graders have higher means than the seventh-graders in both.

The boys have in the combined data and in the seventh grade statistically very significantly ($p < 0.001$) better self-confidence than the girls, but in success and defense orientation there are no statistically significant differences. In the case of the fifth-graders, there is a statistically very significant ($p < 0.001$) difference beside self-confidence also in success orientation: Boys are more strongly success oriented than girls. When looking more carefully the self-confidence factor, very significant differences between boys and girls in the combined data can be found in all ten statements, in favor of boys. The differences between fifth-grade boys and girls were not similar clear, although boys in total have a higher success orientation score.

Table 1. The three-factor solution on the mathematics beliefs of the indicator.

Factors and statements	*Loading*	*Communalities*
***SELF-CONFIDENCE** (alpha 0.89)*		
16. I am not the type who is good in mathematics.	-0.770	0.647
20. I am not very good in mathematics.	-0.761	0.639
8. Mathematics is difficult to me.	-0.755	0.637
5. I am able to get a good mark in mathematics.	0.726	0.597
6. Mathematics is my weakest school subject.	-0.726	0.574
22. I can do also difficult mathematics tasks.	0.677	0.534
11. I believe that I would do also more difficult mathematics.	0.653	0.463
19. I trust in myself in mathematics.	0.643	0.514
24. I know that I can be successful in mathematics.	0.588	0.539
1. I am sure that Ican learn mathematics.	0.578	0.492
***SUCCESS ORIENTATION** (alpha 0.55)*		
25. For me the most important in learning mathematics is to understand.	0.623	0.442
17. I prepare myself carefully for the tests.	0.601	0.373
14. In mathematics one successes with diligence.	0.590	0.355
15. For me it is very important to get a good mark in mathematics.	0.570	0.396
2. I am anxious before mathematics tests.	0.443	0.373
***DEFENCE ORIENTATION** (alpha 0.56)*		
4. I don't like to reveal others, if I don't understand something in mathematics.	0.679	0.477
3. In mathematics one is not needed to understand everything, when one only gets good marks in tests.	0.580	0.403
23. I fear often to embarrass myself in mathematics class.	0.572	0.397
12. I answer in mathematics class only, if I am compelled to.	0.556	0.360
9. I don't like tasks that I am not able to solve immediately.	0.495	0.331

Correlations between sum variables

Success in mathematics will be clarified with the aid of the last mathematics marks and the tasks in the questionnaire. They form with the three factors the five sum variables (self-confidence, success orientation, defense orientation, school marks, and task scores). In order to acquire a holistic view, the correlations between the sum variables are firstly considered. As one may observe from Table 2, self-confidence and defense orientation correlate negatively. Additionally, school marks and task scores correlate strongly with each other. The strongest correlation with success in mathematics has self-confidence, but also defense orientation has some negative correlation with success. The significance of correlations was checked with a random sample on 15 %, which confirmed the validity of correlations.

Table 2. Correlations between sum variables in the combined data (N ≈ 3000).

	Success orientation	*Defence orientation*	*School marks*	*Task score*
Self-confidence	0.156***	-0.397***	0.538***	0.346***
Success orientation		0.003	0.022	-0.030
Defence orientation			-0.248***	-0.212***
School marks				0.489***

*** Correlation is statistically very significant, p < 0.001.

Self-confidence correlates statistically significantly with all other sum variables. Success orientation is in connection only with self-confidence, whereas the rest of the three sum variables seem to form a solid structure with self-confidence. It is worthwhile noting that defense orientation has a negative connection with other sumvariables.

Mathematics achievement and mathematics beliefs

In the case of school marks in mathematics, there are statistically very significant differences between different groups (weak, average, good) in self-confidence and defense orientation: The weak pupils had a remarkably weaker self-confidence and a stronger defense orientation than the good pupils, and the average pupils were between these. The girls had a statistically almost significant difference between groups also in success orientation.

In addition, one may observe that average girls have equal strong or weak self-confidence as weak boys, whereas good girls have almost as strong self-confidence as average boys. We were interesting in focussing on this result, since some earlier results point on that there is no difference in self-confidence of good girls and boys (e.g. Minkkinen 2001). Therefore, we decided to take a still smaller group of good girls (the criteria: school mark[1] is 10), and to compare them with the corresponding group of boys. From Table 3 one may observe that the difference in self-confidence between girls and boys stayes on equal level as in the whole data. Therefore, also the best girls don't reach boys in self-confidence.

Table 3. Self-confidence of the highest achieving (mathematics mark 10) girls and boys.

	Gender	*N*	*mean*	*SD*	*p*
Self-confidence	boy	137	4.4	0.45	
	girl	101	4.0	0.50	0.000***

The similar pattern was also found in groups made according to the task scores of the test. Good girls have even weaker self-confidence than average boys, and average girls weaker self-confidence thank weak boys. Again we wanted to look the most skillful pupils and find out, whether the differences in self-confidence still stay equal. Here our criteria was "the task score 30 or more" (the test maximum being 36 points). In Table 4

[1] In Finland 10 is the best mark in school.

one may notice that the difference between boys and girls in self-confidence is even bigger than in the whole data.

Table 4. Self-confidence of the most skillful (the task score 30 or more) girls and boys.

	Gender	*N*	*mean*	*SD*	*p*
Self-confidence	boy	101	4,4	0.50	
	girl	52	3,9	0.59	0.000***

CONCLUSION

Of the belief factors, self-confidence correlated most strongly both with the last mathematics mark and with the task scores. The weak pupils had the weakest self-confidence and the strongest defense orientation, the good pupils other way round, and the average pupils were between these. A strong connection between self-confidence (and other beliefs on oneself) and mathematical achievement has been found also in earlier research (i.a. Hannula & Malmivuori 1996; Malmivuori & Pehkonen 1996; Tartre & Fennema 1995).

The biggest gender difference was found in self-confidence; boys had remarkably higher self-confidence than girls. And the difference stayed on equal level also when compared the most skillful girls and boys with each other.

In the case of two other factors, one could point, among others, on Yates' research (Yates 1998, 2000). It is interesting that success orientation resulted only one factor, since in the motivational orientation tradition there are usually two different orientations (mastery and performance). On one hand, defense orientation could be connected with "ego-defensive" motivation orientation, and on the other hand, with mathematics anxiety.

Although defense orientation and self-confidence correlated rather strongly negatively, however, they are different constructs. One should not interprete that defense orientation is the same as weak self-confidence. Only a part of those who has weak self-confidence, feels that they need to cover their weak achievement.

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