TEACHERS' BELIEFS ABOUT GENDER DIFFERENCES IN MATHEMATICS: *'GIRLS OR BOYS?'* SCALE

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The focus of the paper is to examine teachers' beliefs about the differences of boys and girls (aged 13-15 years) as learners of mathematics. For this purpose a rating scale was developed with a new type of response format: 'Girls or Boys?'. A sample of teachers of mathematics (N=204) were asked to classify a list of characteristics as being more frequent among girls or among boys in their mathematics classes. Factor analysis revealed six main dimensions indicating beliefs in gender differences and one secondary factor suggesting a core belief dimension 'Mathematics as a gendered domain'. The teachers' scores on the six belief dimensions revealed the following highly believed gender differences: girls avoid using intelligence and boys attain most of the teacher attention.

INTRODUCTION

Since the early 1970's there has been an increasing research activity in the field of gender and mathematics education especially in the English-speaking Western nations (Leder, 1992; Leder, Forgasz & Solar, 1996; Lubienski & Bowen, 2000). Research on affect and mathematics has focused on the affective responses of students rather than those of teachers (McLeod, 1994). Identifying classroom behaviours that influence gender differences in learning, and patterns in how students choose to study mathematics has been difficult (Fennema, 1995). Teachers' knowledge of, and beliefs about, mathematics have been studied from the perspective of cognitive science, but this perspective is less used in studies concerned with gender (Fennema & Hart, 1994). Studies that deal with the mental processes of teachers might give insight into why teachers interact with boys and girls the way they do. The body of literature available regarding gender issues related to teachers' beliefs does not give conclusive evidence that teachers believe that mathematics is more appropriate for males than females (Fennema, 1990; Li, 1999).

The acquisition of beliefs or their modification is a major issue in the activity of teaching. As Green (1971, p.42) further points out, beliefs are always gathered as parts of a belief system. Therefore it is more important to explore the nature of sets of beliefs or belief systems than to examine the nature of a belief alone.

The problem is, that in the educational literature and among researchers, there is no common definition for the concept "belief", nor a clear distinction between beliefs, conceptions and knowledge (Pajares, 1992; Pehkonen & Furinghetti, 2001). Thompson (1992) distinguishes knowledge from belief systems on the basis of the possibility of objective evaluation of validity.

The distinction between the terms "belief" and "attitude" is also problematic. The instruments to asses or measure beliefs are those used in the research of attitudes. Whereas attitude refers to a person's favorable or unfavorable evaluation of an object, beliefs represent the information he has about the object. One distinction that has been repeatedly proposed is the theory of three components of attitudes; affect, cognition, and conation, and beliefs belonging to the category of cognition. Fishbein and Ajzen (1975) reserved the term "attitude" for one of the categories, namely affect. Beliefs are on the border between cognition and affect. The latter, affect, is often more or less emphasised in a teacher's belief concerning gender and especially gender and mathematics.

METHOD

The aim of the study was to examine teachers' beliefs about the differences of boys and girls as learners of mathematics. A new scale was developed for this study. There are two research questions:

Do Finnish mathematics teachers believe in gender differences in mathematics?

What are the components of teachers' beliefs about gender differences in pupil's behaviours in mathematics learning situations?

Instrument

The study was a survey, a belief inventory, and quantitative methods of analysis were employed. The instrument of the study was a belief questionnaire with 55 structured items and some open questions, in which the teachers were asked to characterize, in their own words, boys and girls as mathematics learners. In this paper I approach the belief components, which I call belief dimensions, by factor analysing the answers to the structured items. It was anticipated that starting with a large number of items would be necessary in order to find the most relevant ones. The 55 statements of student characteristics were grouped under the following headings: A) Girls and boys in math-class, B) Girls' and boys' attitudes, C) Girls' and boys' abilities and cognitive skills, D) Upper secondary mathematics choices and career choices, and E) The situation of gender equity in school. This grouping of the statements was only intended to support the teacher in answering.

The topics of the items were mostly found in the literature about gender issues. Some of the items were adopted and modified from earlier studies (e.g. Maccoby & Jacklin, 1974; Leder, 1992; Brusselmans-Dehairs & Henry, 1994). Some items arouse from my experience as a mathematics teacher and reflections upon my beliefs and gender dependent teaching practices. The topics were discussed with a couple of experienced in-service mathematics teachers. The instrument was examined by some ten mathematics teacher educators and researchers. The first version of the questionnaire was tested with a group of fifteen pre-service secondary mathematics teachers. All the groups mentioned above gave valuable feedback and helped in developing the items.

The *Girls or Boys?* scale

According to Fishbein and Ajzen (1975, p.12) with respect any object–attribute association, people may differ in their belief strength, in terms of the perceived likelihood that the object has the attribute in question:

> we recommend that "belief strength," or more simply, "belief," be measured by a procedure which places the subject along a dimension of subjective probability involving an object and some related attribute. (Fishbein & Ajzen 1975, p.12)

The three commonly mentioned rating scales for verbalized attitudes are Thurstone, Likert and Osgood scales (see e.g. Nunnally 1967; Henerson, Morris & Fitz-Gibbon 1978 p. 82; Keats 1997). The Likert method of constructing and applying attitude scales is by far the most common. The items have alternatives e.g. "strongly agree, agree, undecided, disagree, strongly disagree", which are scored 2,1,0,-1, and –2, respectively. The alternative "undecided" has been shown to lead to anomalous results and should possibly not be used (Keats 1997).

Forgasz, Leder, and Gardner (1996) have reexamined the widely used Fennema-Sherman *Mathematics as a male domain* scale and they found evidence that several items in the scale may no longer be valid. For example it is nowadays not obvious what can be referred from disagreement with the item: "Girls can do just as well as boys in mathematics." Are girls doing better or are girls doing worse?

In this study it was aimed to develop a new scale, and to take into account the remarks mentioned above. A Likert-type rating scale with a response format suitable for comparisons and measurements of differences was constructed. The statements in the questionnaire were of the type: "*X finds mathematics difficult*." For each statement, the respondent had to select the subject X out of the following five alternatives:

G usually a girl

g a girl more often than a boy

± a girl as often as a boy

b a boy more often than a girl

B usually a boy

The principle of this *Girls or Boys?* scale is that each item counts for two Likert-type items a) and b) which are opposite to each other and in sum-scales either of them is reversed (Table 1). The scores for the *Girls or Boys?* items are counted as the average of the two scores a and b* of the corresponding Likert items (score b* is a reversed one): G = -2, g = -1, ± = 0, b = 1, and B = 2.

When a G*irls or Boys?* item needs to be reversed for sum-scales, it means that the Likert item to be reversed is item a) instead of item b). For certain this *Girls or Boys?* scale does make only an ordered scale, but like Likert scales it will be used in this study as an interval scale.

Table 1. Two agreement-items make together one *Girls or Boys*? item: an example.

Girls or Boys?	Likert item **a)**		Likert item **b)**	a b* average		
X finds mathematics difficult	X, who finds mathematics difficult, is **a boy**	a	X, who finds mathematics difficult, is **a girl**	(b)	b*	<u>a+b*</u> 2
usually a girl	strongly disagree	-2	strongly agree	(2)	-2	-2
a girl more often	disagree	-1	agree	(1)	-1	-1
no difference	disagree (or undecided)	-1	disagree (or undecided)	(-1)	1	0
a boy more often	agree	1	disagree	(-1)	1	1
usually a boy	strongly agree	2	strongly disagree	(-2)	2	2

*reversed score

The scale of this study meets the requirements of summative models. In the summative scaling of people respect to psychological traits it is assumed only that individual items are monotonically related to underlying traits and that a summation of item scores is approximately linearly related to the trait (Nunnally 1967, p. 604). The response format was based on probabilistic interpretations: it was assumed that e.g. the answer 'usually a girl' means that the respondent assigns a probability of about 90 % (i.e. from 80 % to 100 %) to X being a girl and respectively, a probability about 10 % to X being a boy. The percentages in Table 2 are only hypothethical and used in order to justify reversing and summing up the item scores. The scores (from –2 to 2) are linearly related to the middle of the probability intervals (10 %, 30, % ...).

Table 2. Probability interpretations of response categories.

X finds mathematics difficult

Probabilities		Girls or Boys?	Score
X is a boy	X is a girl	X is	
0-20 %	80-100 %	usually a girl	-2
20-40 %	60-80 %	girls more often	-1
40-60 %	40-60 %	no difference	0
60-80 %	20-40 %	boys more often	1
80-100 %	0-20 %	X is usually a boy	2

Participants and design of the study

The study was a survey. The test participants were Finnish mathematics teachers from a sample of 150 randomly chosen schools for grades 7-9 (13-15 year olds). In each school one female and one male mathematics teacher, if available, were asked to answer to a questionnaire. This was carried out in February 2000. The response rate was approximately 69%. One year later, in May 2001, ten of the respondents were interviewed.

Implementation

The goal of the factor analysis was to detect structure in teachers' beliefs about gender differences in mathematics. In the choice of the analysis method, principal component analysis vs. classical factor analysis was considered. In the former it is assumed that all variability in an item variable should be used in the analysis. In the latter only the variability in an item that it has in common with the other items is used, and it is assumed that the remaining variance of an item is its unique variance (Harman 1976, p.15). Furthermore, the theoretical background of gender beliefs did not suggest the latent factors to be uncorrelated, which directed the choice to an oblique rather than to an orthogonal reference system.

I started with the principal component analysis and then compared it to a classical factor analysis in which I extracted the results by the principal axis method with oblique rotation. Further I factor-analyzed the data with hierarchical principal axis method to divide the variability in the items orthogonaly into that due from shared or common variance (secondary factors) and unique variance due to the clusters of similar item variables.

It was not aimed to use all the items of the questionnaire but to choose the most relevant ones for the belief structure. The amount of items was reduced based on low communality (<0,35) in principal components and classical factor analysis (both methods yielded similar results). After three reiterations 31 items were left for the final analysis. Cattell's scree test and Kaiser criterion (Harman 1976, p.163) were used to determine the number of factors that best describe the data. The former supported five to seven factors and the latter nine factors. The six factor solution was chosen since it appeared to be very interpretable. Moreover the seven and eight factor models would not have raised markedly the accountability except on only one of the item variables. The six factors accounted for 47 % of the total variance.

RESULTS AND DISCUSSION

Both the principal components model and the hierarchical principal axis model with oblique factors represented similar "clusters" of item variables. Each of the obtained six factors determined a sum-scale of the items that loaded highest on that factor. These new variables, called belief dimensions, each representing one component in the belief structure, were taken to measure the direction and intensity of the beliefs about gender differences.

A positive value on a belief dimension indicated that the teacher associated the characteristics of the dimension to a boy more often than to a girl. A negative value indicated that a girl more often was mentioned having the characteristics. Value 0 was the score for no difference between boys and girls. A value 0 or near 0 was also obtained if the respondent gave contradictory answers e.g. "a girl more often" to *X are capable of higher mathematical thinking*" and "a boy more often" to *There are more mathematically talented among X.*

The mean score was negative for *Avoid using intelligence* -0.59 (sd 0.37) indicating a belief in a trait typical for girls. A positive mean score, indicating a feature addressed more often to a boy than to a girl, was found for *Teacher attention* 0.53 (sd 0.49), *Expectations of success* 0.44 (sd 0.37), and *Talent* 0.22 (sd 0.37). Smaller average differences were found on the dimensions *Lack of equity* 0.09 (sd 0.37) and *Work-orientation* –0.12 (sd 0.41). All these means differed statistically from the 'no difference' value zero.

The hierarchical principal axis analysis gave one secondary factor. All item variables of the primary factors *Avoid using intelligence* and *Talent* and one variable of the factor *Expectations of success* loaded on this secondary factor. Of these the item *"X is innately mathematically more talented"* had the highest loading. These results can be interpreted to reflect a core belief dimension *"Mathematics as a gendered domain"*. These three central belief dimensions are represented in Table 3.

Table 3. Examples of belief dimensions and their items.

Belief dimension	Number of Items	Cronbach's alpha
Avoid using intelligence	7	0.75
X's success in mathematics is more due to painstaking practice than to understanding. *X's success in mathematics is based on the use of intelligence and power of deduction. X leans on rote learning and does not even try to understand. X is better at routine tasks than at problem solving. *X can solve unfamiliar tasks. *X can solve by reasoning. *X can solve spatial problems.		
Talent	4	0.71
X passes the extended mathematics course more easily. X is innately mathematically more talented. X is capable of higher mathematical thinking. There are more mathematically talented among X.		
Teacher attention	5	0.65
I have to ask X to behave himself/herself during lesson. X interrupts unduly. *I should interact more often with X. *X is a silent hard worker. X constantly asks for teacher's help.		

*items marked with an asterisk were reversed

The validity of the scales refer to the validity of reported verbalized beliefs, which may not correlate highly with the behaviour pertaining to the belief. The validity is limited to what individuals know about their beliefs and are willing to relate. After a year had passed the reliability of the empirical data was examined by interviewing ten of the respondent. The persistence of the item responses was about 95 %. Also the interpretations of the item contents were confirmed in the interviews.

The instrument developed, the questionnaire with a new answering scale, seemed to be feasible and practical in measuring beliefs about gender differences. According to the interviews it was answered without much effort and maybe frankly as well. It still remains open how sufficient the verbal expressions alone are as evidence of beliefs.

The responding rate (69%) supported representativeness. The results and findings discussed in this paper can be generalized to include the wider population of all mathematics teachers in lower secondary schools in Finland.

The most emergent result of this study was the teachers' belief in girls employing inferior cognitive skills. The results of the factor analysis did not show any general belief factor that would affect all kinds of beliefs measured by the items. Nevertheless the results suggested a core belief dimension "Mathematics as a gendered domain". Is this a "primary belief" as Green (1971, p.44) defines i.e. a belief for which a person can give no further reason?

The results of this study are alarming if these beliefs of mathematics teachers - boys use their brain and girls are just hard workers - reinforce and sustain these differences.

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