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ABSTRACT

This study was conducted to examine the views of seventh-grade students in Finland with regard to the teaching and learning of mathematics. Data were gathered by a questionnaire survey, with follow-up interviews to validate response reliability. Fifty junior high school mathematics teachers in southern Finland were asked to present the questionnaire to their classes in order to get student response. Questionnaires were returned by 34 teachers; 514 students completed the questions. Results of percentage tables suggest that pupils have a pragmatic, calculation-centered, task-oriented view of mathematics; they emphasize process more than product; they stress rigorous working procedures and learning through practice; and they favor pupil-centered activities and small group learning. Students also expect the teacher to give them help and direction along with learning games. Five appendices include a copy of the student questionnaire and tabular responses to structured and open-ended questions, and responses to structured questions. (Contains 49 references.) (LL)

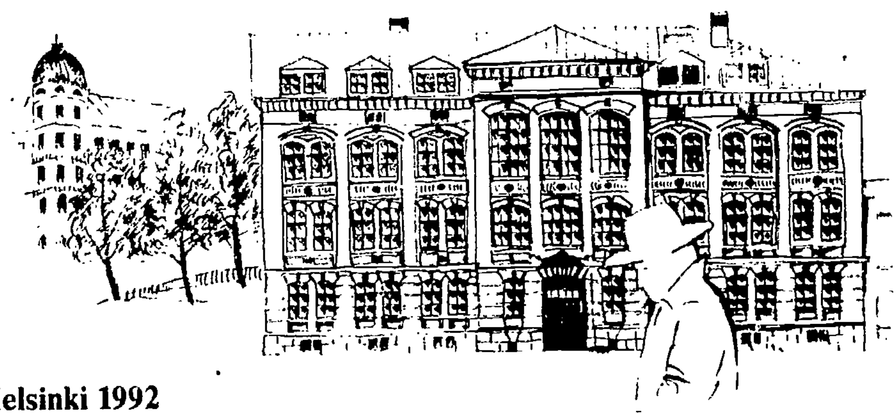
RESEARCH REPORT 108

Department of Teacher Education
University of Helsinki

Erkki Pehkonen

PROBLEM FIELDS IN MATHEMATICS TEACHING

Part 3: Views of Finnish seventh-grades about mathematics teaching



Helsinki 1992

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Research Report 108, 1992

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PROBLEM FIELDS IN MATHEMATICS TEACHING
Part 3: Views of Finnish seventh-grades about mathematics teaching.
66 pp. + 5 appendice

Abstract

The aim of this survey is to clarify the views and conceptions of Finnish seventh-graders concerning mathematics and mathematics teaching/learning.

The data was gathered by a questionnaire survey, additionally, some interviews were made in order to check the reliability of the responses. In the beginning of December 1988, the questionnaire was sent to a sample of mathematics teachers in junior high schools in Southern Finland. The questionnaires were sent to 50 teachers, and 34 teachers returned the completed questionnaires (N=514).

With the aid of percentage tables, we found that the pupils have a pragmatic, calculation-centered, and task-oriented view of mathematics. But additionally, they emphasized the process more than the product, and the importance of rigorous working procedures. In the view of learning/teaching mathematics, the pupils stressed understanding and learning through practice, and were in favour of pupil-centered active, but peaceful learning/teaching, sometimes also in small groups. They also expected the teacher to give them help and directionss, but on the other hand, they liked to have learning games.

The responses to the open questions concerning pupils' experiences and wishes were classified into six groups. Most answers were in the Teacher/teaching-, and Mathematical topics -categories. These made a grand total of from 65 % to 70 %. In addition, a significant percentage (more than 10 %) of the responses was in the class "Pupil" for experiences, and in the class "Interaction and working forms" for wishes.

Key words:
mathematics teaching, pupils' conceptions, seventh-graders

HELSINGIN YLIOPISTON
OPETTAJANKOULUTUSLAITOS

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Erkki Pehkonen

PROBLEEMAKENTÄT MATEMATIIKAN OPETUKSESSA
Osa 3: Suomalaisten seitsemäsluokkalaisten näkemyksiä matematiikan opetuksesta. 66 s + 5 liitesivua

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Tiivistelmä

Tämän tutkimuksen päämääränä on selvittää suomalaisten seitsemäsluokkalaisten näkemyksiä ja käsityksiä matematiikasta ja matematiikan opettamisesta/oppimisesta.

Tieto kerättiin kyselylomakkeella, lisäksi tehtiin joitakin haastatteluja, joilla tarkistettiin vastausten luotettavuutta. Joulukuun 1988 alussa kyselyt lähetettiin joukolle peruskoulun yläasteen matematiikan opettajia Etelä-Suomessa. Kyselylomakkeet lähetettiin 50 opettajalle, joista 34 opettajaa palautti täytetyt kyselyt (siis N=514).

Prosenttitaulukoita käyttäen havaittiin, että oppilailla on pragmaattinen, laskemiskeskeinen ja tehtäväorientoitunut kuva matematiikasta. Mutta lisäksi he painottavat enemmän prosessia kuin produktia ja tarkkojen työskentelymenetelmien tärkeyttä. Kuvassaan matematiikan opettamisesta/oppimisesta oppilaat korostavat ymmärtämistä ja harjoittelun kautta oppimista sekä suosivat oppilaskeskeistä aktiivia, mutta rauhallista opettamista/oppimista, joskus myös pienissä ryhmissä. He odottavat myös, että opettaja auttaa heitä ja antaa ohjeita, mutta toisaalta pitävät myös oppimispeleistä.

Oppilaiden kokemuksiin ja toivomuksiin liittyvien avoimien kysymysten vastaukset luokiteltiin kuuteen luokkaan. Useimmat vastaukset olivat Opettaja/opettaminen- ja Matemaattiset sisällöt-luokissa; niitä oli yhteensä noin 65–70 %. Lisäksi merkittävä osa vastauksista (enemmän kuin 10 %) oli luokassa "Oppilas" kokemusten kohdalla, ja luokassa "Interaktio ja työskentelymuodot" toivomusten kohdalla.

Avainsanat:
matematiikanopetus, oppilaiden käsitykset, 7-luokkalaiset

Preface

The idea of such a survey has its roots in discussions with Bernd Zimmermann (University of Hamburg). During the years 1986-87, we were developed a common research project which was partly realized in the form of "Open Tasks in Mathematics" (Pehkonen & Zimmermann 1989, 1990). This survey forms part of the background studies for the research project, and sketches pupils' views and conceptions of mathematics and mathematics teaching in Finland. The corresponding survey about views of German (Hamburg) pupils forms part of Zimmermann's Habilitation-work (1991).

I would again like to thank all the teachers and pupils who have answered my questionnaires. Without their cooperation, the survey could not have been realized. Last Autumn, I visited University of Georgia (Athens, Ga/USA), for three months and had fruitful discussions with many people. Especially Prof. João Pedro Ponte (University of Lisbon) who was also visiting Athens (Ga) for the same academic quarter influenced me much. I am very thankful for the many ideas and solutions he suggested to be made to my uncompleted manuscript about pupils' mathematical views.

I would express my thanks to the Head of the Department of Teacher Education at the University of Helsinki Prof. Irina Koskinen for allowing my survey to be published in the Research Report -series. Also I would like to thank Prof. Jarkko Leino for kindly reading my manuscript and for the many valuable comments he made. I also thank Arja Wahlstedt who has been a valuable helping hand when dealing with the huge amount of information. The careful checking of my "dictionary English" was done by Donald Smart (University of Helsinki); I am very grateful for his help.

This study was began during my free year 1988-89 from my teaching duties as lecturer in mathematics education at the Department of Teacher Education at the University of Helsinki. The work was then continued and completed during a three-year period I served as a senior researcher at the Finnish Academy, my office being all the time in the Department of Teacher Education. I am very grateful to the Finnish Academy for its financial support of my research.

Helsinki, June 1992

Erkki Pehkonen

Contents

1. Rationale and background

Within a constructivism framework (e.g. Davis & al. (eds.) 1990) as a base for teaching and learning mathematics, it is found that a knowledge of teachers' and pupils' mathematical beliefs is vital if their mathematical behaviour is to be understood (e.g. Noddings 1990, 14). Over the last decade, many studies on the belief systems of teachers and pupils have been undertaken (e.g. Thompson 1984, Cooney 1985, Frank 1985, Schoenfeld 1985, 1989, Grouws & al. 1990, Kaplan 1991, Zimmermann 1991). Especially in the United States, many tens of dissertations have been written on the topic (see e.g. the list of references in the following dissertations: Jones 1990, Wilson 1992). Underhill (1988a, 1988b) has compiled a review of research results on both teachers' and pupils' beliefs. In the review of teachers' beliefs by Thompson (1992), as well as in the reviews of McLeod (1989, 246-248; 1992, 578-581) about affect in mathematics education, one can find more information on the research results.

Research has revealed that knowing the right facts, i.e. algorithms and procedures, does not necessarily guarantee success in solving mathematical problems. There are other factors – such as decisions made by the solver and the strategies he uses, as well as his emotional state at the time he is solving mathematical tasks – which have a major effect on the performance of a solver (Schoenfeld 1985, Garofalo 1989). "Purely cognitive" behaviour is rare. Belief systems shape cognition, even though some people may not be consciously aware of their beliefs (Schoenfeld 1985, 35). Conceptions and views pertain both to the domain of beliefs.

1.1. Beliefs and belief systems

Interest in beliefs and belief systems started mainly in the 1970's through the developments in cognitive science. But the basis of these ideas were first developed in social psychology. Although beliefs are popular as a topic for study, the theoretical concept of 'belief' has not yet been dealt with thoroughly. The main difficulty has been the inability distinguishing between beliefs and knowledge. This difficulty has not yet been clarified (e.g. Abelson 1979, Thompson 1992). Some researchers have argued that it is not important to distinguish between knowledge and beliefs, but rather to find out how belief/knowledge systems affect teachers' and pupils' behaviour in mathematics classes (Thompson 1992, 129).

Beliefs and knowledge

A consequence of its vague definition is that many researchers have formulated their own definition for 'belief'. For example Schoenfeld (1985, 45) states, in order to give a first rough impression, that "belief systems are one's mathematical world view". He later modifies this definition, describing the belief system as conceptions of the nature of mathematics. Hart (1989, 44), influenced among others by Schoenfeld's (1985) ideas, uses the word belief to represent a certain type of assessment pertaining to a group of conceptions. Lester & al. (1989, 77) explain that "beliefs constitute the individual's subjective knowledge about self, mathematics, problem solving, and the topics dealt with in problem statements". Whereas Thompson (1992, 130) understands beliefs as a subclass of conceptions. Yet another different explanation is given by Bassarear (1989) who sees attitudes and beliefs on the opposite poles of a bipolar dimension.

Here, we understand beliefs as rather stable conceptions of a certain object or concern to which there can not be found any tenable ground in objective considerations. The notion of belief system is a metaphor used for describing how one's beliefs are organized (Green 1971).

When discussing teachers' beliefs in the light of research results, Thompson (1992, 129) states that distinctions between knowledge and beliefs are fuzzy (Fig. 1.1), because of their close connections. Fennema & Loef (1992) discussed the meaning of teachers' knowledge, and pointed out that one could not separate the impact of beliefs from that of knowledge.

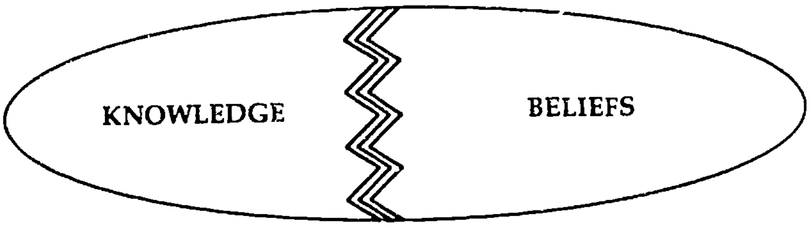

Fig. 1.1. Distinctions between knowledge and beliefs are fuzzy.

Skemp (1979, 30) tried to clear up the problem of distinguishing between knowledge and beliefs, as follows: "Knowledge is the name we give to conceptual structures built from and tested against our own experiences of actuality. Beliefs are what we have accepted as facts for other reasons. These are frequently used in combination as the basis for the functioning of a director system."

Abelson (1979, 356-360) discussed a number of features which in practice seem to differentiate beliefs and belief systems from knowledge and knowledge systems. Some of them will be briefly dealt with here: (1) One feature of beliefs is that they are not necessarily held in consensus with other beliefs. So, one could have beliefs which contradict other beliefs held at the same time. Additionally, the believer is usually aware that others may have different beliefs. Whereas one important feature of knowledge is that it cannot contain contradictions. (2) Belief systems rely heavily on evaluative and affective components. A belief system typically has large categories of concepts which are grouped into "good" and "bad". As a typical example, those who support socalled "green values", also usually believe that nuclear power is bad, materialism and waste are bad, natural alternative energy sources are good, re-cycling is good etc. (3) Beliefs can be held with varying degrees of conviction. "The believer can be passionately committed to a point of view, or at the other extreme could regard a state of affairs as more probable than not ... This dimension of variation is absent from knowledge systems. One would not say that one knew a fact strongly." (ibid 360)

The three dimensions of belief systems developed by Green (1971, 46-48) explain some structural differences between belief systems and knowledge systems: (1) Knowledge systems are formed logically from premises and from conclusions made of them. Whereas the relationships between beliefs cannot be said to be logical, since beliefs are arranged according to how the believer himself sees the connections between them. So, each belief system has a structure which is called quasi-logical, with some primary beliefs and some derivative beliefs. (2) The dimension of psychological centrality is lacking in knowledge systems. It cannot be said that somebody knows some subject strongly. Whereas beliefs have their psychological strength, i.e. the degree of conviction with which beliefs are held. The most central beliefs are held most strongly, whereas the peripheral ones may be changed easier. (3) Beliefs are held in clusters which do not necessarily connect with each other. This cluster structure enables one to hold even conflicting beliefs in one's belief system. The clustering property may help to explain some inconsistencies found in an individual's belief system.

What are views?

Beliefs and belief systems are affected by the way people understand themselves and their surroundings. Belief systems can be seen to be developed from simple perceptual beliefs or authority beliefs – via new beliefs, expectations, conceptions, opinions and convictions – to a general conception of life (Saari 1983, 31-32). Thus, e.g. conceptions are higher order beliefs. They are based on reasoning processes for which the premises are conscious. Therefore, conceptions can be seen to have grounds, at least they are for the person himself justified and accepted.

Views are very near conceptions, but they are more spontaneous, and an affective component is more emphasized in them. Conceptions are more considered than views, and a cognitive component will be more stressed in them. Wishes are very near expectations, and expectations are simple beliefs that can be traced back to perceptual experiences. Apart from perceptual experiences, the source of simple beliefs can be some outside authority.

The role of beliefs in the learning of mathematics

The central position of beliefs for the successful learning of mathematics has been pointed out by many mathematics educators. Baroody & Ginsburg (1990, 62) state that beliefs can have a powerful impact on how children learn and use mathematics. Both Schoenfeld (1985) and Silver (1985) have pointed out that pupils' beliefs about mathematics may form an obstacle to solving nonroutine problems and to effective mathematics learning. Also Borasi (1990, 181) stresses that pupils who have rigid and negative beliefs of mathematics and its learning easily become passive learners, who emphasize more remembering than understanding in learning.

In her dissertation, Frank (1985, 78) introduced a schematic picture of some factors affecting on pupils' problem solving behaviour. Since most of the factors act via pupils' belief systems, her scheme has been reorganized here to take this into consideration (Fig. 1.2).

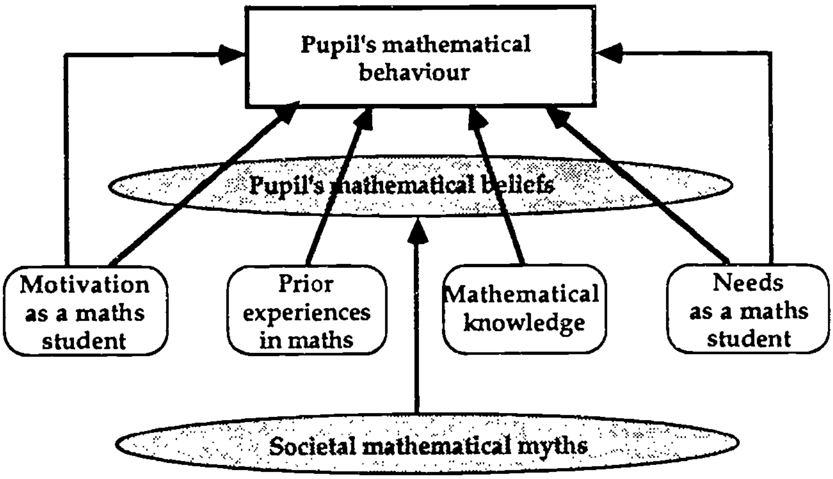

Fig. 1.2. Factors affecting pupils' mathematical behaviour.

Pupil's mathematical beliefs act as a filter which influence almost all his thoughts and actions concerning mathematics. A pupil's prior experiences of mathematics affect fully at the level of his beliefs – usually unconciously. His mathematical knowledge acts also via the filter of his belief system. In contrast to this, pupil's motivation and needs as a learner of mathematics are not always connected with his mathematical beliefs. Additionally, there are some societal mathematical myths, e.g. boys are better than girls in mathematics (for more myths see e.g. Paulos 1992), which also influence pupil's mathematical behaviour via his belief system.

Some research into pupils' beliefs

In the investigation of beliefs, one should naturally differentiate between the viewpoints of pupils and teachers. In classifying pupils' beliefs, several categorizations have been used.

The most common seems to be the use of two groups: Beliefs about mathematics and its learning/teaching, and beliefs about oneself e.g. as a learner (Schoenfeld 1987, Garofalo 1987, McLeod 1989). Whereas Underhill (1988a) has grouped the results in four categories: beliefs about mathematics, beliefs about mathematics learning, beliefs about mathematics teaching, and beliefs about the social context. In her dissertation, Frank (1985, also 1988) classified the beliefs she perceived into five categories: beliefs about one's ability to do mathematics, beliefs about mathematics as a discipline, beliefs about where mathematical knowledge comes from, beliefs about solving mathematical problems, and beliefs about how mathematics is taught and learned.

Frank (1985) noticed that each type of the above mentioned beliefs influenced pupil's problem solving behaviour. Her subjects were 27 mathematically talented junior high school pupils. They were participating in Purdue University's two-week intensive program on problem solving with computers. Fifteen pupils of them were observed daily. Four of them were individually interviewed for at least four hours. In the interviews, the pupils were questioned about their classroom experiences in mathematics and were encouraged to discuss their beliefs about mathematics. Most of the interview time was spent with the pupils using the "think-aloud" technique to solve problems.

Schoenfeld (1989) surveyed 230 mathematics pupils (grades 10-12) using a questionnaire which contained 70 closed and 11 open questions. The results he advanced suggest that the pupils were motivated and they worked hard on mathematics, but problem solving seemed to be only rhetorical for them. Their answers revealed e.g. the following beliefs about mathematics: Any problem that fails to be solved in 12 minutes of work will be impossible for them to solve. Mathematics is best learned by memorization.

Zimmermann (1991) used the same questionnaire as this study, and he surveyed 2658 pupils in grades 6–9 mixed together and their 85 teachers. His aim was to relate pupils' conceptions with teachers' responses to similar statements. Using cluster analysis, he found six pupil groups and five teacher groups, and noticed a certain correspondence between two pairs of them: Problem Orientation and Schema Orientation (cf. section 2.2 of this paper).

Stodolsky & al. (1991) compared pupils' attitudes and conceptions about learning mathematics and social studies, through interviewing 60 fifth graders. Among many other results, they reached a view of mathematics through the eyes of fifth-graders. In the interview, pupils were asked to define mathematics. The majority of pupils described it in terms of the basic arithmetic operations and manipulating numbers. Beyond basic operations, about 30 percent of fifth-graders mentioned fractions and decimals. A smaller number of responses defined mathematics as measuring, doing problems, geometry, counting, and telling the time. (ibid 96-97)

One important area of research on beliefs which has not yet been discussed here concerns gender-related differences. Fennema (1989, 211) notes that, in general, males report higher perceived usefulness of mathematics than females. Another affective variable that she raises from research is confidence: Males seem to be more confident in their ability to learn mathematics than females. Connections of confidence on the ability to solve nonroutine problems is obvious. In the review of gender variables by Leder (1992), one can find more information on the research results.

1.2. The aim of the survey

This survey is part of the background studies for the research project "Open Tasks in Mathematics" (Pehkonen & Zimmermann 1989, 1990), and concerns pupils' views and conceptions on mathematics and mathematics learning/teaching. Teachers' conceptions have been dealt with in earlier reports (Pehkonen 1991, 1992). When we are trying to influence the actual learning situations in classrooms, we naturally also ought to know, what pupils are thinking about mathematics teaching. To do this we need to keep in mind all the time the expectations and conceptions pupils have of mathematics teaching.

The theoretical background of the research project has been discussed in large in the first part of the research reports (Pehkonen & Zimmermann 1990). Therefore, it will not be dealt with here.

Who are seventh graders?

In Finland, we have a nine-year comprehensive school system where pupils move after the primary level (grades 1-6; age 7–12 years) to the upper level (grades 7-9, age 13-15 years) of a comprehensive school. At primary level, pupils do not have individual subject teachers, their class teacher usually teaches every subject, including mathematics, in the class – only the foreign language teaching forms an expection. But in the higher school levels (from grade 7), there is the subject teacher system. In this survey, the experiences of test subjects (seventh-graders) are mostly based on the impressions they formed at the primary level.

Why have we selected just seventh graders (age 13 years)? According to educational psychology (e.g. Good & Brophy 1977, 309-311), children at this age are in the transition phase from the (Piagetian) stage of concrete operations to the stage of formal operations. They are developed enough to be critical in the way they perceive the world outside, e.g. the way mathematics is taught to them. Another reason for choosing these pupils is that mathematics teaching in the first six school years emphasizes numbers and basic calculations done with them (arithmetic), and the teaching of more symbolic mathematics (algebra) does not start before the seventh grade.

2. Realization of the survey

The theoretical framework for the survey is the constructivist learning theory (e.g. Davis & al. (eds.) 1990), according to which learning happens in each learner's mind, and at least a part of the new knowledge structure will be constructed by the learner himself. The way the learner acts and thinks during the learning process will be strongly affected by his belief system (Fig. 1.2). Therefore, it is most important for the teacher to know what pupils are thinking about the subject to be learned and what kind of previous knowledge (preconceptions) they have. The knowledge of pupils' preconceptions and beliefs about mathematics teaching forms a necessary base for the teacher's decisions of organizing classroom teaching.

2.1. Research problems

The aim of this survey is to clarify the views and conceptions of Finnish seventh-graders concerning mathematics and mathematics learning/teaching. The following research problems can be derived from the aim of the survey:

(1) What are pupils' views of mathematics teaching?

(2) What kind of experiences (good and bad) and wishes do pupils have about mathematics teaching?

(3) Are there any differences for these two questions between boys and girls?

2.2. Questionnaire

The questionnaire[1] used (Appendix 1) was developed for the research project "Open Tasks in Mathematics" (cf. Pehkonen & Zimmermann 1990, 83-85). Its purpose was to clarify pupils' conceptions of mathematics teaching as well as their experiences and wishes about mathematics teaching.

In the questionnaire, there are 32 structured items about mathematics teaching, i.e. statements for which the pupils were asked to rate their views on a 5-step scale (Appendix 1). At the end of the questionnaire, there were two open questions. The first one enquired into the pupils' good and bad experiences of mathematics teaching. The other one was concerned with their wishes for mathematics teaching.

Structure of the questionnaire

To structure the questionnaire, we used a modification of Underhill's (1988a) grouping. The statements of the questionnaire (Appendix 1) are classified[2] into three types of views:

- view of mathematics (1,2,3,5,6,9,10,14,16,17,19,20,21,22,23,24,28),
- view of learning mathematics (11,12,18,29,30),
- view of teaching mathematics (4,7,8,13,15,25,26,27,31,32).

The first and third category can be naturally divided into two parts: In the view of mathematics, one can separate mathematical contents (1, 3, 6, 9, 14, 17, 19, 22, 28) and the way of doing mathematics (2, 5, 10, 16, 20, 21, 23, 24). The view of mathematics teaching can be considered from the point of pupils' involvement (4, 7, 8, 13, 27, 31) and from the point of teacher's involvement (15, 25, 26, 32).

[1] Bernd Zimmermann (Hamburg) developed the questionnaire.

[2] The author made this classification in cooperation with Klara Tompa (Budapest).

In his work, Zimmermann (1991, 76–77) used another way of grouping the statements. He described some domains of emphasis in mathematics teaching, and thus ordered the 32 statements into the following eight groups: (1) mathematical contents (1, 3, 6, 9, 22), (2) mathematical rigor (5, 16), (3) problem orientation (4, 13, 24, 25, 31), (4) schema orientation (2, 7, 10, 12, 17, 29), (5) pupil's self-concept (20, 21, 23, 27, 30), (6) pupil's teacher-concept (8, 15, 18, 26, 32), (7) controlled–pragmatic (14, 19), and (8) comprehensive school domain (11, 28). Additionally, he pointed out that the groups are not isolated, but there was some overlap between them.

2.3. Practical realization of the survey

In the beginning of December 1988, the questionnaire was sent to a sample of mathematics teachers in junior high school in Southern Finland. Within the two last years, these teachers had participated in one of the in-service courses (two school days) run by the author. The theme for these courses has been "Open and Active Teaching Methods", and the topics included were learning games, geometrical activities and problem solving. Since participation in courses is voluntary, it can be thought to be extremely likely that the participants would be eager to let their pupils fill in the questionnaires.

In the enclosed letter, the teachers were asked – if they were teaching a class of grade 7 – to deliver the questionnaire (Appendix 1) to their class, in order to have them filled. They were asked to return them the before January 15, 1989. They were sent a total of 50 teachers, and 34 teachers returned the filled questionnaires. Since the return precentage was rather high (68 %), no follow-up surveys were undertaken. Altogether 534 questionnaires were returned, but

20 of them were only filled partly. So, the number of completed questionnaires was N=514, where 260 questionnaires were from boys and 254 from girls.

Statistics used

In discussing the results, it is very natural to separate the structured questions (statements 1-32 in the questionnaire, cf. Appendix 1)) and the three open items (questions 2a, 2b and 3) about pupils' experiences and wishes.

When considering the results of the questionnaire, the statistics used were mainly percentage tables, and means and standard deviations of items. Although the data collected is on the level of ordinal scale, the use of interval-scale-statistics, e.g. the analysis of means, may give some useful information. The structure of the questionnaire described in section 2.2 gives an opportunity to say something about pupils' views. An attempt was using factor analysis to sketch out the beliefs behind the explicit views given in the questionnaires.

The responses to the open questions are classified according to a certain category system (Appendix 2). The description of results was made at the level of percentage distributions, and contained a large variety of pupils' responses. The StatView-program on the MacIntosh computer was used for the analysis.

The reliability of results was estimated with the test-halfing-method. Another measure for reliability was obtained from the communalities of the factor analysis. Additionally, some pupils (N = 18) were interviewed, in order to assess the stability of their responses. The permanence of classification for responses to open questions was checked by parallel classification.

3. Responses to the structured questions

Firstly, we will consider the results generally (3.1), and then try to form an approximation of pupils' views (3.2). Secondly, we will focus on differences and similarities in means between boys and girls (3.3). Then the structure gained through factor analysis will be discussed (3.4). In Appendix 3, there are given some basic statistics for both samples – boys and girls: These are the percentages per-item as well as the means, and standard deviations of the frequencies. Additionally, there are t-values for the differences of the means between boys and girls with the level of significance.

3.1. General look at the responses

Fig. 3.1 gives an overall picture of the means and standard deviations of all responses per-item (cf. Appendix 3). The scale was

1 = fully agree , ... , 5 = fully disagree .

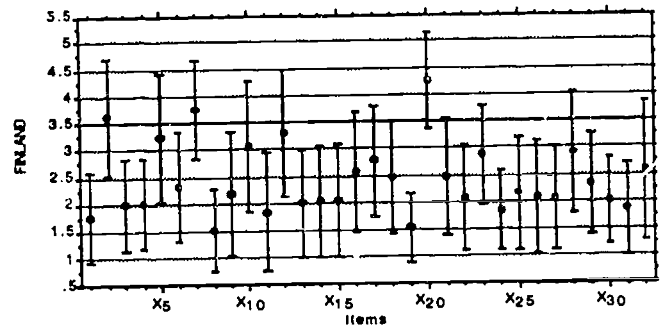

Fig. 3.1. The distribution of means with their standard deviations (1 = fully agree , ... , 5 = fully disagree).

For those agreeing, there are 22 means, i.e. the respondents agreed with two-thirds of the statements. Most of the remaining respondents had a neutral attitude, i.e. the means lie in the interval 2.5...3.5. The pupils only disagreed with three statements. It seems that the statements were too easily agreed with.

The standard deviations varied around 1.0. In both samples (boys and girls) however, they do not differ very much from each other within an item: The differences of the standard deviations between boys and girls are in absolute value typically 0.1. The largest difference is 0.2 – in seven items.

Grouping according to the means

In order to see how the means of the responses for the statements 1–32 are distributed, the means (M) are classified with an interval of half a unit (Table 3.2). Here, the bold type indicates that the mean of the item is not on the same interval in both samples, and the boxes represent agreed, neutral, and disagreed statements.

mean	boys	girls
$1.0 \leq M < 1.5$	-	**8**
$1.5 \leq M < 2.0$	1,4,8,11,**14**,19,22,24,**25**,27,31	1,4,11,19,22,24,27,31
$2.0 \leq M < 2.5$	3,6,9,13,15,16,18,26,29,30,**32**	3,6,9,13,**14**,15,16,18,**21**,**25**,26,29,30
$2.5 \leq M < 3.0$	10,17,**21**,23,28	10,17,23,28,**32**
$3.0 \leq M < 3.5$	5,12	5,12
$3.5 \leq M < 4.0$	2,7	2,7
$4.0 \leq M < 4.5$	20	20
$4.5 \leq M \leq 5.0$	-	-

Table 3.2. Distribution of the means for boys and girls; the bold type represents the difference (1 = fully agree , ... , 5 = fully disagree).

The consensus in the responses of boys and girls is almost 100 %.

Only in five statements (8, 14, 21, 25, 32), the means are not on the same interval; but also in these cases, the differences were not very large (≤ 0.2). In Appendix 3, one can see that the differences within a class in Table 3.2 are often larger than in the above mentioned statements. So, the means of the boys' and the girls' responses are similarly divided.

The most agreed statements

In Table 3.3, there is given a "top ten"-list of the statements. Only in these nine statements, the means are less than 2.00.

8: strict discipline	M = 1.44
19: the idea that studying mathematics has practical benefits	M = 1.60
11: the idea that all pupils understand	M = 1.64
1: doing calculations mentally	M = 1.73
22: calculations of areas and volumes	M = 1.86
27: pupils are led to solve problems independently	M = 1.86
31: the idea that also sometimes pupils are working in small groups	M = 1.86
24: the idea that there are usually more than one way to solve problems	M = 1.90
25: games can be used to help pupils learn mathematics	M = 1.98

Table 3.3. The lowest means, i.e. the statements which are most agreed with.

The most important factors for the pupils seem to be good discipline, and practical benefit of mathematics studied. The emphasis on strict discipline probably reflects the classroom situation in some schools where there might be problems in maintaining peaceful teaching/learning conditions. The pragmatic viewpoint of mathematics learning may reflect the calculation-centered teaching reality which is a consequence of the low amount of mathematics lessons in comprehensive schools (grades 1–9; age 7–15 years).

In the next place, the pupils demand that all understand what is taught, and stress mental calculation. The demand for understanding is very human, since in reality mathematics teaching strive more for formal knowledge than understanding. Mental calculations are somehow thought to be a part of mathematics teaching.

In the fifth, sixth and seventh places, the pupils put calculating areas and volumes, solving problems independently, and working in small groups. The calculation of areas and volumes are such distinctive topics that pupils automatically see them as an essential part of real mathematics teaching. It is natural for children to work together, and they like to work independently. So it is not surprising that they would like to continue both these modes of working in their mathematics lessons.

Additionally, the pupils stressed the idea that there are usually more than one way to solve problems, and they put forward the importance of using games to help them learn mathematics. The pupils have discovered that there are many different ways to solve a problem, and would like to use them. Games offer pupils more freedom in learning.

3.2. A first approximation of pupils' views

The grouping base that will be used in the analysis of the statements of the questionnaire will be the tri-division described in section 2.2, i.e. view of mathematics, view of learning mathematics, view of teaching mathematics. We shall approach the problem in the following manner: If the mean of the responses for a statement lies on the interval 1.0…2.5 (interval 2.5…3.5 and resp. interval 3.5…5.0), we will say that pupils agree (are neutral and resp. disagree) with the statement.

The statements with which the pupils disagreed can be converted through logical negation. The mean of a converted statement will be 6-M, and the conversion will be noted with an apostrophe, e.g. from statement 20 with M=4.15, we will get statement 20′ with M′=1.85.

Since the means of the boys' and the girls' responses are similarly distributed (Table 3.2), we will use their common means. The small differences found in responses will first be put aside, and dealt with later on.

Pupils' view of mathematics

Mathematical content. Firstly, we will consider the content part in the view of mathematics, which consists of 9 items (Fig. 3.4):

1= doing calculations mentally (M=1.73);
3= doing computations with paper and pencil (M=2.29);
6= drawing figures (M=2.20);
9= doing word problems (M=2.01);
14= use of calculator (M=2.00);
17= different topics, such as calculation of percentages, geometry, algebra, will be taught and learned separately (M=2.57);
19= studying mathematics has practical benefits (M=1.60);
22= calculations of areas and volumes (M=1.86);
28= the constructing of different concrete objects and working with them (M=2.73)

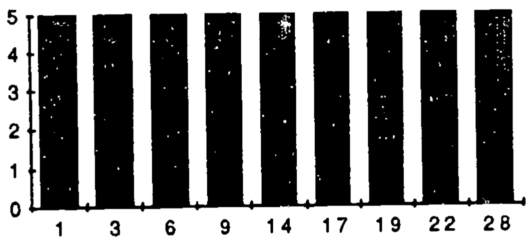

Fig. 3.4. Pupils' view of mathematics (mathematical content).

The pupils agreed with the items 1, 3, 6, 9, 14, 19, 22, and took a neutral attitude to the items 17, 28, but all the means of the items were under 3.00 (i.e. in agreement part of the scale). Summarizing the results in the component of mathematical content, we get the following: The statements with which pupils agreed give a pragmatic (19), calculation-centered (1, 3, 14, 22), and task-oriented (6, 9) view of mathematics. Pupils took a neutral attitude to statements which argued for splitting mathematics into its component parts (17) and for concrete working practices (28).

Way of doing mathematics. In the component of doing mathematics, there are 8 items (Fig. 3.5):

2= getting the right answer is always more important than the way of solving the problem (M=3.77);
5= everything ought to be expressed always as exactly as possible (M=3.11);
10= there is always some procedure which one ought to exactly follow in order to get the result (M=2.77);
16= everything will always be reasoned exactly (M=2.39);
20= only the mathematically talented pupils can solve most of the problems (M=4.15);
21= studying mathematics could not always be fun (M=2.39);
23= studying mathematics requires a lot of effort by pupils (M=2.85);
24= there are usually more than one way to solve problems (M=1.90).

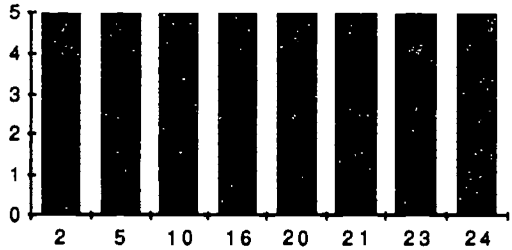

Fig. 3.5. Pupils' view of mathematics (doing mathematics).

Pupils agreed with the items 16, 21, 24, disagreed with the items 2, 20, and took a neutral attitude to the items 5, 10, 23. If we convert the statements with which the pupils disagreed, we obtain two more 'agreed' statements (2', 20'). Summarizing the component of doing mathematics, we can state the following: The pupils agreed with two statements (2',24) which emphasize the process instead of the product, and with two statements (16, 21) stressing rigor work. Additionally, the pupils do not see school mathematics to be too complicated (20'). They took a neutral attitude to statements which emphasize exact and hard work (5, 23), and which stress their belief in the existence of "the right procedure" (10).

Pupils' view of learning mathematics

In the group of learning mathematics, there are five items from the questionnaire (Fig. 3.6):

11= all pupils understand (M=1.64);
12= much will be learned by memorizing rules (M=3.24);
18= there will be as much repetition as possible (M=2.30);
29= there will be as much practice as possible (M=2.10);
30= all or as much as the pupil is capable of will be understood (M=2.00).

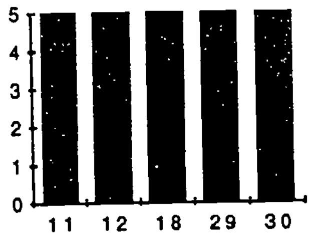

Fig. 3.6. Pupils' view of learning mathematics.

The pupils agreed with the items 11, 18, 29, 30, and took a neutral attitude to item 12. Summarizing, the statements with which the pupils agreed are stressing understanding (11, 30) and learning via practice (18, 29). They took a neutral attitude to the statement which emphasizes learning-by-heart (12).

Pupils' view of teaching mathematics

Pupils' involvement. In the component of pupils' involvement, there are 6 statements (Fig. 3.7):

4= the pupil can sometimes make guesses and use trial and error (M=1.87);

7= one ought to get always the right answer very quickly (M=3.70);
8= strict discipline (M=1.44);
13= pupils can put forward their own questions and problems for the class to consider (M=2.06);
27= pupils are led to solve problems on their own without help from the teacher (M=1.86);
31= also sometimes pupils are working in small groups (M=1.86).

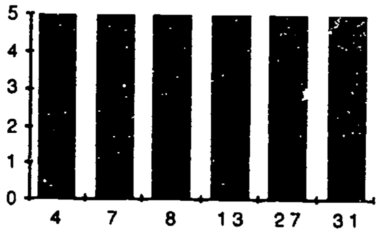

Fig. 3.7. Pupils' view of teaching mathematics (pupils' involvement).

Pupils agreed with the items 4, 8, 13, 27, 31, and disagreed with item 7. If we convert the statement with which the pupils disagreed, we get one more agreed statement (7'). Summarizing, the pupils agreed with statements emphasizing pupil-centred active teaching/learning (4, 13, 27), and with statements stressing peaceful teaching/learning, sometimes also in small groups (7', 8, 31).

Teachers' involvement. In the component of teacher's involvement, there are 4 statements (Fig. 3.8):

15= the teacher helps as soon as possible when there are difficulties (M=2.01);
25= games can be used to help pupils learn mathematics (M=1.98);
26= when solving problems, the teacher explains every stage exactly (M=2.01);
32= the teacher always tells the pupils exactly what they ought to do (M=2.42).

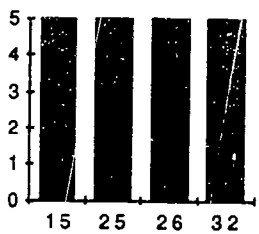

Fig. 3.8. Pupils' views of teaching mathematics (teachers' involvement).

The pupils agreed with all items of 15, 25, 26, 32. Summarizing, in the component of teachers' involvement, the statements support a view of teaching mathematics where the teacher should give help and directions to the pupils (15, 26, 32). Additionally, they agree with a statement which gives a more open view of teaching, using learning games (25).

3.3. Differences in means between boys and girls

Next, we will deal with the differences of the means between the results of boys and girls. In 12 items, the boys' mean is higher than the girls' one, but the situation is reversed for 20 items. As a whole, the boys agreed more with the statements than the girls (Appendix 3). But as earlier stated, the views of boys and girls are very similar, since the largest differences of the means are in absolute value not more than 0.32. The difference of the means was statistically significant in nine items (2, 7, 10, 14, 20, 21, 22, 28, 32).

Items with significant difference

In eight items, the boys agreed more with the statement than the girls. Only in item 21 (it could not always be fun), the difference was positive and statistically almost significant (*). It looks like that girls are more ready to work seriously with mathematics than boys.

In item 10 (there is always some procedure which to follow), the difference of the means was very significant (***). Is it that boys believe more than girls in the existence of some universally applicable algorithms, or could this difference be explained by the fact that women generally apply more creative approaches to problem solving than men?

The girls disagreed more strongly than the boys with the statement that only the mathematically talented pupils can solve problems (20). In this item, the difference of the means was statistically significant (**). Could this result be explained also by the above mentioned difference in creativity?

In the following items, the boys agreed mor strongly than the girls with the statement, and the difference of the means was almost significant (*): the right answer is more important than the way of solving (2), one ought to get the right answer quickly (7), use of calculators (14), calculation of areas and volumes (22), constructing concrete objects (28), and the teacher tells exactly what to do (32). It seems that the boys are more accomplishment-centered (2,7), and need to be directed (32) more than the girls. But on the other hand, the boys are lazier (14) than the girls. The accomplishment-centeredness and the need to be supervised are closely connected with laziness, boys are not willing to do extra and voluntary work (thinking) in school when they are not motivated. Additionally, the boys are more in favour of geometry (22, 28) than the girls. The boys' preference for geometry could be explained by the well-known fact that boys are better than girls in spatial tasks.

Using the structure of the questionnaire

Here, we will discuss the responses of the structured items with the aid of the grouping used by Zimmermann (1991, 76-77). Through computing the means of each eight groups (section 2.2) and applying the t-test, we get Table 3.9.

In the group Schema Orientation (Table 3.9), the difference of the means is statistically significant (**). So, the boys seem to think more schematic than the girls. Also in the group Controlled-Pragmatic, there is a statistically almost significant (*) difference.

	boys	girls	t-value	sign.
(1) mathematical contents	2.00	2.06	-1.68	-
(2) mathematical rigor	2.76	2.74	0.21	-
(3) problem orientation	1.93	1.94	-0.43	-
(4) schema orientation	2.96	3.08	-2.90	** (0.4 %)
(5) pupils' self-concept	2.65	2.65	0.09	-
(6) pupil's teacher-concept	2.03	2.05	-0.52	-
(7) controlled-pragmatic	1.74	1.86	-2.20	* (3 %)
(8) comprehensive school domain	2.13	2.24	-1.62	-

Table 3.9. The means of the boys and the girls, and the statistical significancy of their difference with the error percentages.

Next, we will look at how the nine statements with statistically significant differences just discussed are situated in the structure of the questionnaire described by Zimmermann (1991). In the group Schema Orientation, there are three items (2, 7,10) of nine, and the difference was negative in each. The other six items with a significant difference were scattered all around. Only in the groups Mathematical Rigor and Problem Orientation, there were no such items. So, this confirms the results we have just discussed.

3.4. Factor analysis reveals

As there were quite a substantial number of statements in the questionnaire, it was thought wise to make their interpretation as compact as possible using factor analysis. An additional advantage of the factor solution is that it structures the questionnaire with the pupils' responses as a basis, i.e. in the sense of the constructivism.

Factorization

The use of the scree-test in factorization gives a solution of 11 factors. In Appendix 4, there is given the orthogonally rotated factor matrix. According to the common usage, the loadings are rounded to the nearest two decimal value, and the decimal point is left away.

In the interpretation of factors, the main loadings (the highest loadings) play the most important role. The possible side loading has been shown with brackets.

Factor 1

18:	there will be as much repetition as possible	0.66
8:	strict discipline	0.61
29:	there will be as much practice as possible	0.55
14:	use of calculators	-0.45
21:	studying mathematics could not always be fun	0.37
(9:	doing word problems	0.40)
(15:	the teacher helps as soon as possible when there are difficulties	0.39)

This factor is loaded with statements that stress calculation-centered working which cannot always be fun, and where is no place for a calculator. It is very easy to name the factor of traditional calculation-centered teaching. It explains 11.9 % of the variance.

Factor 2

25:	games can be used to help pupils learn mathematics	0.75
28:	constructing of different concrete objects and working with them	0.67
31:	also sometimes pupils are working in small groups	0.52
(13:	pupils can put forward their own questions and problems for the class to consider	0.37)

In the factor, there are statements gathered which emphasize the use of such teaching components which are not common in the traditional Finnish mathematics teaching. Therefore, it is named the factor of alternative-methods-using teaching. It explains 6.9 % of the variance.

Factor 3

16:	everything will be reasoned exactly	0.68
5:	everything expressed as exactly as possible	0.63
26:	teacher explains every stage exactly	0.54
(12:	learned by heart	0.39)
(23:	it demands much from pupils	0.30)

The teaching that is described with the statements loaded on the factor could be said to stress exactness in performance. Hence, the factor could be named the factor of exact-performance-stressing teaching. It explains 6.2 % of the variance.

Factor 4

20:	only mathematically talented can solve tasks	-0.67
2:	right answer is more important than way of solving	-0.57
13:	pupils put forward questions, they will be dealt with	0.56
(6:	drawing figures	0.32)

Two of the first main loadings in the factor are negative. The third loading brings also out the belief in pupils' possibilities. From this factor, it could be used the name: the factor of in-pupils-believing teaching. It explains 4.7 % of the variance.

Factor 5

11:	all pupils understand	0.71
17:	different topics will be taught and learned separately	0.55
(26:	teacher explains every stage exactly	0.34)

This factor is loaded with statements which are not easy to put together. Perhaps, it could be named the factor of for-understanding-striving teaching. It explains 4.1 % of the variance.

Factor 6

24:	there are more ways to solve tasks	0.62
23:	it demands much from pupils	0.58
(14:	use of pocket calculators	0.36)
(30:	all will be understood	0.33)
(21:	it could not always make fun	0.30)
(29:	practised as much as possible	0.30)

In the factor, it will be stressed challenging in mathematics teaching. This will be supported also by the use of pocket calculator. We could name it the factor of challenging teaching. It explains 4.0 % of the variance.

Factor 7

15:	teacher helps when there are difficulties	-0.68
27:	pupils are let to solve tasks independently	0.50
21:	it could not always make fun	0.37

(4:	pupil can make conjectures, guess and ponder	-0.35)

The loadings of this factor are statements which emphasize independence in pupil's working. Therefore, it could be named the factor of for-pupils'-independence-striving teaching. It explains 3.7 % of the variance.

Factor 8

32:	teacher says exactly what to do	0.72
10:	there is a procedure which to follow	0.69

The factor is loaded on statements which represent such teaching where the teacher gives exact procedures to follow. It could be easily named the factor of procedure-delivering teaching. It explains 3.5 % of the variance.

Factor 9

22:	calculations of areas and volumes	0.72
6:	drawing figures	0.57
9:	word problems	0.56
1:	mental calculations	0.44
19:	tasks which have practical benefit	0.39
4:	pupil can make conjectures, guess and ponder	0.37

This factor is clearly loaded on mathematical contents. Therefore, it could be named the factor of mathematical-content-stressing teaching. It explains 3.3 % of the variance.

Factor 10

7:	one ought to get right answer quickly	0.71
30:	all will be understood	-0.42
(5:	everything expressed as exactly as possible	0.35)

In this factor, the point is in quick performance – it does not matter although everybody does not understand. Without doubt, it could be named the factor of speed-in-performance-stressing teaching. It explains 3.3 % of the variance.

Factor 11

3:	mechanical calculations	0.76
12:	learned by heart	-0.50

In the loadings of the last factor, there is emphasis on mechanical calculations, but not on memorizing. It could be named the factor of for-calculations-with-understanding teaching. It explains 3.2 % of the variance.

Summarizing in the solution just discussed, we will focus on two points: Some factors were rather complicated to interpret, e.g. the factors 5, 6 und 11. Several factors had only two main loadings, as the factors 5, 6, 8, 10 and 11. Item 21 was problematic, since it is loaded as strongly on two factors (1 and 7). Additionally, the factors seem to loose their power of explanation after the 4th factor.

The analysis of the factor intercorrelations (Appendix 5) hint that the right number of factors could be four or five. But several trials with smaller number of factors (a 4-factor, 5-factor, 6-factor, 8-factor solution) led to an even worse situation: There were difficulties in interpreting the factors obtained, and the factors together did not explain the situation any better than the first four factors in the 11-factors solution. Therefore, we decided to reduce the number of factors with a second order factor analysis.

Second order factor analysis

Using as a starting point the factor intercorrelation matrix, we obtained with the scree-test a solution of four factors – the orthogonally rotated factor matrix is given in Table 3.10. The second order factors are labeled with letters (A)–(D), in order to differ them from the earlier factors.

When interpreting the rotated matrix, we consider in the first place the main loadings. From the eigenvalues, we can see that these four factors together explain about the half (49.4 %) of the variance.

	factors				
	A	B	C	D	h^2
factor 1	**60**	44	08	-12	58
factor 2	-34	09	**55**	-46	64
factor 3	21	**68**	14	07	53
factor 4	-35	-02	-01	**62**	51
factor 5	13	-10	**71**	07	53
factor 6	-04	**63**	04	-16	43
factor 7	**-67**	17	04	-02	48
factor 8	01	33	**54**	30	49
factor 9	**52**	17	38	-22	49
factor 10	04	-10	12	**61**	40
factor 11	21	**-46**	30	10	36
Ev	2.0	1.3	1.2	1.0	5.4
Ev %	17.7	11.4	11.0	9.3	49.4

Table 3.10. The varimax-rotated factor matrix of 11 factors: the main loadings are in bold type and the most important side loadings are underlined.

Factor A

F7:	for-pupils'-independence-striving teaching	-0.67
F1:	traditional calculation-centered teaching	0.61
F9:	mathematical-content-stressing teaching	0.52
(F4:	in-pupils-believing teaching	-0.35)

This factor is loaded with such components of teaching which emphasize teacher's directions, calculation and contents. Hence, it could be named the factor of mathematics-centered teaching.

Factor B

F3:	exact-performance-stressing teaching	0.68
F6:	challenging teaching	0.63
F11:	calculations-with-understanding teaching	-0.46
(F1:	traditional calculation-centered teaching	0.44)
(F8:	procedure-delivering teaching	0.33)

The factor loads on the statements which represent exact and challenging teaching. The negative loading on calculation-with-understanding fits very well into the scheme. It can be named the factor of good traditional teaching.

Factor C

F5:	for-understanding-striving teaching	0.71
F2:	alternative-methods-using teaching	0.55
F8:	procedure-delivering teaching	0.54
(F9:	mathematical-content-stressing teaching	0.38)
(F11:	calculations-with-understanding teaching	0.30)

In this factor, there are loadings on different approaches to mathematics teaching. Therefore, it could be named the factor of ideal teaching from pupil's viewpoint.

Factor D

F4:	in-pupils-believing teaching	0.62
F10:	speed-in-performance-stressing teaching	0.61
(F2:	alternative-methods-using teaching	-0.46)

The last factor is loaded with statements which emphasize the use of pupils' capabilities and stress speed in performance. The negative side loading on alternative methods fits well into the scheme. It can be named the factor of effective pupil-centered teaching.

In summary, we obtained a four factor structure for the questionnaire: (A) factor of mathematics-centered teaching, (B) factor of good traditional teaching, (C) factor of ideal teaching from pupil's viewpoint, (D) factor of effective pupil-centered teaching. These four factors together represent the beliefs of mathematics teaching that seem to be the basis for the pupils' views of reality.

It is interesting to notice that the above mentioned factor structure contains similar components as the tri-division of mathematics teaching used by Dionne (1984): traditional view where mathematics is seen as a set of skills, formalist view where mathematics is seen to involve logic and rigor, constructivist view where mathematics is seen as a process. First two of these coincide with factors (B) and (A), and the third is very close to factor (C).

4. Responses to the open questions

At the end of the questionnaire (Appendix 1), there are open questions about pupils' experiences (2a, 2b) and wishes (3) of mathematics teaching. Here we will consider the responses given to these questions.

4.1. General look at the responses

The amount of all responses to open questions is given in Table 4.1. Additionally, there is calculated the amount of answers per boy (a./boy) and per girl (a./girl).

	boys (%)	girls (%)	a./boy	a./girl
good experiences	225 (35)	297 (37)	0.87	1.17
bad experiences	210 (32)	285 (35)	0.81	1.12
wishes	216 (33)	231 (28)	0.83	0.91
Σ	651 (100)	813 (100)	2.50	3.20

Table 4.1. The amount of all responses to each open question, both as absolute numbers and percentages.

In Table 4.1, we see that the responses are distributed almost uniformly for these three questions which could have been expected. The girls' average response rate to the open-ended questions was 3.20, whereas that for the boys was 2.50.

Main classification

In the classification of the responses, the starting point was the natural tri-division of the teaching/learning situation:

teacher – pupil – mathematics.

The pupils' responses were first grouped into six main classes: (1) Teacher/teaching, (2) Mathematical topics, (3) Learning control, (4) Pupil, (5) Interaction and working forms, (6) Resources. Table 4.2 presents the percentage distribution of all the responses according to this classification. Typical examples of the responses in each group are given in the sections 4.2 and 4.3.

main classes		1	2	3	4	5	6
good experiences	BOYS	42	28	5	16	4	4
	GIRLS	44	27	3	15	8	3
bad experiences	BOYS	39	20	13	15	5	8
	GIRLS	46	19	8	19	3	5
wishes	BOYS	21	43	12	3	10	12
	GIRLS	35	37	6	3	14	5

Table 4.2. Percentage distribution of responses
(1= Teacher/teaching, 2= Mathematical topics, 3= Learning control,
4= Pupil, 5= Interaction and working forms, 6= Resources).

In the distribution of the responses, the pattern is similar for boys and girls. Most answers are in the first and second category (Teacher /teaching, and Mathematical topics), altogether from 65 % to 70 %. Additionally, a significant percentage (more than 10 %) was in the fourth main class (Pupil) for experiences, and in the fifth main class (Interaction and working forms) for wishes. In the third and sixth category (Learning control, and Resources), the percentage of responses was only occasionally more than 10 %.

Each main class was in turn divided into subclasses, numbered from 2–6 (Appendix 2).

4.2. Experiences

Here, the good and bad experiences which the pupils have expressed in the questionnaire will be dealt with.

Good experiences

The percentage distribution of pupils' good experiences (from Table 4.2) is given as a diagram in Fig. 4.3.

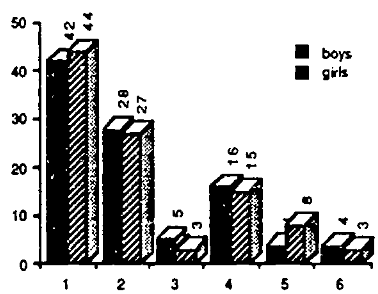

Fig. 4.3. Percentage distribution of pupils' good experiences.

In Fig. 4.3, the mod· of the good experiences is in the first category (Teacher/teachi..g), where the amount of responses is more than two-fifths in both samples. Almost one-third of the responses have been gathered in the second main class (Mathematical topics). Additionally, the fourth category (Pupil) is in both samples about 15 %. The percentage distribution of the responses in these three categories is given in Table 4.4 (for the number codes see Appendix 2), and the differences between these percentages.

subclasses	11	12	13	21	22	23	24	41	42	43	44	45
boys	51	48	2	22	51	8	19	46	19	3	30	3
girls	42	57	2	40	28	14	19	34	20	23	20	3
difference	+9	-9	0	-18	+23	-6	0	+12	-1	-20	+10	0

Table 4.4. Percentage distribution of pupils' good experiences in some main classes (for the number codes see Appendix 2).

First main class (Teacher/teaching). In this class, there are 95 responses from the boys and 130 from the girls. The boys' responses were almost uniformly divided between the first subclass (General evaluation of teacher/teaching) and the second subclass (Evaluation of spesific features). The girls gave significantly more responses in the second subclass (cf. Table 4.4). Some typical expressions in the first subclass were, as follows: "*good teachers*", "*teaching has been good*", and "*we were better taught at primary school*". In the second subclass, good experiences were expressed with words as "*teachers have explained the topics thoroughly*", "*teacher has helped much*", and "*peaceful working conditions*".

Second main class (Mathematical topics). In this class, there are 73 responses from the boys and 80 from the girls. In the first subclass (General evaluation of contents/problems/topics), the boys' share of the responses was about 20 % smaller than the girls' share, whereas the distribution was reversed for the second subclass (Evaluation of specific mathematical contents or procedures). Characteristic responses in the first subclass are e.g. "*easy tasks*", "*problems not always difficult*", and "*sometimes mathematics is interesting*"; in the second subclass "*one learned many practical things*", and "*basic things became clear*". In the third subclass (Evaluation of learning tools), there were about one-tenth of all responses. Some typical responses were *"use of calculators"*, and *"playing games"*. Additionally, there was the fourth subclass (Else) into which about one-fifth of the responses were classified in both samples; here the characteristic response was *"learned much"*.

Fourth main class (Pupil). In this class, there are 37 responses from the boys and 44 from the girls. Almost half of the boys' responses and one-third of the girls' responses were dealing with pupils' understanding (the first subclass). Here, some typical responses were *"one has learned to calculate"*, *"I have understood"*, and *"I got the idea"*. In the second subclass (Cognitive component) and the fourth subclass (Notes), there were also a great many of responses in both samples, e.g. *"I have learned well"*, and *"good notes in classwork"*. Additionally, about one-fourth of the girls' responses was classified into the third subclass (Affective component), where the following comments were typical: *"I like mathematics"*, and *"when one discovers new solutions"*.

Summary. In the main classification of the good experiences (Fig. 4.3), the responses of boys and girls were very similarly scattered. But the distribution within the main classes (Table 4.4) showed many differences.

The main differences in responses were the following: The boys gave significantly more specific evaluation in the case of mathematical topics (subclass 22) than the girls, whereas the situation was reversed for general evaluation (subclass 21). As a slightly similar situation which was the otherway round was found for the results of the first main class. The result seems to fit very well together with the fact that girls are, in general, more interested in people and boys more in things. Additionally, the girls' responses emphasized affective component (subclass 43), whereas the boys gave more expressions which stressed pupils' understanding (subclass 41). This can be explained by the girls' greater affective behaviour.

Bad experiences

The percentage distribution of pupils' bad experiences (from Table 4.2) is given in Fig. 4.5.

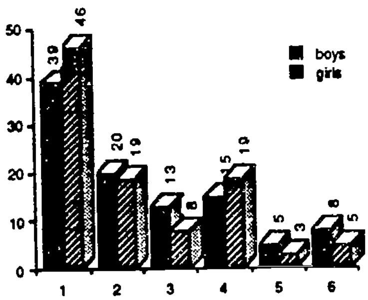

Fig. 4.5. Percentage distribution of pupils' bad experiences.

In Fig. 4.5, almost half of all bad experiences belong to the first category (Teacher/teaching). In the second (Mathematical Topics) and fourth (Pupil) category, the amount of the responses was almost 20 %. In the third category (Learning control), the percentage of the boys' responses exceeded 10 %. The percentage distribution of the responses in these four categories is given in Table 4.6 (for the number codes see Appendix 2; here means that the proportion in Table 4.2 was under 10 %), and the differences between these percentages.

subclasses	11	12	13	21	22	23	24	31	32	41	42	43	44	45
boys	52	48	-	44	37	19	-	21	79	41	19	-	31	9
girls	38	61	1	50	48	2	-			59	13	15	11	2
difference	+14	-13	-1	-6	-11	+17	-	-	-	-18	+6	-15	+20	+7

Table 4.6. Percentage distribution of pupils' bad experiences in some main classes (for the number codes see Appendix 2).

First main class (Teacher/teaching). In this class, there were 81 responses from the boys and 130 from the girls. Here, the responses are divided in a very similar manner to the distribution of good experiences in the "Teacher/teaching"-category. They are scattered between the two first subclasses, as follows: the boys' responses almost uniformly, and the girls' responses about 20 % more in favour of the second subclass (Evaluation of specific features). The most common words used to describe teacher/teaching were, as follows: *"boring"*, *"bad"*, *"difficult"*, *"quick"*. Some examples of pupils' expressions in the first subclass (General evaluation of teacher/teaching) are the following: *"it was boring"*, *"a bad teacher at primary level"*, *"very difficult"*, and *"teaching too quick"*. In the second subclass (Evaluation of specific features), some typical responses were, as follows: *"not clearly explained"*, *"unpleasant teacher"*, *"teacher had not time to give advice"*, *"too strict discipline"*, *"memorizing"*, and *"too much repetition"*.

Second main class (Mathematical topics). In this class, there are 43 responses from the boys and 54 from the girls. About half of the responses were involved with the first subclass (General evaluation of contents/problems/topics). The pupils complained that the problems were too difficult or boring, e.g. *"complicated problems"*, *"difficult ways to calculate"*, *"some topics are boring"*, and *"too much mechanical calculations"*. The amount of the responses classified into the second subclass (Evaluation of specific mathematical contents ...) was somewhat smaller (cf. Table 4.6). Some typical responses were *"mental calculations"*, *"word problems difficult"*, and *"problems not useful"*. Additionally, one-fifth of the boys' responses was concerning the third subclass (Evaluation of learning tools), with words as *"calculators not used"*.

Third main class (Learning control). Bad experiences of the boys (28 responses) divided, as follows: about one-fifth to class work/tests and four-fifths to home work. Typically, they were complaining about the amount of homework, e.g. *"too much homework"*.

Fourth main class (Pupil). In this class, there are 32 responses from the boys and 54 from the girls. The mode in both samples was in the first subclass (Understanding), only with a different weight – the difference was almost 20 %. The following examples show pupils' feelings: *"I have not understood all, nor do I now"*, and *"one did not always understand"*. One-third of boys' responses complained about the quality of the teaching notes (the fourth subclass), the typical response was *"bad notes"*. One-fifth of the boys' responses was classified into the second subclass (Cognitive component), and more than 10 % of the girls' responses. Characteristic responses were *"you must study hard"*, and *"I learned some topics very slowly"*. In the third subclass (Affective component), there were additionally one-seventh of the girls' responses, e.g. *"I am not good in maths"*.

Summary. Considering the bad experiences of boys and girls globally, the distributions (Fig. 4.5) seem to be rather similar. But when looking at the distribution of the responses within the main classes (Table 4.6), we see that there are some clear differences between the responses given by boys and girls.

The boys expressed significantly more than the girls their dislike of notes (subclass 44). But as we have already observed earlier (in chapter 3.3) boys are more lazy than girls when it comes to working in mathematics. The girls more than the boys complained about a lack of pupils' understanding (subclass 41). Could an explanation for this be the fact that girls are usually more satisfied with the given situation, or at least they don't show their dissatisfaction, whereas boys react easily, e.g. during mathematics lessons, if they are not satisfied? The boys' responses were more than the girls' responses dealing with the lack calculators and computers (subclass 23). This difference could be explained with the boys' laziness and interest in technical tools. The girls' responses more emphasized the affective component (subclass 43). The girls placed more emphasis on evaluation of teacher and teaching (subclasses 11 and 12) than the boys. It seems that girls are able to express themselves more clearly than boys.

4.3. Wishes

The percentage distribution of pupils' wishes (from Table 4.2) is given in Fig. 4.7.

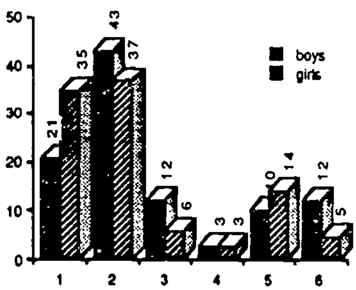

Fig. 4.7. Percentage distribution of pupils' wishes.

The pupils' wishes are distributed in a different manner to their experiences (Fig. 4.7): In the first category (Teacher/teaching) and the second category (Mathematical topics), there is an equal amount – about one-third – of the girls' responses in both, whereas the boys' responses are distributed otherwise: In the second category, there is twice as many responses as in the first category (Fig. 4.7). Only in wishes, there are more than 10 % of the responses in the fifth and sixth category (Interaction and working forms, and Resources). In the third category (Learning control), the percentage of the boys' responses exceeded the limit of 10 %. The percentage distribution of the responses in these five categories is given in Table 4.8 (for the number codes see Appendix 2; here means that the share in Table 4.2 was under 10 %), and the differences between these percentages.

subclasses	11	12	13	21	22	23	24	31	32	51	52	53	54	55	61	62	63
boys	31	69	-	12	35	53	-	31	69	68	18	10	5	-	44	28	28
girls	45	55	-	16	43	41	-			72	6	19	3	-			
difference	-14	+14	-	-4	-8	+12	-	-	-	-4	+12	-9	+2	-	-	-	-

Table 4.8. Percentage distribution of pupils' wishes in some main classes (for the number codes see Appendix 2).

First main class (Teacher/teaching). In this class, there were 45 responses from the boys and 80 from the girls. The mode for both samples lies in the second subclass (Evaluation of spesific features). The pupils wanted both more and less repetition, e.g. *"there should be more repetition"*, and *"less mechanical problems"*. There were wishes for the better quality of explanation as well as a more friendly and understanding form of teaching, e.g. *"I would like to have more accurate explanations and teaching"*, *"it should be more free"*, and *"more relaxed"*. Secondly, the pupils wanted a better teacher (the first subclass) who would teach with a more relaxed manner and with different methods. E.g. *"good teaching"*, *"slower progress"*, *"varying teaching"*, *""we shouldn't change teachers too often*, and *"teaching more easier"*.

Second main class (Mathematical topics). In this class, there are

92 responses from the boys and 86 from the girls. About half of the wishes was in the third subclass (Evaluation of learning tools). Some typical expressions were *"more learning games", "more calculators"*, and *"working with computers"*. In the second subclass (Evaluation of specific mathematical contents ...), there were about two-fifths of all responses. These were expressed with words as *"more constructing of thing, e.g. box", "more problems to think about", "more practical problems"*, and *"more word problems"*. Here, the amount of generally evaluating responses (the first subclass) was smallest, about one-eighth. Some examples of the responses are *"easier problems"*, and *"something different and nice"*.

Third main class (Learning control). About two-thirds of the boys' wishes (26 responses) were connected with home work (the second subclass). They wanted *"less home work"*.

Fifth main class (Interaction and working forms). In this class, there are 22 responses from the boys and 32 from the girls. About two-thirds of the responses in both samples were concerned with more differentiation during mathematics lessons (the first subclass), e.g. in the form of group work. In the pupils' words *"more working in groups"*, and *"more working in pairs"*. In the girls' responses, there were additionally about one-fifth of them who wanted more independence in their working mode (the third subclass), e.g. *"free working in groups"*, and *"more independent tasks"*. And in the boys' responses, about one-fifth of the wishes were concerned with more external differentiation (the second subclass) in the form of supplementary lessons, e.g. *"more supplementary teaching"*.

Sixth main class (Resources). About half of the boys' wishes (25 responses) were concerned with teaching materials. They wanted *"easier maths books"*, and *"more tasks to be done in maths books"*.

Summary. The overall picture of wishes is very different from the responses to the other two questions. Here, the responses are more scattered than in pupils' experiences (Fig. 4.7). The biggest difference in the pattern is that the boys' wishes are clearly more concentrated in the second category (Mathematical topics) than the girls' wishes. Within the main classes, there are also differences between the percentages of boys' and girls' responses (Table 4.8), but they are not so big and not so many as in pupils' bad experiences.

In wishes concerning teacher and teaching, the girls' responses were more generally evaluative (subclass 11), whereas the boys expressed their wishes more specifically (subclass 12). This could be explained by the fact that boys are, in general, more interested in mathematics. The boys wanted more computers and learning games (subclass 23) than the girls. Also the boys wanted more supplementary lessons (subclass 52). In general, boys are weaker than girls in mathematics, and therefore are more in need of supplementary teaching.

5. Discussion

Here, we will considered questions about reliability and validity of this study (5.1). We will also discuss some answers to the research problems posed earlier (5.2). Finally, the current status of mathematics teaching in Finland will be briefly dealt with, and some suggestions for improving it considered (5.3).

5.1. The question about reliability and validity

As the completed questionnaires were collected, there were many instances of teachers spontaneously making comments such as: *"Such a questionnaire ought to be administered every autumn with a new class"* and *"May I use this questionnaire later on?"* These opinions show that the teachers who have read through their pupils' answers in questionnaires realized that they can in this way get valuable in-formation from their pupils.

In assessing reliability, a distinction is often made between external reliability (repeatability of results) and internal reliability (constancy of results). Validity, too, can be divided into external validity (transferrability of results) and internal validity (correspondence of results). (E.g. Leino 1990, 31–32)

Reliability

The reliability of the questionnaire was calculated using the halfing method and the Spearman–Brown formula. This gave a test reliability of 0.68, which is an estimate of the constancy of the results (internal reliability).

The factor analysis performed on the questionnaire, using the scree-test, resulted in 11 factors. The factor analysis provides another way of assessing the reliability of the questionnaire. It is well known that reliability is always at least as high as communality. Since the communalities of the items varied between 42 % and 72 % (Appendix 4), the mean being 54.8 %, the estimated reliability is about of the same order of magnitude as the figure (0.68) presented above.

In another study with the same questionnaire (Pehkonen & Tompa 1992), two pupils were interviewed, taken at random from each class (altogether N=18), about a month after the filling in the questionnaire. The goal of the interview was to estimate the consistency of pupils' answers in the questionnaire. In the interviews, the pupils changed the responses in 12.4 % cases of all their answers. This gives an estimate (88 %) of the repeatability of results (external reliability).

The classification of responses to the open questions was done by Arja Wahlstedt. The reliability of the classification was checked by twice classifying the first 50 papers. Comparing the first and the second classification, there were differences between them 16 % of all the classification units.

Validity

Although the pupils' conceptions of mathematics teaching did not surface in a pure form in the survey, the results may still reflect the conceptions that the pupils actually have. And in particular, these conceptions are interesting, because they will influence the pupils' mathematical behaviour.

Extrapolation of the results (external validity), to make them applicable to all Finnish seventh graders, is questionable for the following reasons: The sample was not selected randomly. The survey was carried out with the help of the teachers who have attended one of the in-service courses arranged by the researcher. Therefore, the teachers who conducted the questionnaire in their classes form a positively selected sample, representing Finnish teachers who have applied for supplementary training. But their seventh-grade-pupils have acquired most of their experiences and developed their attitudes already in primary school, since they had only been studying for five months with their current teacher. Therefore, the sample of pupils can be considered as representative of the seventh-graders in Southern Finland.

The researcher's conceptions of mathematics teaching and learning are very strongly involved when interpreting the results. E.g. the responses to statement 20 (only the talented can solve most of the tasks) gave us the picture that mathematics teaching in Finland has been successful, since the pupils disagreed with the statement. We think that they have learned to struggle with mathematics and not to think of it as being impossible. But there could be another contradictory interpretation to the same fact: One could say that mathematics teaching in Finland uses too simple and easy problems, since the majority of pupils consider mathematics accessible for everybody.

It is clear that the use of questionnaire alone will not give an adequate picture about pupils' conceptions of mathematics teaching. It should be deepened with interviews. Therefore, the view of mathematics teaching reached here can be thought to be only a first approximation of pupils' views.

5.2. Summary of results

Here, we will gather together the most central results obtained in chapter 3 and 4. At the same time, we will provide some answers to the research problems which were put forward in section 2.1.

View of mathematics teaching

The most accepted statements in the questionnaire were those concerning good discipline, and the practical benefit of mathematics studied. In next place, the pupils demanded that they all understand, and put an emphasis on mental calculation.

In the component of mathematical content, the agreed statements give a pragmatic, calculation-centered, and task-oriented view of mathematics. In the component of doing mathematics, the pupils emphasized process instead of product, and rigorous working methods. Additionally, they do not think school mathematics to be too complicated.

In the pupils' view of learning mathematics, understanding and learning through practicing were stressed.

The pupils' view of teaching mathematics emphasized, in the component of pupils' involvement, pupil-centered active teaching/learning, and stressed peaceful teaching/learning situation, where learning sometimes took place in small groups. In the component of teacher's involvement, they required a situation where the teacher would give help and directions to the pupils; additionally, they were in favour of learning games.

The factor analysis revealed a four factor structure for the questionnaire: a factor of mathematics-centered teaching, a factor of good traditional teaching, a factor of ideal teaching from pupil's viewpoint, a factor of effective pupil-centered teaching. These four factors together represent the beliefs of mathematics teaching that seem to be the basis for the pupils' views of reality.

Pupils' experiences and wishes about mathematics teaching

In the distribution of the responses, the pattern for six main groups is similar for boys and girls in all three questions. Most answers are in the Teacher/teaching-, and Mathematical topics - categories, altogether from 65 % to 70 %. Additionally, a significant percentage (more than 10 %) is in the main class "Pupil" for experiences, and in the main class "Interaction and working forms" for wishes. In the third and sixth category (Learning control, and Resources), the percentage of responses was only occasionally more than 10 %.

The mode of the good experiences is in the first category (Teacher /teaching), where the amount of responses is more than two-fifths in both samples. Almost one-third of responses was to be found in the second main class (Mathematical topics). Additionally, the fourth category (Pupil) was about 15 % in both samples.

Almost half of all bad experiences belongs to the first category (Teacher/teaching). In the second (Mathematical Topics) and fourth (Pupil) category, the amount of the responses was almost 20 %. In the third category (Learning control), the percentage of the boys' responses exceeded 10 %.

Pupils' wishes are distributed in a different manner to their experiences: In the first category (Teacher/teaching) and the second category (Mathematical topics), there is an equal amount – about one-third – of the girls' responses in both, whereas the boys' responses are divided differently: In the second category, there is double as many responses as in the first category. Only in wishes, there are more than 10 % of the responses in the fifth and sixth category

(Interaction and working forms, and Resources). In the third category (Learning control), the percentage of the boys' responses exceeded the limit of 10 %.

Differences in responses between boys and girls

Looking at the responses in separate statements, we reached following conclusions: The girls are more ready to work seriously at mathematics than the boys. The girls disagreed more strongly than the boys with the statement that only the mathematically talented pupils can solve the problems. The boys are more accomplishment-centered, and require more supervision than the girls. But on the other hand, the boys are more lazy to work than the girls. Additionally, the boys are more in favour of geometry than the girls. Using the structure of the questionnaire, we found that the boys seem to think more schematic than the girls.

In good experiences, the distribution of responses within the main classes showed many differences: The boys gave significantly more specific evaluations in the case of Mathematical topics than the girls, whereas the situation was different for the general evaluation. A slightly similar situation which was however the other way round was found in the results of the Teacher/teaching-category. Additionally, the girls' responses emphasized affective component, whereas the boys were more in favour of expressions which stressed pupils' understanding.

When looking at the distribution of the responses in bad experiences within the main classes, there were some differences. The boys expressed significantly more than the girls their dislike of notes. The girls were more than the boys complaining about a lack of pupils' understanding. The boys' responses were more than the girls' responses concerned with the lack of calculators and computers. The girls' responses emphasized more the affective component. The girls gave a more detailed evaluation of the teacher and the teaching situation than the boys.

The boys' wishes are clearly more concentrated in the Mathematical topics -category than the girls' wishes. Within the main classes, there are also differences between the percentages of boys' and girls' responses, but they are not as big and varied as e.g. in pupils' bad experiences. In wishes concerning Teacher/teaching, the girls' responses were more generally evaluative, whereas the boys expressed their wishes more specifically. The boys also wanted more computers and learning games than the girls. Also the boys wanted more supplementary lessons.

In order to place these results in perspective it should be noted that the differences between the boys' and the girls' views within a country are very small compared with the differences found between different countries (cf. Pehkonen & Tompa 1992).

5.3. Conclusions and implications

Finally, the position of mathematics teaching in Finland will be discussed. Some suggestions on how to improve the teaching of mathematics are also presented.

What is the current status of mathematics teaching in Finland?

Superficially, the situation in Finland in mathematics teaching seems quite encouraging. We have a nine-year comprehensive school where all pupils have an opportunity to study following the same national curriculum, and thus equality in education ought to be realisable.

However, the number of mathematics lessons in schools in Finland is one of the lowest in the world according to the UNESCO study (1986). E.g. in Switzerland, they have more than twice as many mathematics lessons during the first nine school years. Since we are trying to compete at the college level with other countries, the results of mathematica learning at school are consequently much on the level of surface learning.

In Finland, pupils will study all subjects, including mathematics, through the whole comprehensive school (i.e. nine first years) in heterogeneous classes. The teaching methods used are very tasks based. A typical mathematics lesson at every level of the comprehensive school will take the following form: The teacher shows the pupils how to solve a problem using an example, and the pupils then have to solve similar tasks on their own. Teaching is usually based on the abilities of the average pupil, and is very mechanical. During time set aside for the pupils' to work independently, the teacher tries to give extra help to the low-attainers. The talented do not usually receive the attention they require to fully develop their talents from the teacher, as he spends most of his time with the less talented individuals. Thus, mathematics for most pupils consists of the mechanical solution of an infinite series of tasks, and probably the mere imitation of an example.

How could the situation be improved?

For a permanent improvement of mathematics teaching, we should be able to change pupils' beliefs about mathematics teaching, since they have a powerful impact on learning. This will be described briefly with two strategies: short and long term management schemes. Short term management schemes give some methods which teachers can implement immediately.

But, it is well documented in the literature that teachers and teaching are the factors which most influence pupils' beliefs (e.g. Zimmermann 1991, 73). So, if mathematics teaching is to improve, it is necessary to offer teachers opportunities to develope their beliefs about mathematics and mathematics teaching/learning. Methods for long term improvements must therefore involve schemes which influence teachers' beliefs. These schemes will be dealt with later.

Short term improvements. From the results on this survey (section 5.2), we can propose some immediate managements strategies: The pupils agreed most with statements which stress good discipline and practical benefits of mathematics to be learned. So, the teacher ought to use such examples and problems that will show the meaning of mathematics also in everyday life. It is very important for the pupils, regardless of their level, that they understand what is to be learned. Mental calculation should be stressed as it develops the pupils' thinking ability, since it needs a lot of concentration.

In pupils' wishes, there are wishes for a better quality of teaching (better explanations), wishes for more open teaching (learning games, problems to think about), wishes for alternative organisation of mathematics lessons (working in groups or pairs, independent working), and wishes for use of technical tools (more calculators, computers).

Long term improvements. To develop the teaching of mathematics, an attempt should be made to take account of the views shared by pupils and teachers about mathematics teaching. Teachers should be made aware of the opportunities that considering of pupils' views might offer to them. They should be helped to see that, in accordance with the spirit of the Act on comprehensive school (Anon. 1983), teaching practice should be pupil-oriented and not mathematics-oriented. The emphasis in teaching should be shifted from arithmetic routines towards the improvement of higher-level thinking skills

– a conclusion also drawn in the final report of the Leikola committee (Anon. 1989).

As a remedial measure, work should be started on teachers' views of mathematics and its teaching. Courses that would tackle with the key questions of mathematics teaching, in both theory and practice with the emphasis on the latter, could give the participants some experience of the essence of mathematics. The theoretical component of the courses would deal with both pupils' and teachers' views of mathematics, as revealed by research, and emphasis would be placed on the learning of thinking skills, as expressed by the Act on comprehensive school. Practice would consist of e.g. problem solving by the participants themselves – not forgetting the help given by manipulatives. Of course, there ought to be as a part of the course some model teaching in school for participants to observe, too.

Teachers could thus develop their teaching in a more open direction, and their views of the teaching and learning of mathematics would undergo a change. Consequently, pupils' views of mathematics teaching might change to a more realistic conception of mathematics, where the different components of mathematics (e.g. creativity and mathematical thinking) are valued, too.

End notes

The dominance of calculations and tasks in pupils' conceptions will be easy to understand, because of small amount of mathematics lessons during the compulsary school (9 first years). In such a situation, the teacher feels that he has not time enough and therefore he concentrates in that he thinks is most important – basic calculations.

The overall view of mathematics that the pupils gave is in coherence with the experiences that the writer has gathered when discussing about mathematics teaching with teacher educators from different countries. All they are claiming that pupils (as well as teachers) in their country consider mathematics teaching almost plainly calculation-centered and task-oriented activity. Usually, teacher educators are trying – and they feel that without result – to get teachers with, in order to change mathematics teaching more to correspond pupils' needs. Therefore, it is delightful to observe that the pupils agreed with some constructivist statements: There are many ways to solve a task, the way of solving a task is more important than the right answer, pupils can make conjectures, guess and ponder, and working in small groups. It looks like that in changing mathematics teaching we are in good start, in contrary to the general opinion.

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Appendix 1: Questionnaire

University of Helsinki
Department of Teacher Education

Name: _______________
Class: ____ Date: _____

Pupil questionnaire about mathematics teaching

In the following, there are some statements concerning mathematics teaching. You are asked to circle the point corresponding your opinion. You will have the scale:

1 = fully agree 2 = agree 3 = cannot say 4 = disagree 5 = fully disagree

1. GOOD MATHEMATICS TEACHING INCLUDES ...

1 2 3 4 5	mental calculations	(1)
1 2 3 4 5	that the right answer is always more important than the way of solving	(2)
1 2 3 4 5	mechanical calculations	(3)

See for the missing items
Appendix 3

1 2 3 4 5	that, according to pupils' capabilities, all will be understood	(30)
1 2 3 4 5	that also sometimes pupils are working in small groups	(31)
1 2 3 4 5	that the teacher says to pupils always exactly what they ought to do	(32)

2. What kind of experiences do you have until today (from the primary level up to now) about mathematics teaching? Can you explain with a couple of words!

good: ....

....

bad: ....

....

3. What wishes do you have for mathematics teaching? Can you explain with a couple of words!

....

....

Appendix 2: The categories of responses in the free questions

1. Teacher/teaching
11 General evaluation of teacher /teaching
12 Evaluation of spesific features (as Quality of explaining, Friendly teaching, Helpfulness, Patience, ability to hear, Keeping discipline, Repetition/ practice, Equality in dealing with pupils, Challenging of pupils, Structuring of teaching)
13 Else (as Absences of teacher)

2. Mathematical topis
21 General evaluation of contents/problems/topics
22 Evaluation of spesific mathematical contents or procedures (as Geometry, Mental calculation, Basic calculations, Word problems, Algebra, Set theory, Fractions, Percentages, Practicality, application, usefulness, Logical thinking/puzzles, Function, Number sequences, Probability, History of mathematics)
23 Evaluation of learning tools (as Computer/calculator, Learning games, Textbook working/calculating)
24 Else

3. Learning control
31 Class work/tests
32 Home work

4. Pupil
41 Understanding
42 Cognitive component (as Cognitive self-concept/cognitive style)
43 Affective component (as Motivation, Self-esteem, affective self-concept, Anxiousness)
44 Notes
45 Else (as Absence of the pupil, Expressions of an adolescent, Pupil's rights)

5. Interaction and working forms
51 Inner differentation (as Group work, Working together/working in pairs)
52 Outer differentation (as Private teaching/supplementary lessons, Clubs, competitions etc.)
53 Progressive working (as Independent working/independency, Discussions of problems)
54 Traditional working (as Working at the blackboard)
55 Else (as Attitude of class mates)

6. Resources
61 Teaching materials (as Text books, Other materials)
62 Amount of lessons
63 Else

Appendix 3: Responses to the structured questions

There are the frequencies per-item as well as their means (M), and standard deviations (SD) of the frequencies, the percentages are given in brackets. Additionally, there are t-values (t) for the differences of means between boys (N=260) and girls (N=254) with the level of significancy.

1. GOOD MATHEMATICS TEACHING INCLUDES

	agree 1	2	3	4	disagree 5	M	SD	t
1: doing calculations mentally								
boys	117 (45)	122 (47)	11 (4)	9 (3)	1 (0)	1.67	0.75	-1.66
girls	94 (37)	132 (52)	19 (7)	7 (3)	2 (1)	1.78	0.76	
2: the idea that getting the right answer is always more important than the way of solving the problem								
boys	13 (5)	27 (10)	51 (20)	110 (42)	59 (23)	3.67	1.09	-2.13
girls	7 (3)	18 (7)	40 (16)	126 (50)	63 (25)	3.87	0.96	*
3: doing computations with paper and pencil								
boys	58 (22)	120 (46)	58 (22)	14 (5)	10 (4)	2.22	0.98	-1.50
girls	51 (20)	102 (40)	67 (26)	28 (11)	6 (2)	2.35	1.00	
4: the idea that the pupil can sometimes make guesses and use trial and error								
boys	86 (33)	135 (52)	36 (14)	1 (0)	2 (1)	1.84	0.73	-0.91
girls	84 (33)	124 (49)	33 (13)	10 (4)	2 (1)	1.90	0.83	
5: the idea that everything ought to be expressed always as exactly as possible								
boys	29 (11)	62 (24)	56 (22)	81 (31)	31 (12)	3.09	1.22	-0.43
girls	18 (7)	71 (28)	60 (24)	69 (27)	36 (14)	3.13	1.18	
6: drawing figures (e.g. triangles)								
boys	60 (23)	123 (47)	46 (18)	25 (10)	6 (2)	2.21	0.98	0.13
girls	62 (24)	111 (44)	54 (21)	23 (9)	4 (2)	2.20	0.98	
7: the idea that one ought to get always the right answer very quickly								
boys	6 (2)	43 (17)	46 (18)	118 (45)	47 (18)	3.60	1.04	-2.11
girls	3 (1)	25 (10)	50 (2[illegible]	121 (48)	55 (22)	3.79	0.93	*
8: strict discipline								
boys	179 (69)	61 (23)	10 (4)	2 (1)	8 (3)	1.46	0.86	0.56
girls	174 (69)	66 (26)	6 (2)	4 (2)	4 (2)	1.42	0.76	
9: doing word problems								
boys	91 (35)	117 (45)	23 (9)	15 (6)	13 (5)	2.00	1.06	-0.17
girls	78 (31)	132 (52)	16 (6)	17 (7)	11 (4)	2.02	1.02	
10: the idea that there is always some procedure which one ought to exactly follow in order to get the result								
boys	40 (15)	91 (35)	75 (29)	39 (15)	15 (6)	2.61	1.09	-3.36
girls	23 (9)	63 (25)	95 (37)	56 (22)	17 (7)	2.93	1.05	***

	agree 1	2	3	4	disagree 5	M	SD	t
11: the idea that all pupils understand								
boys	137 (53)	90 (35)	19 (7)	13 (5)	0 (0)	1.65	0.82	0.23
girls	159 (63)	61 (24)	13 (5)	12 (5)	9 (4)	1.63	1.02	
12: the idea that much will be learned by memorizing rules								
boys	14 (5)	77 (30)	64 (25)	67 (26)	38 (15)	3.15	1.16	-1.87
girls	9 (4)	54 (21)	72 (28)	82 (32)	37 (15)	3.33	1.08	
13: the idea that pupils can put forward their own questions and problems for the class to consider								
boys	78 (30)	115 (45)	37 (14)	17 (7)	10 (4)	2.09	1.03	0.69
girls	69 (27)	128 (50)	41 (16)	12 (5)	4 (2)	2.03	0.88	
14: the use of calculators								
boys	108 (42)	94 (36)	36 (14)	16 (6)	6 (2)	1.92	1.00	-2.04
girls	85 (33)	92 (36)	49 (19)	23 (9)	5 (2)	2.10	1.03	*
15: the idea that the teacher helps as soon as possible when there are difficulties								
boys	100 (38)	98 (38)	35 (13)	23 (9)	4 (2)	1.97	1.01	-0.90
girls	75 (20)	122 (48)	32 (13)	19 (7)	6 (2)	2.05	0.97	
16: the idea that everything will always be reasoned exactly								
boys	50 (19)	104 (40)	59 (23)	39 (15)	8 (3)	2.43	1.06	0.90
girls	54 (21)	91 (36)	79 (31)	27 (11)	3 (1)	2.35	0.97	
17: the idea that different topics, such as calculation of percentages, geometry, algebra, will be taught and learned separately; they have nothing to do with each other								
boys	49 (19)	81 (31)	85 (33)	26 (10)	19 (7)	2.56	1.13	-0.16
girls	51 (20)	68 (27)	84 (33)	38 (15)	12 (5)	2.57	1.11	
18: the idea that there will be as much repetition as possible								
boys	56 (22)	113 (43)	42 (16)	33 (13)	16 (6)	2.39	1.14	1.84
girls	56 (22)	126 (50)	40 (16)	26 (10)	6 (2)	2.21	0.98	
19: the idea that studying mathematics has practical benefits								
boys	132 (51)	113 (43)	8 (3)	4 (2)	1 (0)	1.56	0.67	-1.11
girls	125 (49)	105 (42)	16 (6)	5 (2)	2 (1)	1.63	0.76	
20: the idea that only the mathematically talented pupils can solve most of the problems								
boys	12 (5)	14 (5)	36 (14)	95 (37)	103 (40)	4.01	1.08	-3.08
girls	6 (2)	12 (5)	14 (6)	93 (37)	129 (51)	4.29	0.94	**
21: the idea that studying mathematics could not always be fun								
boys	52 (20)	107 (41)	43 (17)	36 (14)	22 (8)	2.50	1.20	2.19
girls	58 (23)	109 (43)	53 (21)	21 (8)	11 (4)	2.28	1.05	*
22: calculations of areas and volumes (e.g. the area of a rectangular and the volume of a cube)								
boys	103 (40)	120 (46)	29 (11)	7 (3)	1 (0)	1.78	0.78	-2.25
girls	78 (31)	129 (51)	35 (14)	4 (2)	7 (3)	1.95	0.87	*

	agree 1	2	3	4	disagree 5	M	SD	t
23: the idea that studying mathematics requires a lot of effort by pupils								
boys	23 (9)	81 (31)	86 (33)	58 (22)	12 (5)	2.83	1.02	-0.48
girls	19 (8)	76 (30)	90 (36)	55 (22)	13 (5)	2.87	1.01	
24: the idea that there are usually more than one way to solve problems								
boys	88 (34)	135 (52)	24 (9)	12 (5)	1 (0)	1.86	0.80	-1.18
girls	63 (25)	154 (61)	30 (12)	4 (2)	3 (1)	1.94	0.73	
25: the idea that games can be used to help pupils learn mathematics								
boys	95 (37)	110 (42)	35 (13)	15 (6)	5 (2)	1.94	0.95	-0.98
girls	71 (28)	119 (47)	53 (21)	7 (3)	3 (1)	2.02	0.84	
26: the idea that when solving problems, the teacher explains every stage exactly								
boys	85 (33)	118 (46)	27 (10)	22 (9)	6 (2)	2.02	0.99	0.04
girls	85 (33)	107 (42)	37 (15)	24 (9)	1 (0)	2.01	0.95	
27: the idea that pupils are led to solve problems on their own without help from the teacher								
boys	96 (37)	111 (43)	42 (16)	9 (3)	2 (1)	1.89	0.85	0.60
girls	81 (32)	140 (55)	26 (10)	6 (2)	1 (0)	1.84	0.73	
28: the constructing of different concrete objects (e.g. a box or a prism) and working with them								
boys	39 (15)	95 (37)	70 (27)	37 (14)	19 (7)	2.62	1.12	-2.29
girls	15 (6)	92 (36)	86 (34)	38 (15)	22 (9)	2.84	1.04	*
29: the idea that there will be as much practice as possible								
boys	65 (25)	124 (48)	39 (15)	25 (10)	7 (3)	2.17	1.00	1.75
girls	59 (23)	149 (59)	27 (11)	17 (7)	2 (1)	2.03	0.82	
30: the idea that all or as much as the pupil is capable of will be understood								
boys	63 (24)	138 (53)	46 (18)	9 (3)	3 (1)	2.04	0.82	1.03
girls	87 (34)	105 (41)	51 (20)	7 (3)	4 (2)	1.96	0.89	
31: the idea that also sometimes pupils are working in small groups								
boys	99 (38)	120 (46)	20 (8)	11 (4)	10 (4)	1.90	0.98	0.92
girls	96 (38)	119 (47)	28 (11)	7 (3)	3 (1)	1.82	0.82	
32: the idea that the teacher always tells the pupils exactly what they ought to do								
boys	85 (33)	83 (32)	40 (15)	35 (13)	17 (7)	2.29	1.24	-2.56
girls	45 (18)	94 (37)	53 (21)	52 (21)	10 (4)	2.56	1.12	*

Appendix 4: The rotated factor matrix of items 1–32

The varimax-rotated factor matrix of the items 1–32 in the questionnaire: the main loadings are in bold type and the most important side loadings are underlined.

	factors											
item	1	2	3	4	5	6	7	8	9	10	11	h^2
1	25	02	16	-25	09	-03	26	10	**44**	-27	-05	51
2	-07	06	-28	**-57**	18	11	-11	-12	-07	26	08	55
3	11	03	14	-06	10	-03	12	23	16	-03	**76**	72
4	-08	19	-08	12	-18	25	-35	-04	**37**	-15	00	44
5	08	-06	**63**	00	-15	-05	13	07	11	35	09	60
6	-29	22	02	32	06	-08	-02	13	**57**	11	-17	64
7	09	08	13	-23	14	12	01	10	-04	**71**	-03	63
8	**61**	-08	08	10	12	-08	-01	-11	18	17	08	49
9	40	06	-01	11	-04	00	09	-18	**56**	01	18	56
10	-02	-05	16	-03	14	06	-01	**69**	-02	14	10	56
11	04	11	13	07	**71**	-01	-05	-07	10	02	-04	56
12	18	08	39	-15	12	-12	12	26	20	-02	**-50**	61
13	20	37	06	**56**	03	04	03	-05	17	06	02	53
14	**-45**	18	-05	-10	23	36	-14	-03	02	-16	-08	49
15	39	-09	01	06	30	13	**-68**	21	01	02	-08	64
16	18	-03	**68**	18	07	10	-07	10	04	-02	-01	56
17	-04	-07	-09	04	**55**	-16	05	33	-05	06	14	48
18	**66**	07	23	03	02	08	-02	11	01	-14	-04	54
19	22	23	11	-07	09	-05	-25	-19	**39**	-13	-15	42
20	-11	06	02	**-67**	-20	-04	02	16	00	09	-04	54
21	**37**	-12	-28	16	14	30	**37**	22	10	07	-23	61
22	14	-08	04	03	06	14	09	10	**72**	01	11	60
23	04	-15	30	-10	-09	**58**	21	02	29	15	-10	62
24	03	21	01	05	-07	**62**	-11	-01	-03	02	07	45
25	-11	**75**	07	-05	07	-02	-03	-03	-03	-06	10	60
26	15	09	**54**	-01	34	18	-08	06	-06	-15	02	51
27	09	01	02	20	25	13	**50**	-07	25	-08	03	45
28	-02	**67**	-03	01	02	14	-02	02	16	19	-06	53
29	**55**	-03	14	18	-03	30	05	21	17	-10	-05	53
30	17	04	22	-02	24	33	10	09	07	**-42**	03	44
31	06	**52**	-16	28	-04	16	17	21	-07	-20	-12	53
32	11	13	07	-09	-06	-02	-16	**72**	06	-10	00	60
Ev	3.8	2.2	2.0	1.5	1.3	1.3	1.2	1.1	1.0	1.0	1.0	17.5
Ev%	11.9	6.9	6.2	4.7	4.1	4.0	3.7	3.5	3.3	3.3	3.2	54.8

Appendix 5: The intercorrelations of the factors

The intercorrelations of the 11-factor solution. The bold type indicates that the correlation is statistically very significant (N=514).

factors	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11
F1	1										
F2	.007	1									
F3	**.296**	.070	1								
F4	**-.204**	-.058	-.084	1							
F5	.081	.094	.066	-.030	1						
F6	**.168**	.119	**.202**	-.071	-.009	1					
F7	**-.157**	.057	.000	.079	-.048	.014	1				
F8	.115	.082	**.165**	.020	**.190**	.092	-.006	1			
F9	**.313**	.117	**.180**	**-.171**	**.170**	.110	**-.166**	.114	1		
F10	-.077	-.031	-.044	.109	.036	-.077	-.008	.011	-.026	1	
F11	-.011	-.028	-.063	.024	.073	.088	-.047	.015	.029	.044	1

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