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IMPORTANT PREREQUISITES FOR STUDENTS' MATHEMATICAL ACHIEVEMENT

ÖĞRENCİLERİN MATEMATİK BAŞARISI İÇİN ÖNEMLİ ÖNGEREKLİLİKLER

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ABSTRACT

The overall purpose of this study is to disclose plausible prerequisites for students' success in mathematics. The assumption is that a number of interactional conditions are important for students' achievement in mathematics. Certainly, there are individual differences with respect to intellectual qualifications. However, this study concentrates on contextual aspects in the sense of educational preconditions and family background. A basic assumption is that such aspects may be related to the students' attitudes to the school subject "mathematics" which in turn may influence their performance (grades). In order to verify or falsify these hypotheses, information about students' attitudes towards mathematics, their perception of classroom settings, their parental support as well as their actual achievements was collected. Using data from a national survey including 120 different comprehensive schools, information from 6758 students (school year nine, age about 16) was analysed. The results show that one and the same classroom setting or educational strategy may have a different impact on dissimilar students. To some students, high demands, distinct objectives and invitations to participation can result in positive attitudes to mathematics. However, the same conditions can end up in a negative attitude among students. The reason for this outcome is discussed with reference to students' home situation.

Key Words: Mathematics, learning, teaching, attitudes, achievement.

ÖZ

Bu çalışmanın genel amacı öğrencilerin matematik başarısındaki önkoşulları ortaya çıkarmaktır. Bu çalışma öğrencilerin matematik başarısı için birbiriyle ilişkili bir takım şartların var olduğu varsayımı üzerine kurulmuştur. Gerçek olan şu ki bireylerin zihinsel yetileri arasında farklar bulunmaktadır. Ancak bu çalışma bağlamsal boyutları açısından eğitsel önkoşullar ve aile arkaplanına odaklanmıştır. Temel varsayımlardan biri şudur ki, bir öğrencinin matematik dersine karşı olan tutumu onun başarısını ve aldığı notları etkileyebilmektedir. Bu varsayımları doğrulayabilmek veya çürütebilmek için öğrencilerin matematik dersine olan tutumları, sınıf ortamları ile ilgili algıları, aileden gördükleri destek ve gerçek başarıları ile ilgili veriler toplanmıştır. Ulusal çapta 120 farklı okulu kapsayan bir anket sonucunda yaklaşık 16 yaşlarında 9.sınıfta okuyan 6758 öğrenciden toplanan veriler analiz edilmiştir. Sonuçlar göstermektedir ki aynı sınıf ortamı ve eğitsel strateji, farklı öğrencilerde farklı etkiler meydana getirebilmektedir. Bazı öğrenciler için belirli hedefler, yüksek beklentiler ve katılım yönündeki teşvikler matematik dersine karşı olumlu tutum geliştirmede etkili olurken, aynı durumdaki başka öğrenciler bundan zarar görmekte ve olumsuz tutum geliştirmektedir. Bu çalışmada elde edilen veriler öğrencilerin ev ortamları da göz önünde bulundurularak değerlendirilmektedir.

Anahtar Sözcükler: Matematik, öğrenme, öğretme, tutumlar, başarı

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INTRODUCTION

Cuban (1993), who has in a very interesting overview of the American school system, including descriptions of how teachers taught during the period 1890-1990, concluded that there have been several research studies focusing on teachers, their work and work conditions. However, he holds the opinion that one perspective is missing. "I have pointed out what is missing from the study: information about classroom climate, the impact upon students of different forms of instructions, teacher-student relationships, and the students' perspective on teaching". (p. 286). Certainly, it is not quite correct to say the students' perspective is totally missing in research concerning classroom environment and impact of different forms of instruction. As we will show below, there are studies with reference to forms of instruction, some of them also taking into account the students' opinions (e.g. Granström, 2006). However, we agree with Cuban when he states that it is important to get information from students about their experiences and perspectives on teaching. In this study the aim is to interpret students' experiences and perceptions of different aspects of the classroom settings related to their perception of mathematics as a school subject. We will also relate the students' experiences to their actual performance in mathematics, and to their social background.

School settings and mathematics achievement

There is no common agreement on what defines effective teaching (Tuckman, 1995). A frequent opinion among researchers is that teachers make a difference on students' achievement (Behets, 1997; Fetler, 2001; Ma, 1999, Giovanelli, 2003). Some studies also indicate that there is a correlation between teaching behaviours and student achievement (Lowman, 1996; Patrick & Smart, 1998; Tang, 1997). It looks as though teachers who explain, and listen to the pupil's way of thinking, may be more supportive of students' achievements. Thus, in school mathematics the teachers' mode of handling the meeting between the pupil and the subject seems to be important. Such a meeting can be exploratory or confusing, inspiring or depressing, promote growth or be perceived as an obstacle. The teacher who is the one choosing methods has a strong influence on the learning context and in creating successful meetings between pupils and the subject. Cobb (1998) stresses that the activities in the classroom, the repeated actions in which students and teachers engage as they learn, are important because they come to constitute the knowledge that is produced. There is some evidence that different teaching styles can have different impact on student achievement (Aitkin & Zukovsky, 1994) and that choice of teaching approach can make an important difference to student's learning (Wentzel, 2002). Granström (2006) shows that different teaching approaches in classrooms affect students' benefits from the lessons. Settings where students are allowed to and encouraged to co-operate with classmates and teachers give the students better opportunities to understand

and succeed. Boaler (2002) found that practices such as working through textbook exercises or discussing and using mathematical ideas were important vehicles for the development of delimited mathematical knowledge. One outcome of Boaler's research was that students who had worked on textbooks performed well in similar textbook situations. However, they found it difficult using mathematics in open, applied or discussion-based situations. The students who had learned mathematics in group- based projects were more able to use mathematics in a range of situations. Behets (1997) found that effective teachers spend more time with student activities, less time on teacher instruction, and more time observing pupils. According to Crocker (1986), achievements are reinforced when teachers use (a) substantial emphasis on academic instruction and pupils' engagement in academic tasks, (b) whole-class instruction, (c) effective question-answer and seatwork practices, (d) minimal disruptive behaviour and (e) prompt feedback to pupils. Clarke (1997) argues that successful teachers engage in and focus on pupils' thinking in a whole-class activity. In the interaction with pupils, teachers use questions in order to challenge the children's thinking and reasoning, they do not give the right answers immediately, instead they encourage pupils to describe their thoughts and ideas about mathematics, encourage them to listen and evaluate their classmates' reflections and ideas. Clarke's (1997) ideas about successful teaching differ from Crocker's (1986) results. They also differ from how Swedish mathematics lessons are carried out. A common method in Swedish classrooms is for the teacher to instruct, impart knowledge and have the pupils practise their skills (NU, 2003). One explanation for the differences in research results might be the researchers' definition of mathematics knowledge. The qualities of mathematics to be learned today are more multifaceted than ever before. Kilpatrick et al. (2001) exemplify that by such aspects as *conceptual understanding, procedural understanding, strategic competence, adaptive reasoning*, and *productive disposition.* Case (1996) and Samuelsson (2006) argue that a variation of teaching methods is important because different teaching methods draw attention to different competencies in mathematics (e.g. Boaler, 2002). Thus, the mode of teaching method in mathematics seems to be important for the students' performance.

Different teaching methods also seem to be important to student's attitudes to mathematics (interest, view of the subject's importance, self-perception, attribution) (Boaler, 2002). Students who are expected to cram for examinations describe their attitudes in passive and unattractive terms. Those who were invited to contribute with ideas and methods described their attitude in active and positive terms that were inconsistent with the identities they were developing in the rest of their lives. It is also well known that a student's self-perception, interests and the value they place on doing well, are critical predictors of academic success (Conell, Spencer & Aber, 1994; Eccles, 1993; Fuligni, 1997; Guay, Marrsh, & Boivin, 2003; Valentine, DuBois, & Cooper,

2004). Thus, how students participate in the classroom seems to be an important factor in their outcome.

The importance of teachers' and students' interactions in the classroom is a recurring theme in research on effective schools (Andersson, 1991). Oppendekker and Van Damme (2006) stressed that good teaching involves communication and building relationships with students. The synthesis of meta analysis and reviews of Teddlie & Reynolds (2000) gives evidence for positive relations between achievement and different classroom settings. Significant factors for effective teaching such as *time on task, effective learning time, classroom management, classroom climate,* and *relationships* within the classroom have often been proven in educational research. It is also stressed in research on effective schools that classroom climate is related within non-cognitive outcomes as *well-being, working attitudes, interests,* etc. (Konu, Linton, & Autio, 2002; Opdenakker & Van Damme, 2006).

There is a substantial amount of research that shows how negative attitudes to mathematics affect students' achievements (Wigfield & Meece, 1990; Gierl & Bisanz, 1995; Foire, 1999). Negative attitudes to mathematics are, for instance, influenced by too much individual practice (Tobias, 1987), and teachers who expose students' defective ability (Samuelsson, 2006). Students who do well at school (Chapman & Tunmer, 1997) demonstrate an appropriate task-focused behaviour (Onatsu-Arvillomi & Nurmi, 2000). If the students are reluctant in learning situations, and avoid challenges, they show low achievements (Midgley & Urdan, 1995; Zuckerman, Kieffer, & Knee, 1998).

As can be seen, several studies point to the fact that classroom settings such as *teaching methods, group climate, students participation* and *classroom behaviour* seem to influence the students' achievements, with respect to cognitive as well as non-cognitive outcomes. However, the relationships of how students perceive these factors have not fully been made clear.

Research on effective teaching has been criticised on the grounds where correlations between teaching parameters and students' achievements usually are low (Dunkin & Biddle, 1984). However, even weak correlations can make important differences as the impact of different variables may be additive. Small improvements in a specific area may contribute to a total change in students' achievements (Davis & Thomas, 1989). In this study, our ambition is to investigate the students' perceptions of different classroom settings in relation to their perceptions of mathematics as a school subject, as well as to their actual success, in order to put forward a data-based theory about prerequisites for mathematics achievement.

Social background and mathematics achievement

There are several studies (for instance: Carpenter, Brown, Kouba, Lindquist, Solver & Swafford, 1987; Saxe, Guberman & Gearhart, 1987; Zevenbergen, 2000; Lubienski, 2001) that indicate that students from lower

socio-economic homes do worse in mathematics than their classmates coming from middle or high social strata. Teaching implies that students are socialized into the norms and discourse practices of the mathematics class (Boaler, 1999, 2000). Teachers need to consider differences in social background and fostering students' ability to see themselves as "doers of mathematics" (Cobb, Wood, & Yackel, 1993; Greeno, 1998). A great number of studies have documented that parental perceptions of students' competence predict students' own academic self-concept and performance (Eccles, 1993; Halle, Kurtz-Costes, & Mahoney, 1997; Jussim & Eccles, 1992; Wigfield & Harold, 1992). When parents encourage their child to do maths, for instance, by listening to them, counting together with them and rehearsing their homework, they do better in school, and they also manage daily math situations better (Walkerdine, 1988; Snow, 1992). One important condition for achievement in mathematics is the parent's educational level, which Jones and White (2000) have shown to affect students' achievements in mathematics. In the present study we concentrate on students in school year nine and how parents' educational level may affect student's attitudes to mathematics. Certainly such results are not restricted to maths. Maccoby & Martin (1983) have shown that children from non-supportive homes, with authoritarian parents, tend to perform poorly in school. However, there is no need to question the importance of parents. In this study we sought to find out how encouraging parents affect their children's achievement in mathematics. "Another important contribution to the field of education relates to the empowerment of the parents and other caretakers." (Pelligrini & Blatchford, 2000, p 167).

Thus, more knowledge about the relationship between the home situation, classroom conditions and school achievement is needed. Some researchers (e.g. Cooper & Dunne, 2000; Opdenakker & Van Damme, 2006) have tried to compose models constructed upon the above presented factor but very few have taken students' perceptions or their social background in consideration. In this study, the students' social background will be accounted for in different ways and related to their attitude to mathematics and their perceptions of different classroom characteristics.

THE AIM OF THE STUDY

The overall purpose of this study is to disclose some important prerequisites for students' success in mathematics. We assume that a number of interactional conditions are important for their achievements. Certainly, there are individual differences with respect to intellectual qualifications. In this study, however, we concentrate on contextual aspects in terms of educational preconditions and family background. A basic assumption is that such aspects are related to the students' attitude to the school subject "mathematics" which in turn may influence their performance (grades). Thus, the hypotheses, formulated as four research statements, are as follows.

1. There is a relation between students' success in mathematics (in terms of grades) and their attitude to mathematics as a school subject.
2. Students' attitude to mathematics is related to the mode of arranging the classroom setting.
3. Students' attitude to mathematics is also dependent on their family background (parents' educational level, interest and support).
4. Knowledge about the above postulated relationships can be a base for formulating a tentative model of successful mathematics acquisition among students.

METHOD

In order to verify or falsify the hypotheses formulated above, we need information about students' attitudes towards mathematics, their perception on classroom settings, their perception on parental support, as well as their actual achievements. The National Agency of Education has by order of The Swedish Department of Education collected a lot of data about Swedish schools. The purpose of this research is to create a general picture of the compulsory school and its outcome. A similar evaluation took place in 1992. One argument for a new evaluation in 2002 was changes in society including the school system and teacher education. To get a wide scope of the situation in Sweden, a survey study with pupils, teachers and parents as informants was carried out. The questions concerned areas such as attitudes to different subjects, organisation, time use, teaching methods etc.. Results from this national survey including 120 different comprehensive schools, data from 6758 students (school year nine, age about 16) were utilised in this study. The data were selected from the larger national questionnaire study administered by the National Agency for Education. However, this study is restricted to the students' attitudes and opinions.

Furthermore, as about one hundred statements composed the entire instrument, we just used items relevant to our research questions. Twelve questions concerned the students' *attitude to maths*. Items giving information about the students' perception of the *learning environment* amounted to 35, and five items accounted for students' perceptions of *parental support* of the students' school attendance. All items in the questionnaire were presented as statements, to which the students had to respond on a four-point scale (don't agree = 1; totally agree = 4). Students' grades were collected from statistics available in Sweden.

Data analysis

To be able to verify our hypothesis, a number of multiple regression analyses were carried out. These analyses made it possible to estimate the relationship between multiple independent variables and one dependent variable. Each of the factors of *perceived school settings, perceived home situation* and *attitude to mathematics* was used as an independent variable in

the regression equations. The dependent one was *math achievement*. The data analyses were made in three steps. (a) The attitude to mathematics was related to students' achievements. (b) Students' perceptions of the school settings were related to their attitude to mathematics. (c) Students' perceptions of their home situation were related to their attitude to mathematics. Thereby the relationship between different environmental aspects and attitude to mathematics can be scrutinised. Reliability test (Cronbach α) was carried out on each factor.

Because of a large number of tests made in the regression analyses and a large number of students, quite small correlations may be statistically significant ($p<.05$). Therefore, Bonferroni's correction for setting the alpha level of $p<.05$ was used. The outcome of Bonferroni's test suggested an alpha level lower than $p<.007$. With reference to Bonferroni we only comment on correlations at a significance level of $p<.001$.

RESULTS

Students' attitudes to mathematics related to their achievements

The first hypothesis predicted a relationship between the students' attitude to mathematics and their achievements. This is not a daring assumption; nevertheless, it has to be proven. The analysis was carried out by use of the following components.

Students' attitudes: One section of the entire questionnaire dealt with students' attitudes to mathematics as a school subject, 12 items in all. Principal component analysis completed by a Varimax rotation factor analysis resulted in two factors (49.2% of the variance was explained, eigenvalues were 3,9 and 2,0). Six items were loaded on a factor that could be labelled *positive attitude (*α=0,83), as all items concerned positive experiences of mathematics. Six items were loaded on a factor called *negative attitude (*α=0,69) (Appendix 1). These items gave vent to negative feelings. Boaler (2002) also uses factors such as a positive and negative relationship with mathematics, which indicates that our parameters fit the discourse.

Students' achievements: The Swedish school system is goal-directed which means that the education is governed by objectives. The students' grades are to be related to these objectives, which are competencies important in mathematics. Our data accounted for the students' grades in mathematics, which are divided into four steps, from failed (1), passed (2), passed with distinction (3) to superior (4).

The analysis, with reference to the first hypothesis, concerned the relation between the students' attitude to mathematics and their grades. All standardized regression coefficients for the equation are shown in Table 1. The multiple regression coefficient is R= 0.46, $F(2, 5566)=736,5$, $p< .001$.

Table 1: Correlation Between Attitude to Math and Mathematics Achievement

Attitude	correlation	t-value
Positive	.203	16,4***
Negative	-.357	-28,8***

*p<.05; ** p<.01, ***p<.001

The result very clearly shows that there is a relationship between students' grades and their attitude to mathematics. Positive attitudes seem to affect students' achievement in math in a positive way, while negative attitudes affect students' performance in maths in a negative way. It is also obvious that negative attitudes predict a student's grade in mathematics twice as much as positive attitudes. Thus, the first hypothesis, stating that there is a relation between students' success in mathematics (in the sense of grades) and their attitude to the subject, has been supported. Thereby the following research question remains still more interesting. What conditions may influence the students' attitude to maths? This question is dealt with in the next two sections.

Classroom settings related to students' attitudes to math

1. *Classroom settings.* Teachers arrange the classroom setting in different wayn order to facilitate learning and practice. This could be seen as part of the learning environment. The questionnaire accounted for the students' perceptions of such learning conditions. As many as 35 items were relevant to this study. Principal component analysis followed by Varimax rotation on all 35 items revealed seven factors (54.3 % of variance explained; eigenvalues = 8,1; 3,3; 1,8; 1,6; 1,4; 1,1; 1,1). The seven factors were labelled as shown below. The 35 items and the factor loadings are displayed in Appendix 2.
2. *Group climate.* This factor is signified by a perception of supportive classroom conditions where students help each other, the teacher encourages, and there is a positive and fair atmosphere (α=0,84).
3. *Participation.* Indicates that the students are invited to influence their work conditions (α=0,87).
4. *Understandable objectives.* High values show that the teacher evidently communicates objectives and expectations (α=0,75).
5. *Variation.* High values indicate that the teacher uses a variation of work methods such as projects, group tasks and authentic materials, and low values show that students are mainly practicing individually (α=0,63).
6. *Disruptions.* Concerns off task behaviour in the classroom (α=0,76).
7. *Instructions.* High values show that the teacher makes use of whole class lessons to talk and discuss with the students (α=0,72).
8. *Demands*. High values mean high demands and pronounced expectations from the teacher (α=0,54).The statistical analyses

concerned the relations between the above environmental factors and the students' attitudes to maths. In Table 2 the results are presented with respect to positive and negative attitudes.

Table 2: Relationship Between School Settings and Attitudes to Mathematics

Classroom settings	Positive attitude		Negative attitude	
	Correlation	t-value	Correlation	t-value
Group climate	.30	17,47***	-.18	-11,04***
Participation	.01	.45 ns	.08	5,25***
Understandable objectives	.04	2,12*	.06	3.35***
Variation	-.09	-5,86***	.02	.19 ns
Disruptions	-.01	-.57 ns	.16	12,26***
Instructions	.06	3,99***	.06	4,14***
Demands	-.24	-16,98***	.39	30.86***

*p<.05; ** p<.01, ***p<.001

All standardized regression coefficients are shown in Table 2. Below the results are summarised with respect to positive and negative attitudes separately.

Classroom settings related to a positive attitude to mathematics. The multiple regression coefficient was significant R= 0.44, $F(7, 4909)=173$, $p<$ .001. This implies that there is a relationship between classroom conditions and students' positive attitude to math. This relationship seems to be explained by four of the factors. A positive attitude to maths is positively correlated with a *supportive group climate*, and *whole class instructions*. However *high demands* and *varied work methods* seems *not* to support a positive attitude to math, rather contrariwise. A noisy classroom and participation have no relationship to a positive attitude.

Classroom settings related to a negative attitude to math. The multiple regression coefficient was significant also in this case, R= 0.51, $F(7, 4903)=243.8$, $p<$ .001. The relationship between contextual factors and negative attitude to math is explained by a *lack of supportive group climate, disruptions, high demands* and *understandable objectives*. Request or invitation for participation is also related to a negative attitude and so are *whole class lessons*. *Group work* and *projects* do not seem to affect the attitude.

To sum up. The group climate in the classroom seems to be important to the students' attitude to maths. A supportive climate is related to a positive attitude, while a non-supportive climate is related to a negative attitude. Students with a *negative attitude* to mathematics perceive the school as demanding in terms of objectives, with expectations of being active in whole class lessons. They are also easily disturbed by disorder in the classroom. Students with a *positive attitude* do not seem to be disturbed by disorder, but

they take advantage of traditional whole class lessons more than group work. They also perceive the demands as low and manageable.

Students' perceptions of parental support and attitude to math

The above analyses confirmed a relationship between teacher-governed aspects of the students' learning conditions and attitudes. Whether there is a relationship between parental support and attitude was investigated in a third analysis.

There were five items in the questionnaire about the parents' support of their children's school attendance. A principal component analysis followed by Varimax rotation resulted in a two-factor solution (64.7 % of variance explained, eigenvalues=2,0; 1,3). Three items were loaded on a single factor called *supportive homes* (α=0,72), and two items were loaded on a factor *no interest in schoolwork* (α=0,52) (Appendix 3).

The parents' educational level was accounted for (the father as well as the mother) in six steps; (1) compulsory school less than 9 years, (2) compulsory school 9 years, (3) upper secondary school, (4) less than two years at university, (5) two years or more at a university, (6) Ph D degree. Thereby, four aspects concerning home conditions were available. In Table 3 the results are shown.

In the concluding analysis, students' attitude to mathematics was related to their perceptions of the home situation and their parents' educational level. All standardized regression coefficients for the equation are shown in Table 3. Both positive and negative attitudes to mathematics are in some sense related to the home situation.

Students with a positive attitude to mathematics: The multiple regression coefficient with respect to a positive attitude is R= 0.18, $F(4, 4887)$=40,5, $p<$ .001. In this case the relationship between attitude and home situation seems to be explained by a supportive home and the father's educational level. Thus well-educated fathers and a supportive climate seem to reinforce a positive attitude to mathematics as a school subject.

Students with a negative attitude to mathematics: The multiple regression coefficient, in this case, is R= 0,12, $F(4, 4883)$=17,0, $p<$ .001. Parents who show no interest in their children's school work tend to affect students towards developing negative attitudes to mathematics as a school subject. A father not well-educated seems to be a predictor of students' negative attitudes.

Table 3: Relationship Between Home Situation and Attitude to Mathematics

Home situation	Positive attitude		Negative attitude	
	Correlation	t-value	Correlation	t-value
Supportive homes	.15	10,73***	-.33	-2,29*
No interest in school	-.02	-1,24 ns	.05	3,78***
Educational level:				
Father	.09	5,67***	-.07	-4,64***
Mother	-.10	-.66 ns	-.04	-2.31*

p<.05; ** p<.01, ***p<.001

To sum up, Students with a positive attitude to mathematics seem to come from well-educated homes (with respect to their fathers). They have parents with an interest and a supportive attitude to school matters. Students with a more negative attitude to mathematics come from homes with a less educated father and from homes with little interest and support as to school matters.

DISCUSSION

The purpose of the present study was to scrutinise how students' perceptions of school settings and their home situation may influence the students' attitude to mathematics, which in turn is considered to influence their achievement in this subject (in terms of grades). Even though there are critics who argue that there is usually a low correlation between teaching conditions and students' achievement (Dunkin & Biddle, 1984), we found a number of rather evident relationships. The variance explained by the school settings ranged from 20% to 26% with reference to attitudes to mathematics as a school subject. Corresponding values as regards the home situation were 1% and 3%. However, the correlations between home situation and achievements are statistically significant which makes them interesting. Factors that affect students' achievement are considered to be additive (Davies & Thomas, 1989), which means that a change in one or several aspects can be important for improvement of the students' attitudes and their learning.

From the analyses above the following tentative model can be formulated. The model is based on the factors and relationships disclosed in this study and assumes different explanations for success and failure. The model is summarised in Figure 1.

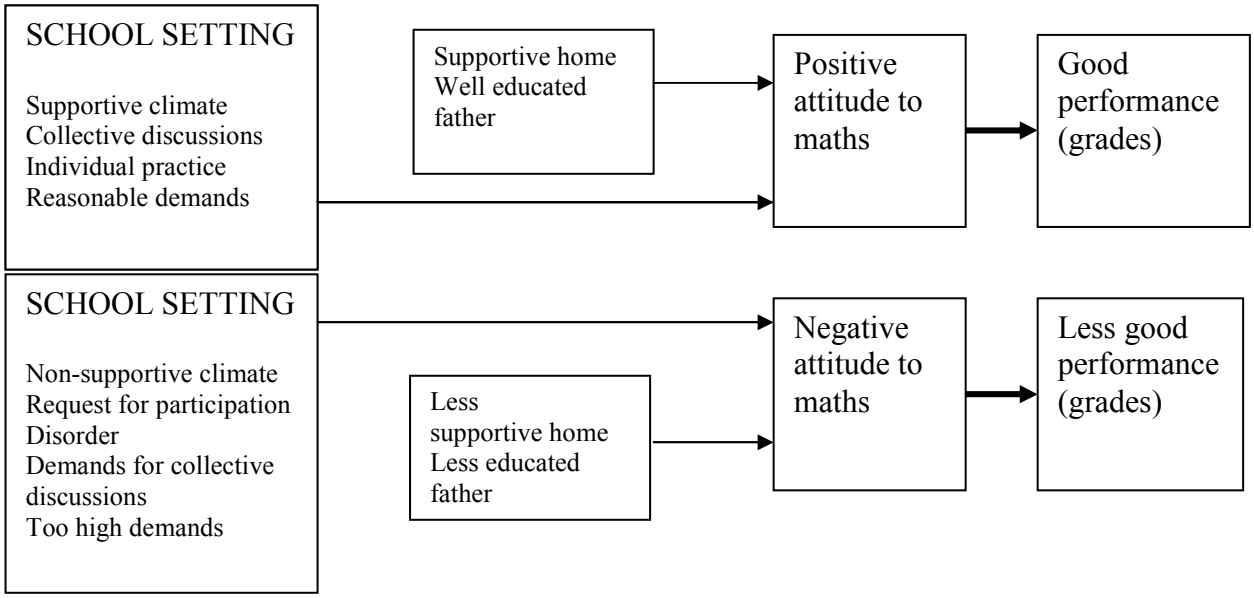

Figure 1: A Tentative Model for Explaining Success in School Mathematics Interpretations and Implications

The analyses presented in this study give evidence for a bipartite explanation of the grounds for attitudes to mathematics. In order to understand the students' perception of different classroom aspects, their home situation needs to be taken into consideration. Students from homes not so interested in the child's school attendance seem to have a more negative attitude to mathematics than students from more supportive and well-educated homes. However, the students also perceive the classroom setting in different ways. Probably there is an interrelationship between student's perceptions of their home situation, their perceptions of school settings and their attitude to mathematics. This implies that aspects of the school setting, which are related to a positive attitude in supportive homes, will not necessarily have the same impact for students from homes uninterested in school matters.

The present study is based on statistical correlations, it does not account for *causal* relationships. However, the results can be used for tentative causal interpretations. Thus, the following interpretations seem to be plausible and a possible starting point for further studies.

Students with a negative attitude to math: Our findings are in line with other researchers (e.g., Wigfield & Meece, 1990; Gierl & Bisanz, 1995; Foire, 1999) who argue that a negative attitude to math affects students' achievement in a negative way. If students' beliefs are negative they will not be persistent in learning situations and avoid challenges (Midgley & Urdan, 1995; Zuckerman, Kieffer & Knee, 1998), which will cause low achievement.

The negative attitude to mathematics seems to be reinforced by classroom arrangements that are perceived as *demanding*. This could mean demanding objectives, difficult tasks, and/or teachers' requests for their

participation in discussing plans and in whole class discussions. The negative attitude also seems to be related to a lack of peer and teacher support and to classroom disorder.

A learning environment signified by *high demands seems to affect these students' attitudes in a negative way*. It is obvious that teacher's mode of arranging the classroom setting makes a difference (Behets, 1997; Cobb, 1998; Ma, 1999; Fetler, 2001; Boaler, 2002).

Apparently, a negative attitude is also related to perceived demands to *participate in decisions regarding working methods in the classroom and the learning content*. The results of the study illustrate the importance of having a professional teacher who is able to argue for a specific content and reasonable methods rather than imposing demands on the students, especially students from non supportive homes. If a teacher has knowledge about math as a subject and knowledge about how to teach mathematics, how to choose content, and working methods, it is reasonable that he or she may draw the students' attention to objectives without threatening the students. This study points to the importance of a teacher who can support students taking part in discussions concerning method and content.

Students who have a negative attitude to mathematics seem to be uncomfortable when they have to *participate in whole class discussions*. A plausible explanation for this could be that their weakness in mathematics will be exposed in such situations. Students with low confidence in their mathematical ability will probably perceive their problems embarrassing in whole class lessons. Due to their home situation, they may not be used to participating in conversations like that.

Disruptive behaviour has a negative effect on students' achievement (Crocker, 1986). In this study it is also clear that *disruptive behaviour is related to students' attitudes* in a negative way. The negative attitude is also related to *lack of support from parents* (cf. Walkerdine, 1988; Snow, 1992). These experiences could fairly well be explained by what Bernstein (1971) calls different codes. Students not used to discussing school matters at home may not be familiar with the school code, in terms of objectives, collective planning and discussions. They do not perceive such activities as supportive in their mathematics learning. On the contrary, such elaborated school concepts are not in line with their home experiences. Thus, as these students are not familiar with the school code they feel uncomfortable in situations where the teacher makes this code explicit. The students seem to perceive such expressions as insuperable demands and therefore become easily disturbed.

Students with a positive attitude to math: A positive attitude to mathematics seems to be related to a supportive group climate and expectations and willingness to take part in whole class discussions (e.g. Andersson, 1991; Teddlie & Reynolds, 2000; Konu, Linton, & Autio, 2002; Opdenakker & Van Damme, 2006). However, group work and projects do not seem to reinforce these students' attitudes to mathematics.

The results of this study show that *a supportive group climate* makes a small but statistically significant positive contribution to these students' positive attitudes. Clarke (1997) as well as Boaler (2002) showed that teachers who encourage students to listen to each other and express their thoughts had a positive effect on a student's mathematics achievement. Also, this study discloses a statistically significant relation between peer support and students' positive attitude to mathematics as a school subject.

As has been shown, students with positive attitudes seem to prefer *whole class discussion* to group work. One explanation could be that students with a positive attitude and a good mathematical ability get positive feedback in a whole class discussion. In such situations their performance becomes visible and reinforced.

The relationship between group work and project work on the one hand and mathematics achievement on the other hand indicates the importance of working procedures. This means that a motivated student who works alone with skills training, rather than participating in group work, seems to develop a positive attitude to mathematics. This outcome is contrary to that of Tobias (1987), who argues that too much individual practice could end up in a negative attitude to mathematics. Our study shows that Tobias' conclusions seem to be valid for students with a negative attitude, while the reversed condition is true for those with a positive attitude to maths.

This study also stresses the importance of well educated parents, at least *a well educated father*, in order to succeed in mathematics (cf. Jones & White, 2000). A father with a high education probably doesn't see mathematics as something difficult; thereby he will provide his child with positive attitudes, which is a prerequisite for doing well in maths. The school code (Bernstein, 1971) seems to be well adapted to students coming from well-educated and supportive homes. To state it explicitly: teachers have no problems in educating motivated students from well educated homes.

Different strategies are needed for different students: As a consequence of the results presented above, one and the same classroom strategy may have a different impact on different students. To some students, high demands, formulated objectives and invitations to participation can result in a positive attitude to mathematics. However, the same conditions can end up in a negative attitude among other students. The explanation for these differences is probably to be found in the language used in the classroom (Bernstein 1971). Teachers may easily transmit objectives and tasks to students from well educated homes, while they have problems in communicating demands and objectives and arranging discussions that engage students from homes with a low interest in school matters. Thus, increasing the demands and requests for participation will probably stimulate the already empowered students, but will increase the resistance among students with a negative attitude. Surely, there is no problem in motivating those already motivated with well-tried strategies. As such strategies seem to be counter-productive to less motivated students;

other strategies have to be chosen. This study indicates that group work and projects seem to be more suited for students with negative attitudes to mathematics than individual work and whole class lessons. In group work the students are free to consult their classmates using their own language. Exposing weakness is not so frightening in a small group outside the teacher's range of hearing. Probably, whole class lessons and individual work exclude students not familiar with the school code, while students from well-educated homes take advantage of such settings. Thus, "traditional maths lessons" seem to reinforce those already complying, while such lessons seem to increase the resistance to maths among those who are uncertain. Consequently, it seems reasonable to compose classroom settings that promote not just the already empowered, but also those in need of support.

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Appendix 1

Table 4: Items related to different factors of attitude to maths as a school subject

Components	Question	Loading
Positive attitude	1) I'm interested in mathematics	0.592
	2) It is important to have maths knowledge	0.805
	3) Adults think maths is important	0.695
	4) Maths knowledge is important in future education	0.793
	5) Maths knowledge is important in future work	0.737
	6) I am going to use the maths I learn in school	0.747
Negative attitude	1) I only work with maths to pass tests	0.630
	2) Too much time learning mathematics	0.507
	3) Mathematics is a difficult subject	0.652
	4) I give up if the task is too difficult	0.735
	5) I could have been better in math if I had tried more	0.574
	6) I've learned a lot of unnecessary knowledge in maths lessons	0.590

Appendix 2

Table 5: Items related to different factors of the learning environment at school

Components	Question	Loading
Group climate	1) I am pleased with the support I've received in year 7-9.	0,665
	2) Nice, positive climate.	0,445
	3) My suggestions are taken seriously.	0,493
	4) I speak to the teacher if I have problem with mathematics.	0,522
	5) I receive the support I need.	0,761
	6) The teacher has time to help me, if I need help.	0,727
	7) Maths is a subject where students help each other.	0,487
	8) The teacher supports and encourages me.	0,699
	9) It is possible to show my skills in maths.	0,653
	10) The teacher gives me correct grades.	0,608
	11) I've learned most of my maths skills in school.	0,404
Participation	1) The teacher plans the activities with students.	0,607
	2) The students influence the selection of content.	0,808
	3) The students influence the selection of method.	0,782
	4) The students influence how long they will work on a task.	0,803
	5) The students influence the maths tests.	0,669
Understandable objectives	1) The teacher investigates students' maths skills before he/she starts to teach a new topic.	0,452
	2) The students are informed of what they should learn according to the national curriculum.	0,753
	3) The teacher communicates his/her expectations to students.	0,744
	4) The students are informed of what they should know according to different grades.	0,734
	5) The teacher and student communicate about the student's achievement in math.	0,357
Variation	1) The students work in groups.	0,726
	2) The student works on individual tasks.	-0,411
	3) The students work on projects.	0,725
	4) The student work on tasks out of the textbook.	0,517
Disruptions	1) The students do not listen when teacher talks	0,777
	2) Noise and disorder.	0,840
	3) It takes a long time to start studying during lessons.	0,793
Instructions	1) The teacher talks, the student listens.	0,835
	2) The teacher talks, asks questions, the students answer.	0,845
	3) Teachers and students discuss maths problems.	0,543
Demands	1) I've been working with too many easy tasks in year 7-9.	-0,280
	2) I have been working with too many difficult tasks in year 7-9.	0,625
	3) The teacher has too high demands on me	0,589

Appendix 3

Table 7: Items related to different factors of the learning environment at home

Components	Item	Loading
Supportive homes	1) They help	0,723
	2) me with my homework	
	3) They ask about achievements in tests	0,827
	4) They show interest in school	0,816
No interest in school	1) They don't think studies will pay off	0.802
	2) My parents think school is my own business	0.743