THE RELATIVE INFLUENCE OF THE TEACHER IN THIRD GRADE MATHEMATICS CLASSROOMS

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Whereas different studies have each emphasised the importance of different variables for productive mathematics learning, this study has found the teacher to be of major importance. In the 13 third grade classrooms of five different elementary schools students' feelings about mathematics and their performance in routine and novel problems were examined. No strong links could be found between levels of positive or negative feelings about mathematics and performance in routine or novel problems, and neither between gender and any of the other items. There were, however, major differences in some items among the different classes in the same school, indicating that the teacher plays a crucial role in matters such as students' feelings towards mathematics, performance in routine and novel problems, and the occurrence of systematic errors.

INTRODUCTION

In the past number of decades, much effort has gone into investigating the effects of different variables on students' mathematical learning, for example mathematics anxiety, gender, the teaching approach, the teachers' content knowledge, etc. However, some of the research studies produce seemingly conflicting results on the relative importance of the different variables.

For example, it is not only popular belief but also substantiated by a number of research studies that mathematics anxiety has a detrimental effect on students' mathematical performance, that problem solving is more sensitive to mathematics anxiety than routine computation, and that girls suffer more from mathematics anxiety (and are better at routine computations and worse at problem solving) than boys (e.g. Wood, 1988; Fennema, Peterson, Carpenter & Lubinski, 1990; McLeod, 1994). Yet three overviews on research about mathematics anxiety (Wood, 1988; McLeod, 1994; Ma, 1999) report mixed results on the effects of mathematics anxiety on students' mathematics learning, because, according to Ma (1999) "…the relationship can change dramatically for students with different social and academic background characteristics" (p. 536). Students with different approaches to learning also experience learning environments in different ways, for example field-dependant learners and learners with surface approaches to learning feel more comfortable with structured, externally regulated environments (Vermetten, Vermunt & Lodewijks, 2002), whereas deep-level learners may experience irritation and frustration in such environments.

In the same way, the importance of the teacher in the learning environment has been brought into question by some studies and then again affirmed by others. After a large-scale comparison of primary schools' levels of performance in the United Kingdom, Lake (2001) concludes that "…the major influences on children's school performance clearly stem from outside school" (p.65) and that "differences in educational standards among primary schools are predominantly due to background wealth and health differentials" (p. 59). Brown, reporting on the Leverhulme Numeracy Research Programme, states that “teaching and teachers have a rather small effect on pupils’ gains…at most 10% of the variance in attainment” (p. I-26).

However, those studies where students themselves were interrogated as to the reasons for their attitudes towards and achievement (or lack of it) in classroom mathematics, ascribe a major role to the teacher (for example, Jackson & Leffingwell, 1999; Quilter & Harper, 1988). In line with these studies, in 2001 and 2002 I requested our university’s B.Ed first year students to write a response to the question: “Which was your worst or most unpleasant year (or topic or semester) in school mathematics? Try to describe the reasons for your choice as clearly and honestly as possible”. These students are following a four-year degree course in elementary school education, come from stable, disciplined schools and obtained a good pass-mark in their twelfth-grade national school leaving examinations. In both groups, at least 90% of the students also elected and passed mathematics as twelfth-grade subject.

In both year groups, the “worst” grades nominated were spread over grades 1 to 12, and students indicated that their marks had also suffered in these years. The reasons given were as follows: (The two percentages refer to the 2001 and 2002 groups consisting of 77 and 63 students respectively.)

> the teacher (72%, 70%)
>
> the student wanted to make sense of the mathematics, but was not encouraged to do so, or the student was required to memorise methods and/or facts, but could not/would not learn in that way (8%, 8%)
>
> the mathematics was too difficult (10%, 14%)
>
> external factors such as changing schools, family crises, no friends in the class, unhappy in the school (10%, 8%).

The majority of students therefore experienced the influence of the teacher to be very important. The reasons given for teachers’ negative effects on students’ learning involved teachers’ lack of mathematical and pedagogical content knowledge, teachers’ lack of classroom management skills and discipline, and teachers’ unpleasant behaviour towards students, ranging from impatience to destructive personal remarks (by far the most common reason).

In the face of the conflicting reports on what affects students’ learning, we can only conclude that productive learning environments are indeed sensitive to many interrelated influences. As teacher trainers, however, we also need to be aware of what type of information can be of use to teachers, and I believe that making teachers aware of the impact they can and do have, is more important than concentrating on the influence of the home and locality of the students on students’ achievement.

In the study reported here, I have attempted to study the teacher as a variable in the mathematics classroom. For this purpose, five different schools providing for children from different socio-economic backgrounds were chosen, and written tasks including items on “feelings towards school mathematics” and items on mathematical problems were presented to their Grade 3 classes. Since these schools reshuffle their classes at the beginning of each academic year to create similar groups (i.e. the opposite of streaming or setting), it was hoped that if classes in the same school were then compared, differences in feelings and performances could be attributed more to the effect of the teacher than to other (outside) influences.

The aims of this study were to gather information on:

- Gender. For example, are girls better at routine problems and boys better at novel problems? Are girls more prone to anxiety? Are some classrooms more conducive to girls' learning (or boys') than others?
- Feelings about mathematics. For example, do classes where students feel positive about their mathematics do better, or do they do better in specific problems but not in others?
- Differences among classes in the same school. To what extent do classes in the same school differ and in which ways do they differ? To what extent, therefore, is the teacher a factor in young students' mathematics learning?

METHOD

Five schools were chosen for this study because they reshuffle their classes at the beginning of each academic year and because among the five of them, they represent a range of teaching approaches to mathematics. Each class therefore contains a fairly evenly distributed balance of abilities, gender, socio-economic and home backgrounds and emotionally disturbed children (school B).

All 13 Grade 3 classes in the schools were involved, the class sizes ranging from 22 to 30 depending on the size of the school.

THE SCHOOLS

The five schools involved in this study will be called A, B, C, D and E. School A is a large elementary school in a large country town. The teaching approach is traditional. Schools B and C are also situated in country towns and use a teaching approach which welcomes students' informal methods and encourages some informal and whole-class discussion and feedback, but the teacher features strongly as arbiter and leader. Schools D and E are affluent suburban schools in a city, where the teachers are committed to implement a problem-centered approach to mathematics teaching and learning (Murray, Olivier & Human, 1998).

All five schools are stable, disciplined and well-organised. The principals of schools B, C, D and E are supportive of their staff and accessible to the students. The schools are multiracial but all students receive instruction in their home language except for the English-medium school D, where there are four or five African students in each class who receive their instruction in English.

The students of schools A, B and C are mixtures of very different socio-economic backgrounds. School B in particular includes children from a children's haven which harbours emotionally and physically abused children, which comes to approximately three children per classroom.

All the teachers involved have similar school and teacher training qualifications. None were novice teachers.

The situation is therefore such that, although the schools themselves and their students and parent populations are different, the classrooms in each school are quite similar as regards students.

THE WRITTEN TASKS

The tasks were presented to the students during the sixth month of the academic year. The items addressed the following:

Students' feelings about the mathematics classroom. Students were requested to complete a number of sentences. In this report, the following sentences were used:

Item 1a) When we do mathematics, I feel …

1b) When I have to do a difficult mathematics problem, …

Routine calculations. Context-free two-digit addition, subtraction and multiplication problems involving "borrowing" and "carrying".

Division problems. A contextualised quotitive (grouping) problem ($100 \div 23$) and a contextualised partitive (sharing) problem ($96 \div 6$).

Proportional sharing. This contextualised problem involved dividing 20 in the proportion of 3:1. It may seem extremely easy, but very few of our lower elementary teachers think of posing this problem type, and the problem may therefore be regarded as novel (i.e. strange to the students).

Pattern extension. The first four dot configurations of a sequence are given. Students must then work out how many dots will be used in the fifth and then the twentieth configuration. This is regarded as a novel problem.

We also made provision for students to write free comments on their mathematics classroom and to draw a picture, but some schools could not give us time for this to be completed and they were therefore not taken into account.

In school B, one student from each class was interviewed, and the information obtained during the interview matched the student's responses to the written test exactly. In school B, the teachers also completed a beliefs questionnaire, but their expressed beliefs about pedagogical matters like how weak students should be handled, the role of memorization of facts, etc. were not substantiated by the information gained during their students' interviews nor by classroom observation and videotapes of their mathematics lessons. It was therefore decided not to use the teachers' questionnaires.

RESULTS

Students' responses to the written tasks were coded so that the way in which the student solved the problem, misconceptions, faulty reasoning, guesswork, etc. were preserved. These data were accumulated for each classroom, by gender and also for each classroom as a whole.

Students' responses for items 1a) and 1b) (completing the sentences) were coded as positive or negative only when students expressed themselves strongly. "OK" was not coded as positive, and "a bit uncomfortable" was not coded as negative.

Those responses for the mathematical items which showed flawed reasoning based on misunderstood properties of numbers and operations were later clustered under "systematic errors". Systematic errors therefore do not include careless mistakes, but are rather of the following type:

42 – 28 = 10 because 40 – 20 = 20

20 – 8 – 2 = 10

FEELINGS ABOUT THE MATHEMATICS CLASSROOM

The sentence "When I do mathematics, I feel …" gave what we feel to be a falsely positive impression which did not match the students' responses to item 1b), "When I have to do a difficult mathematics problem, …". We had a similar experience in an earlier study (Murray, Olivier and Human, 1994), where students were invited to write free comments on their mathematics classrooms. Many would start off by saying "I love mathematics", but then continue by describing anxiety and fear. In this study, for example, in classroom B, school B, 86% of the students claimed that they felt good or great when doing mathematics, but 75% said that they were frightened, wanted to cry, wanted to run away, etc. when they had to do a difficult problem. We therefore take item 1b) responses as better indicators of students' real feelings.

Some responses for item 1b) show great distress, for example:

"I feel terrible"; "I feel like crying"; "I want to scream"; "I am scared".

Some positive responses were:

"I make a plan"; "I use my head and think it out"; "I am happy because I like difficult problems".

In each of schools A and B one of the classes had a much higher negative count than the other two classes in the same school, and these classes had a slightly lower success rate for most but not all of the mathematical items, including the novel problems. These classes did not have a higher incidence of systematic errors than the other two classes in the same school.

GENDER

In nine of the 13 classrooms girls' and boys' success rates were very similar, or girls might do slightly better in one or two items and boys slightly better in another one or two items.

In school B, classroom A, girls did better in the subtraction, quotitive division and proportional sharing problems (differences of 19, 18 and 46 percentage points).

In school D, classroom A, boys did significantly better in the division problems and in the proportional sharing (differences in success rate of respectively 42, 30 and 23 percentage points), yet girls obtained a 25 percentage point gain over the boys for the more difficult pattern extension problem. This was also the only classroom where there was a significant difference between the "positive about mathematics and difficult problems" count for boys and for girls (boys 38 percentage points more positive).

DIFFERENCES AMONG CLASSES IN THE SAME SCHOOL

There was little difference between the two classes of school E. In school A, the one class had a very high count of negative feelings (more than three times that of the other two classes) and its success rates on the mathematical items were slightly lower than those of the other classes. School B classes showed major differences in the following items:

Classroom	A	B	C
negative feelings	36%	75%	21%
success rates for subtraction	55%	78%	100%
quotitive division	18%	50%	79%
partitive division	68%	50%	75%
proportional sharing	32%	21%	79%
pattern extension a)	36%	32%	58%
pattern extension b)	5%	4%	29%
systematic errors for subtraction	45%	21%	0%
quotitive division	69%	49%	21%

School C's two classes had different success rates for subtraction (62%, 80%) and proportional sharing (48%, 84%). School D classes differed as follows:

success rates for			
quotitive division	87%	51%	81%
partitive division	61%	78%	95%
pattern extension a)	87%	43%	62%
systematic errors for			
partitive division	35%	21%	5%

Given the situation, we can only ascribe these differences in negative feelings and in performance among the classes of the same school to the influence of the teacher.

DISCUSSION

This study has not brought gender differences to light as regards feelings about mathematics, routine tasks or novel (problem-solving) tasks. In only one of the classes boys performed significantly better than the girls in most items and were also significantly more positive about mathematics, yet girls did better in the more difficult problem solving item. In all twelve other classes the success rates for boys and girls were very similar or girls scored slightly better.

As regards feelings about school mathematics, two of the thirteen classes showed high levels of fear or discomfort, but this did not lower the success rates for the mathematical items to a great extent as compared to the other classes of the same school. It is, however, extremely disturbing that these children are caused much distress by adults who are supposed to have their best interest at heart. Unfortunately such unpleasant experiences may have lasting effects on students' learning. Many of my first-year students wrote that their "worst year" was something they never recovered from (compare also Jackson and Leffingwell, 1999).

As regards the mathematical items, the effect of the teacher could first of all be seen when the class performs badly in a contextualised problem with a specific mathematical structure. For example, class A in school B scored only 18% for quotitive division, which is much lower than the other classes and also much lower than their own score for partitive division. Since schools B, C, D and E do not "block" the operations (e.g. three months of addition, followed by three months of subtraction, etc.) but mix the problem types, the excuse cannot be that they have not dealt with that particular problem type yet, but rather that the teacher had neglected to include the problem type in her mix. The same problem with quotitive division surfaces in school D, class B, but not as severely. This emphasises the responsibility of the teacher to make available to her students the necessary opportunities for becoming familiar with different important mathematical structures.

The effect of the teacher on the development of systematic errors is well illustrated by the relatively high incidence of systematic errors in school D, class A, for partitive division, whereas in school B, class A, subtraction and quotitive division have very high incidences of systematic errors.

Systematic errors can develop when students imitate the teacher or a classmate's method without understanding, or when the methods constructed by the students are not sufficiently discussed and reflected on. Students may also misapply a technique because when it was first used (correctly), it did not provoke any argument from other students and the teacher therefore did not think it necessary to spend time on discussing it. For example, this works:

$27 \times 16 = 27 \times 10 + 27 \times 6$
so let us do the same here:
$360 \div 16 = 360 \div 10 + 360 \div 6$

Systematic errors may also occur as a result of limiting constructions being formed by students through limited exposure to a concept or through experiences of a particular (limited) kind (Murray, Olivier & Human, 1998). The above error could also have developed if students had for some time been solving addition and multiplication problems involving two- and three-digit numbers, but division problems limited to only single-digit divisors.

IN CONCLUSION

This study has found no gender-related differences in performance for different types of mathematical tasks among Grade 3 students, which encourages the idea that such differences reflect learnt behaviour and can be prevented. There does not seem to be a clear inverse relationship between negative feelings towards school mathematics and performance, but when other research is taken into account we may infer that factors like the classroom culture (teachers' and students' mutual expectations of one another) make this relationship far from straightforward. As regards teachers, there is very clear evidence that teachers do make a great difference to *what* students learn and *how* they learn it; in other words, not only how well students learn mathematics but what kind of mathematics they learn.

This depends on the teachers' *choice* of tasks presented to the students, the *sequence* in which these tasks are presented, and especially the *classroom culture* he or she establishes (the teacher's and students' belief about the nature of mathematics and what is expected of them when they "do mathematics").

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