TIM – A TWO-YEAR MODEL TEST ON THE CALCULATOR USE FROM CLASS 7 AND 9

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This article provides an overview of the concept and some results of a two-year model test on the use of calculators in maths lessons from class 7 and 9 at grammar schools. The results of the study suggest graphic calculators already from class 7 and show the importance of respective teaching concepts for their effective use. In all analysed class levels the use of calculators helped improve the communication competency.

BACKGROUND

New technologies are gaining more and more importance also in learning and teaching processes. In the teaching methodology it is assumed that the adequate use of calculators has considerable effects on the development of mathematical competency of learners, providing a general educational value (cf. Ali et al 2000, Kaput 1992, Stacey 2003,). This assumption is based on studies and convincing examples with a rather project-bound, punctual and limited use of calculators in maths lessons, (Berry et al 2006, Tan/Forgasz 2006, Vale/Leder 2004, Weigand/Weth 2002 a. o.). Long-term studies on the calculator use in maths lessons are not available so far.

However, in most federal states of Germany computer-supported maths teaching is still underrepresented. This is why initiatives have been started to analyze to what extent calculator-supported lessons are accepted by students and teachers. It is also intended to study the conditions for successful learning with the calculator and various potential effects of the calculator use on the students' concept of mathematics, their perception of the lessons and development of competencies.

The following report describes a two-year model test in Rhineland-Palatinate which was supported by the Ministry of Education and Texas Instruments. The students worked with the graphic calculator TI-84 Plus in the 7th classes or with the CAS-Calculator TI- Voyage in the 9th classes.

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The project was started in 2005 with six 7th classes and seven 9th classes at different grammar schools (Gymnasiums). The 13 teachers involved – with the exception of the two coordinators – had no or only little experience with such calculator use so far. They met once quarterly to become more familiar with the calculator and to work together on the didactic concept. A learning platform (Moodle) under www.proLehre.de put at their disposal contained the material developed like tasks, teaching plans, proposed solutions and technical advice.

The participants of the project expected that their acceptance of calculators would increase within the 2 years of the project and the potential of the calculator use would take effect with respect to the development of competencies like communicating and mathematical modelling as frequently described in the literature (cf. Laughbaum 2000, Stacey 2003, Weigand/Weth 2002 and many others). Part of the project was to maintain basic calculating skills without calculator support.

The participants of the project agreed that the use of the calculator should become an increasingly self-evident tool in the competency development of the learners. Basically the competency development of the students was focused, not to gain insight in specific effects of the used technology.

EVALUATION CONCEPT

At TU Darmstadt we developed an evaluation concept for the project with the three following elements: student performance tests at the beginning and the end of each school year, three student and two teacher surveys as well as lesson reports to be kept by teachers in the first project year and partly standardized lessons reports to be kept by students in the second project year. After the first project year the results of the tests and of the student surveys were communicated to the teachers, allowing them to compare their classes with the total sample.

Purpose of the performance test was to observe the learning progress within a school year. Two parallel tests were conceived as open end test to make sure that students had to meet identical requirements in the pre- and post-test. It was not expected that all tasks would be solved by all students in the given period of time. The requirements of the test were wave-like, i.e. easy items were followed by difficult items and again by easy ones. More information about these testdesign in (Komorek et al 2007). The students were informed about these particular test requirements. According to the quantity of solved problems, to the manner and quality of processing and to the solution success it was possible to show learning improvements over a school year.

The one-hour performance tests at the beginning and the end of each class level included both open and closed items, partly in MC-format. For each item the solution or solution approach (solution concept or method for complexer tasks) were evaluated. The outcome was a substantial cross-section regarding the mathematical competencies to be expected in the respective classes according to the teaching plan on mathematical basic education in Rhineland-Palatinate. In addition a mental arithmetic test without calculator was employed in the pre-post-comparison.

This project did not include a comparison with classes where calculators were not used. However, certain comparative values are necessary to analyse the performance increase within a class level. In the frame of an overall study of the learning situation at the outset and the learning development in class 9 run in Hamburg (LAU) it was elaborated as rough orientation that the normal performance increase during a school year without interventions amounts to around one third of the standard deviation per learning group (cf. Lange/Lehmann 2001). If the result attained in one sphere of competence it can be supposed that effective interventions have been carried out in this domain.

In the evaluation of the result it was relevant to analyse the acceptance of calculators and the test results with and without calculators, also according to sex and to the previous maths attainment of students (cf. Vale/Leder 2004).

In order to find out - at least hypothetically - possible factors for a more or less successful working with calculators, three classes with different results were analysed (deterioration of performance, lack of performance increase, high performance increase in the project period). More information under www.math-learning.com.

Some central results of the study are presented below. Given the small population the statements are rather hypothetical, their generalization value is currently tested in the framework of the bigger project CALiMERO, run in Lower Saxony with 29 project classes and 5 comparison classes (cf. Ingelmann/Bruder 2007). Further details and the instruments used in the project TIM are documented under www.math-learning.com.

RESULTS OF THE PERFORMANCE TESTS

The results of the calculator-free mental arithmetic tests are very positive (accomplishment ca. 60%) and remain stable during the following school years. This shows that the teaching concept developed by the teachers to provide regular mental arithmetic is effective.

Test results in class 7 and 8

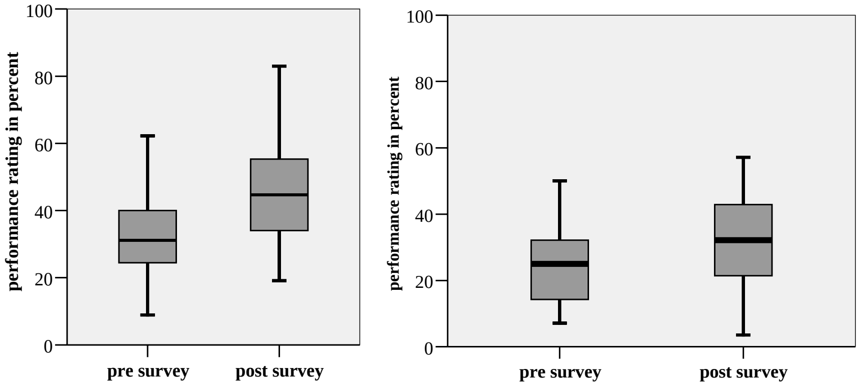

Fig.1 Performance development in class 7 (left) N=121 and 8 (right) N=81

On average the performance increases observed (cf. fig.1) are clearly above the expected increase during a school year and attained by all participating classes. Particularly interesting is the performance increase by almost 18% within the group of low attainers. The fact that girls reached the biggest performance increase in this age group is particularly eyecatching, cf. fig. 2.

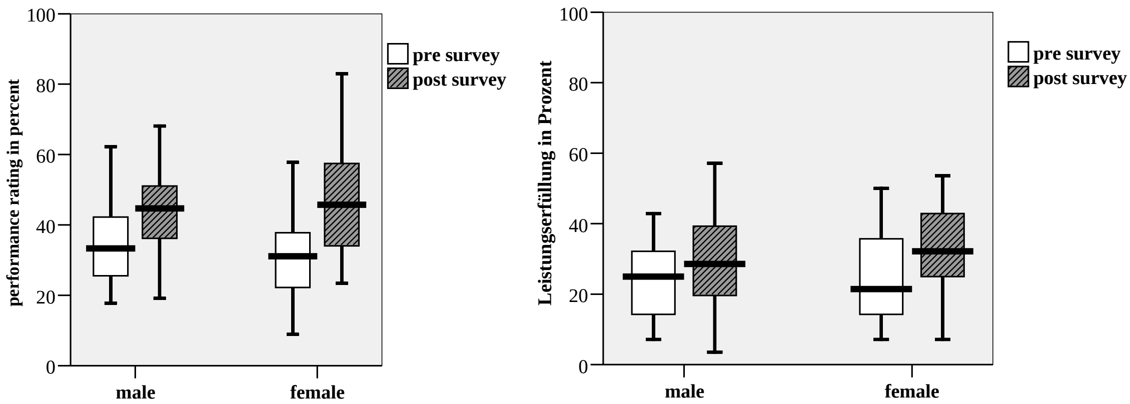

Fig. 2 Performance increase of boys and girls in classes 7 and 8

However, the increase is not evenly spread per item, cf. fig. 3. It reveals that girls had significant problems to fill in a value table for a task on mobile phone rates which had not occurred at the beginning of class 8. The girls did not attain any visible learning progress for these kind of tasks which were more the subject of the lessons in class 7 than in class 8. The boys had significant problems to solve the question when a change is advantageous with two different tariffs. These effects occurred in almost all classes. On the other hand the boys adopted more graphic presentations, this effect can be attributed to the calculator use in this school year.

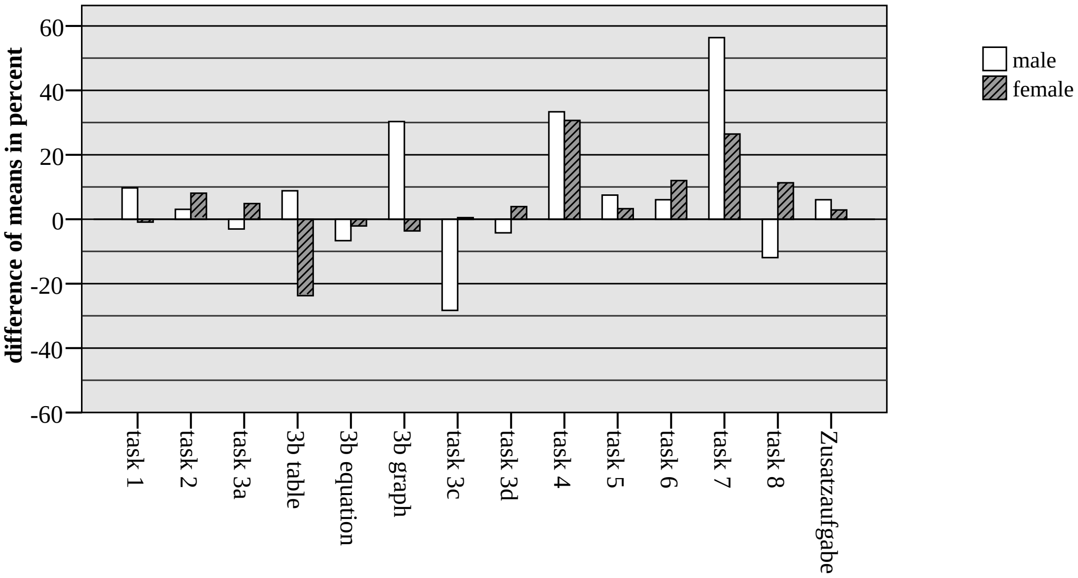

Fig. 3 Gender-specific test comparison of tasks in class 8

The performance increase in class 8, particularly of boys, is eyecatching for task 7. The task corresponds to an item from the TIMS-study. The positive result has to be attributed to a successful implementation of the curricular requirements in class 8, the item is the concept of variables. The calculator use was advantageous in this case (cf. Bardini et al 2006) as the results are clearly above the comparable data from the TIMS-study.

Task 7:

Katja tries to find three natural numbers with the sum 126. She wrote the following equation. What represents n? $(n-1)+n+(n+1)=126$

a)The smallest of the three natural numbers

b)The middle of the three natural numbers

c)The largest of the three natural numbers

d)The difference between the smallest and the largest of the three natural numbers.

Test results in class 9 and 10

On average the test results in class 9 and 10 are clearly above the expected increase within a school year (cf. fig. 4), and in contrast to the classes 7 and 8 there are positive effects for almost all tasks, regardless of the gender. However, there are class-specific effects: two out of the seven participating classes 9 did not show any significant performance increases during the 9^{th} school year. As the student survey revealed there was only little acceptance of the calculator use in these two classes.

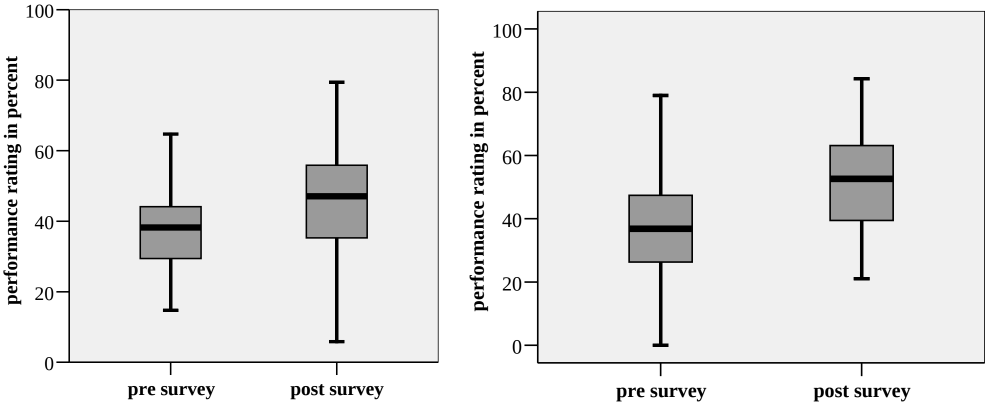

Fig. 4 Performance development in class 9 (left) N= 159 and 10 (right) N=91

Now the boys are attaining better performance increases, cf. fig. 5. There are almost no percent differences between the learning increases in the performance groups.

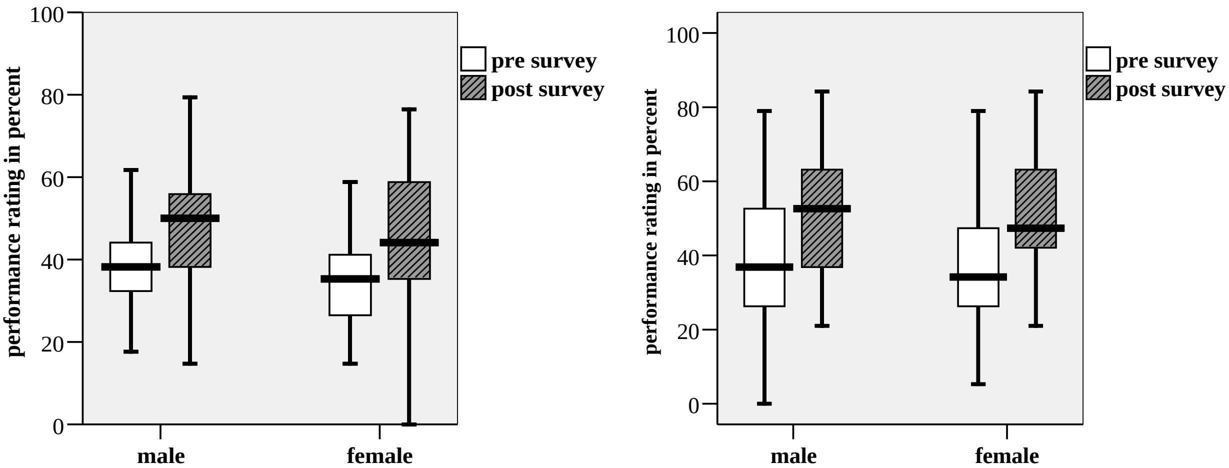

Fig. 5 Performance development of boys and girls in classes 9 (left) and 10 (right)

Test results of anchor items in classes 7 and 9 respectively 8 and 10

Throughout the different school years continuous tasks, so-called anchors, have been employed, which allow to study longterm effects as the consolidation of knowledge and capability. It shows that there was a remarkable learning increase in the anchor tasks in the classes 7 and 10. This result confirms curricular particularities: If due to curricular requirements algebra – to give an example – is a main topic in class 9, other competencies might be neglected. This is exactly what has been observed in this study.

Students in class 7 have a better command of different mathematical presentation forms than students in class 9. A possible consequence is: the pocket calculator should serve as supporting tool for the change between presentation forms though mechanical skills have to be maintained to guarantee the suitable documentation of working results.

Moreover a substantially increased differentiation in the approaches of anchor tasks was stated in class 10, compared with class 8. It can be assumed that the calculator use enhances a diversity of individual approaches. This is confirmed by the subjective perception of the solution attitude expressed in the student and teacher survey.

Selected results of the student surveys with respect to the test results

In class 7 a positive attitude regarding the calculator use and mathematics leads to improved performance. The average acceptance of the calculator as supporting tool to learn mathematics is good, with a higher proportion of girls in class 7. While all 7^{th} classes are favouring calculators there are only 5 out of 7 classes in class level 9 to support the calculator use. The results of the student and teacher surveys in connection with the test results reveal that the early and reasonably planned application of pocket calculators can enhance both the learning motivation and the learning results. For the classes 9 and 10 the result is more ambivalent: the flexibility of the students to cope with new teaching forms or learning possibilities seems to be less developed.

Selected results of documented teaching lessons

Every student in the 8 project classes took record of one lesson with a partly standardized document. One teaching sequence per class was recorded, however there are not enough records available from all classes. 173 recorded protocols in total were evaluated. The results show that calculators had been used in half the lessons, regardless of the mathematical topics. This proportion of calculator use is almost identical in all classes though with varying functions.

While some teachers favour demonstrations with the calculator, others recommend the calculator use rather for individual work or teamwork (cf. Tan/Forgasz 2006). There is no clear correlation between the kind of the calculator use and the estimation if students found the lesson interesting or not.

Independent of the calculator use it is noticeable that in around 60% of all lessons the teaching conversation is perceived relatively constantly whereas individual working decreases in favour of teamworking between the classes 8 and 10. There is also a shifting of methods in the classes 8 to 10. The introduction of new themes is steadily increasing with every school year, while the repetition of previous themes is less practised. So-called mental exercises are practised in 9% of the lessons which might explain the positive effects in the mental arithmetics test.

CONCLUSION

The results of the study confirm the methodical insights just considered as experience so far without being documented. Part of it is the following insight: as expected, special performance increase can be stated in one school year for topics from the current school year. If important topics are not regularly repeated and maintained, they are not kept available and a performance decrease must be expected – regardless of any calculator use.

In case there are deficits occurring in the calculator-free handling of maths the use of calculators should not be blamed, the project TIM shows clearly that this effect depends on the teaching concept. Where calculator-free exercises are practised, mental arithmetic skills are kept stable.

The results attained in class 7 underline that the starting conditions of this class level are particularly favourable for the use of a calculator as supporting tool for the development of competency. The test results show that the above-average performance increases in class 9 and 10 are especially related to modelling and communication competencies and in class 7 and 8 to problem-solving and communication competencies. In the perception of the students these effects are related to their maths lessons and reveal the influence of the calculator use.

So far there are no comparative results about the question how and how often calculators are used in normal lessons and how they might be used to enhance certain learning increases. Therefore the first insight gained in the project TIM is an important basis for further studies of this subject.

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