



CALCULATORS IN PRIMARY GRADES ?

Hartwig Meissner

Westf. Wilhelms-Univ. Muenster, Germany

Abstract: Briefly we will reflect issues how to change mathematics education with regard to the existence of calculators and computers. In Germany there was no change at all in arithmetic education in primary schools, though outside from schools calculators are everywhere. Thus our research group developed and administered a project "Use the calculator to become independent from it" in eight 3rd grade classes. In the CIEAEM workshop the participants will practice some of the activities from the project and they will get the same test as the pupils got. By the use of calculators our activities will concentrate on how to train mental arithmetic and how to develop number sense.

1. Almost Thirty Years Ago

In 1976 at ICME III in Karlsruhe Hans Freudenthal chaired a panel discussion on "What May in the Future Computers and Calculators Mean in Mathematical Education?" Some of the questions were (see ICME III Proceedings, p. 291 ff):

- What to do with calculators today?
- How will calculators ... influence teaching mathematics?
- Must we introduce ... calculators in mathematical instruction, and if so what kind, and at which age?
- Is there a danger that numeracy will suffer if such calculators are introduced, ... or may numeracy be improved by using calculators?
- Will teachers of science complain even more about the lack of mathematical abilities of their pupils, or will they be able to profit of the use of calculators in mathematical instruction?

The author of this paper was one of the panelists and already in 1976 I claimed that calculators "must be introduced early, because mathematical education reaches all pupils only up to the age of 15. The calculator must then be introduced as a teaching aid and pupils must be given not only the necessary knowledge but the methods to use the calculator properly. Mental numeracy, the abilities of estimating and approximating will be extremely important, otherwise mistakes will not be realized, results cannot be checked" (p. 294).

Nievergelt, one of the other panelists, "agreed ... that calculators are a great help in schools" but "algorithms in his opinion do not have a dominant role in mathematics ..., for many of our reactions are spontaneous" (p. 294). Pollak, also one of the panelists, concentrated on "What are the pedagogical difficulties in teaching and how can calculators and computers help with these problems?" (p. 295)

In the late seventies our research group TIM (**T**aschenrechner **I**m **M**athematikunterricht¹) was quite active in discussing many of these issues. Together with our teacher students and many interested schools we designed, realized, and evaluated a lot of teaching experiments with calculators,

¹ which means "Calculators In Mathematics Education". For those who are especially interested, there still is a list of TIM references available from the author.



especially in primary schools. We explored many case studies, studied learning processes and observed the conscious or unconscious behavior of children when working with calculators. In 1978 I also studied about 30 calculator projects or investigations with calculators in the USA and we developed recommendations how to use calculators in mathematics education in primary schools.

2. Changes, a challenge for mathematics education

Changes in the curriculum depend on many aspects. The frame of the CIEAEM 57 subthemes is an opportunity to compare the statements given in the seventies with the developments we can observe since then. In this paper we only will concentrate on:

- Is there today, in comparison to the seventies, a change in mental processes and activities when adults or children today work with calculators or computers?
- How much did the existence of calculators influence the mathematics curriculum in primary schools?

2.1. Changes in people's conceptions about mathematics

Is there today, in comparison to the seventies, a mental change when we approach mathematics, calculators, or computers? Our answer is YES. When we study children or adults working with computers or sophisticated calculators we can observe many trials and many guess and test activities. The same is true for playing calculator games or computer games. Or, when you ask a computer specialist for rules to solve a specific problem you have, they are quick in pressing diverse sequences of buttons, often trying again and again, but after becoming successful very often they cannot give a precise verbal reconstruction of their doing. And often they cannot give verbal explanations how to solve that problem next time when you get it again.

The development of a powerful, flexible, and effective concept image² depends on two types of mental activities which both are necessary to build up a cognitive net, but which often also interfere. We distinguish "common-sense *Vorstellungen*" and "analytic-logical *Vorstellungen*"³. Traditional mathematics education certainly prefers analytic-logical *Vorstellungen*. A formal, logical, deterministic, and analytic thinking is in the center, including reflecting and making conscious. In the traditional top down teaching the "common-sense *Vorstellungen*" like intuitive ideas or spontaneous reactions or guess and test procedures or unconscious trials more or less are "non-mathematical" and get ignored or unconsciously rejected or even "forbidden".

In a top down teaching the teacher is dominant, but using calculators or computers the students may become more independent and they can shift, mainly unconsciously, to a more common-sense behavior, see examples above. In a long term effect the constructing of mathematical *Vorstellungen* with calculators or computers may become more spontaneous, cf. the comment from Nievergelt at ICME III. Thus we already now claim for a more common sense behavior in mathematics education, we argue for allowing guess and test, for thinking aloud, for trying and verifying. We must support common sense activities to develop more effective estimating abilities and to further number sense, proportional reasoning, function sense, etc.

2.2. Changes in primary schooling

² "Vorstellung" in German

³ This dichotomy already was discussed by Vygotski, Bruner, Ginsburg, Strauss, and others. Also the term "procept" is a special amalgam of these two types of "Vorstellungen". For more details see Meissner (2003).



Did the existence of calculators influence the mathematics curriculum in primary schools? For Germany, our answer is NO. Personally, I am sad and disappointed. Calculators are everywhere in daily life but the arithmetic education in our primary schools just ignores that fact. We still teach mental arithmetic and paper and pencil algorithms as we did thirty years ago. There was no teacher in-service and the results from investigations in the seventies and eighties with calculators get forgotten step by step. New generations of teachers grow up, but they still will teach arithmetic like their grandfathers did. How to change this situation?

3. A calculator project in primary schools

In our teacher pre-service seminars the teacher students also become acquainted with books which pupils and teachers use in the class room. In none of the primary school books there were activities with calculators. This was the starting event for a new project. The old TIM reports got new readers. Advantages and disadvantages were discussed if or how to use calculators in primary schools. All agreed that mental arithmetic still will remain important and that in our traditional mathematics education we almost do not develop a common sense feeling if a result is correct or not. We often force the pupils to make a guess before doing the calculations or we force them to "verify" their result after having done the calculations. But both activities are performed "analytically" or "logically" and there is no intuitive feeling in parallel if the calculation or the result might be correct.

Our teacher students agreed that calculators should be introduced in primary schools, but they also claimed, that the pupils must become able to develop "automatic alarm bells" to detect independently from the calculator use if the calculator result is a reasonable result. The goal of the project became summarized into the slogan "Use the calculator to become independent from it".

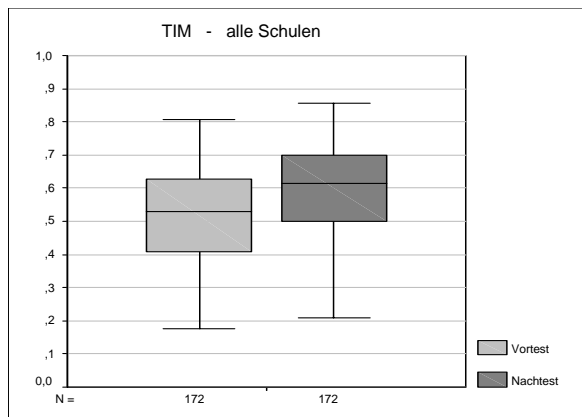
In a pre-service seminar the students developed a teaching unit with 8 lessons using simple calculators with a constant facility. There were two main goals, the training of mental arithmetic on a stimulus response level and playing a diversity of calculator games which all need guess and test to get the result. We went into schools to find interested teachers to allow our students to teach these lessons and to evaluate the output. The investigation with pretest and posttest was carried out parallel in time in eight primary schools with about 180 pupils (3rd graders).

After introducing the calculators in the first lesson we started almost every other lesson with a short competition "Mental Arithmetic" contra "Calculator Group". At the beginning some students were "allowed" to be the calculator group or the teacher formed a group or "the girls" or "the boys" became the calculator group. The teacher then called the problem, i.e. "how much is 7×6 ?", and the group shouting the correct result first got a score (10 problems for each competition, 2 or 3 competitions each lesson). At the beginning each pupil cried to become a member of the calculator group, but after some lessons they cried **not** to become a member of that group. "I am quicker in head" or "Pressing the keys takes too much time" or "I know the table" were the arguments.

Hit the Target was one of our favorite games: A number and an interval are given. Find (by guess and test) a second number so that the product of the two numbers is within the interval. The game trains proportional feeling: The two factors and the result intuitively grow together to one entity.



Before starting the project the teachers and parents were very reluctant and we had to introduce our activities first to these adults. There were no difficulties at all with the pupils, they enjoyed the use of the calculator, they loved the games, and obviously they also reported at home very intensively. After the course we got positive replies from all schools, especially when they received their successful test results (see boxplot on the right)



4. The CIEAEM Workshop

In the workshop the participants will practice some of the activities from the project. They will get the worksheets from the pupils and work with the simple calculators we used in the project (4 basic operations, constant facility, memory, %-key). To demonstrate key stroke sequences on the black board we will use styrofoam plates. Finally the participants of the workshop also will work on the same test as the pupils did.

We first will learn to “program” these little machines to become a $\times 7$ -operator or a $\div 3.831$ -machine. We then will play different calculator games “*Find the Operator*”. Basic idea: One “pupil” hides an operator and the partner then must find the hidden operator by trial and error. Two special games of this type are “*Hit the Target*” (see above) and the calculator game “*BIG ONE*”. In the latter a division operator is hidden and the partner must find that input which gives the output “1” (BIG ONE) in the display. - Some other work sheets explain themselves:

Which operator, circle the mistake:

(1)

○	
→	
46	92
57	103
96	142
103	159
114	160

(2)

○	
→	
10	80
6	48
20	160
31	240
40	320

Invent your own problem:

○ ?

? → [,]

input display



The calculator is broken, only the following keys are working:



Try to get the following numbers into the display (try to get all numbers till 20)

15:

18:

Finally in the workshop we will discuss on the base of these activities:

- What do we mean by “number sense”?
- How can we further the development of "automatic alarm bells" to detect mistakes?
- Which shall be the future of paper-and-pencil algorithms in the school curriculum?

Reference

Meissner, H. (2003): Constructing Mathematical Concepts with Calculators or Computers. In: Proceedings of CERME 3, Bellaria Italy