

**New perspectives in teaching mathematics
due to the use of the TI-92**

*(Based on surveys at 15 technical colleges in Austria – involving 30 classes of 750
students in total)*

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The purpose of writing this paper is to report about recent research being done on this topic in Austria. This research has been carried out during the last academic year as the diploma thesis of Elisabeth Koenig at the Department of Didactics of Mathematics at the University of Linz/Austria.

Last fall all teachers of mathematics from all technical colleges in Austria who had been using the TI-92 in their classes were invited to report their experiences in teaching with the TI-92. 15 teachers agreed to be interviewed about their experiences with the use of this calculator in their classes. Only classes where every single student was in possession of a calculator of his/her own were chosen. Personal interviews with all responding teachers were made to get a thorough impression of the changes in teaching as seen by the teachers. These interviews were recorded on tape for ease of examination.

The situation of the classes:

This study is dealing with 30 classes, which have been taught by the participating teachers. There are many different branches in Austrian technical colleges like electrical engineering, electronics, mechanical engineering, constructional engineering or economic engineering. Depending on the branch four to five years of mathematics are compulsory. The students are from 15 to 19 years old. Most of the classes started to use the calculator in their second year. Only a few used it from their first year on. Only classes, where the students used the calculator for at least one year were examined. Most of the classes were in grade 3, some in grade 4. That means most of the students have an experience of two, a few even of three years in using the calculator TI-92. Most of the teachers involved in this research have more than one year of experience in teaching with the TI-92.

The authors thank Gail FitzSimons and Juergen Maasz for helpful comments.

Ways the calculator is used in the classwork:

During the first year the TI-92 is mostly used as a tool to make large computations possible. Most teachers do not regard this the real goal. They want their students to use the calculator as

*An aid to understand mathematics better and
to improve their ability of building mathematical models themselves.*

For example one teacher used the calculator in teaching calculus to demonstrate how the slope of the secant slowly changes to the slope of the tangent line.

Some teachers trained their students in the first grade to understand the rules of rearranging equations by using the SOLVE-command. In second grade the calculator is widely used to understand all kinds of functions using the ability of the calculator to graph all kinds of functions. Exploring the different shapes of one specified function by changing one or more parameters is seen as an important application where the student can (and loves to) experiment on his own.

Some teachers told us in their interviews that starting in third grade students like to develop programs for better understanding the building of mathematical models. One teacher mentioned that one of his students developed a program for the TI-92 to find out and analyse maximum and minimum points of a curve.

Effects on teaching methods:

The answer of all teachers show overwhelmingly that independent work of the students is increasing and has become an important part of the training of students. In groups students may help each other in all ranges of the use of the calculator. Thereby they will realize where they have problems. In many cases students will solve these problems on their own. This point is very appreciated by teachers, because it increases the ability to understand mathematics.

The overhead display is often used by teachers at the beginning of each subject to show typical examples to their students. After that it is not regarded as necessary in most cases because the students know the commands and the menus of the calculator. Most teachers attach special importance to the use of this calculator at technical colleges, because it should not only be used in math classes, but in technical classes, too. As far as technical applications are concerned the use of the TI-92 is very helpful, because of the possibility in getting results of computations in a short time.

Effects on the topics taught in classes:

The argument of saving time is obvious:

a lot of time which used to be spent on long computation by hand can be saved when using this calculator. On the other hand students have to spend some weeks to learn how to handle this calculator. They learn the commands and the built in menus very fast, but understanding the mathematical meaning of the various commands and menus is difficult for all new users.

Mathematical models and the interpretation of these models is the main goal of the teachers, even though it is a very pretentious one, indeed.

Another problem in teaching is the following: the calculator gives the correct answer to most problems, but some answers do not look familiar to the students. This makes it difficult for the students to understand why some answers are equivalent.

The graphical opportunities of this calculator are often mentioned by teachers in order to help students to understand the mathematical theory behind a certain example.

Teachers specify reductions of certain topics in their subjects and name mainly methods of computations performed by hand in various fields. On the other hand it must be mentioned that some teachers have extended their topics due to the possibilities of the calculator. They name matrices and determinants, sequences and functions in polar and parametric representation. Some problems like zeros of polynomial functions of higher order or the Fourier representation of periodic functions can only be solved with the help of the TI-92.

As a result, I would say, we found in our interviews some changes in the examples the students are told to study. And I have the feeling that these changes are increasing. The most important question still is:

Which computations does the student still have to do by hand and which computations can he / she do with this calculator.

Effects on results:

All computations which follow a strong scheme were very helpful to the poor student. If these examples are now done by the calculator, many teachers point out that it might be more difficult for the poor student to reach the goals of the course.

Teachers believe that it might be easier for the good student to achieve better results with the help of the calculator.

The good student will understand much more of the mathematics behind the examples because the calculator shows him the theoretical relations in a faster and better way. Teachers report that the first test in a course, shortly after they had started to use the TI-92, was very bad, compared to a course without this calculator. Some teachers

suspect that the students didn't study as hard as usual because they thought they could do it anyway as they were using the calculator . In the interviews we got the impression that students only afterwards realize that they have to study to get good marks even if they are using this calculator because we did not see so many poor marks on subsequent tests.

If students are used to the calculator they may reach excellent marks if they study very intensively. According to these interviews we believe that poor students do not reach better marks if they use the TI-92. All the teachers participating in this research allow their students to use the calculator during their tests, even if there is a part of the test which must be worked out by hand.(In this case the calculator may be used to control the results.)

One problem, which must be mentioned here, is the difficulty of students have in documenting how they have reached their results.Because the calculator comes without a printer, it is necessary for the students to draw functions on their test sheets by copying the screen. (According to our interviews teachers do not use the LINK attachment during tests.)

Effects on the students:

We found three phases in the interviews:

The enthusiastic phase:

Students are proud to become experts in new technology. Some students become experts in playing games on the TI-92, which they may download from the internet.

The phase of disappointment:

Most students are disappointed by the bad results of their first exam with the TI-92

The phase of intensive work:

Students start to study very intensively to do their maths work with the calculator. Therefore the students working hard in general get good marks on their next test.

Conclusion:

The end result is that after a year there will be a larger gap between excellent and poor students. The poor students still will have difficulties in understanding the mathematical theory behind their work examples.

Effects on the teachers:

All teachers interviewed started teaching with this calculator because they wanted to use modern technology. They wanted to use a system which is independent of a computer, they wanted to use this calculator which every student can carry all the time.

An important goal for the teachers is teaching their students the theory and leaving the computations to the calculator.

A second goal is the technical education in the different courses. This will only be possible if the teachers of the technical subjects use the TI-92 in their lessons, too. All this is only possible if the teachers know the handling of the calculator. If a teacher knows how to handle the TI-92, he / she will slowly adapt his lessons to using the calculator. He / she must spend extra time for preparations, but will gradually reach a better way of teaching.

Conclusion:

After this research there will be a tremendous change in teaching mathematics in the next years. Caused by the existence of the TI-92 there will be a change in teaching methods, in topics and in results.

Even teachers who have not used this calculator so far for various reasons, will have to change their teaching methods in the course of time because of the existence of this calculator.

This research shows that teachers who use this calculator in their classes will in general get better results.

Students who have been taught with this calculator and who use this calculator on their own will get better grades and will understand mathematics much better.