**Introduction**

As I stated in § 3 of my ICTM3-article [1] "…using advanced CAS-technology at this level, rather than graphic calculators and the like, strongly enhances the enthusiasm of the teacher. This enthusiasm can not be overrated in the learning process."

Though many interesting and stimulating exercises can still be made with logarithm tables and logarithm rulers and though some mathematics teachers use scientific and graphic calculators in the most creative and imaginative ways, I think the teaching of mathematics at secondary school level and above would benefit greatly from the use of full-blown computer algebra systems (CAS) in general, and Maple in particular. This technology should be made available to students and teachers, as it puts them in direct contact with current practice, and makes the doing and learning of mathematics more adventurous.

Some twelve years ago we chose Maple for the following reasons:

- It respects international mathematical notations.
- It was (and is to a large extent still) an open system: you can look into its algorithms and even adapt them to your own purposes.
- It has a large community of users in education, industry and commerce.
- An awareness of the needs of education through the development of features like: the Maple Tutors, Maplets and MapleTA.
- Before the Maple licence was time-limited, an important argument was that students would still have their copy of Maple available to assist in tackling mathematics problems in their future lives. Maplesoft in turn might expect such students to prefer Maple should a CAS ever have to be bought in their organisation.

**Now how do we go about this in practice?**

Let me first refer to the ICTM3 article again (§ 1.2) [1] for the mathematics curriculum in our Professional Bachelor in Applied Informatics. Since the level of mathematics is comparable to that of Secondary School - except the highest (and probably lowest) maths classes – we thought it would be interesting to show what we do with teachers in Secondary School. This might create some interesting dynamics.

We have two types of sessions with the students:

- Theoretical concepts, through examples, are shown during classes. Students take notes as in the old days (without laptops). I mostly use the Alice-CD and Maple.
During workshops students tackle exercises and solve problems, using all materials they wish (there is wireless internet access and the Alice-TI CD-ROM that contains all their courses over the entire three years). Approved and select student solutions are published in the Dokeos (our electronic learning environment) course. Polya’s method is our guidance.

Parallel to this students are trained in technical matters via the AIM-server. So, for example, definitions, methods and algorithms of Linear Algebra or Cryptography are introduced in a few colleges. Usually, and if possible, I start from a problem that requires the introduction of a particular subset of mathematics. Then we get to work on exercises (solving systems of equations, encrypting and decrypting, etc.) together.

List of instructions students have to know:

> `nextprime` > `isprime` > `ifactor` > `Power(...,...) > root[n](x)`
> `mod` > `modp` > `factor` > `sort` > `expand` > `subs...` > `evalf` >
> `with(Logic):` > `BooleanSimplify` > `matrix (with(linalg)):` >
> inverse, det, tanspose, multiply, adjoin, rank, gaussjord,
> `submatrix > solve > fsolve > plot` >
> `with(plots): display implicitplot > limit, Limit, > iscont,
> diff, D > int, Int > numer, denom > % > sin,
> cos, exp, ln, tan, abs, > with(stats): statevalf, > describe >
> convert(..., confrac)

Some basic examples of places where Maple is used

1. Linear Algebra: > `eqns:=[...,...,...]; vars:=[...,...,...];`
   > (f)solve(eqns, vars).

2. Analysis: transformations of argument and image of functions, operations with functions.

3. Analysis: derivatives and integrals (We are amazed at how much time and effort is still given to learning integration techniques in other than high level maths classes.).


5. Boolean simplification (instead of VK-diagrams and the like).


Examples of a few powerful tools Maple provides

Maple’s symbolic spreadsheets

![Maple’s symbolic spreadsheets](image)

![Limits example](image)

Maple in the classroom: practice, pitfalls and policy – Roland Maerivoet
2. Derivatives

![Derivatives example](image1)

Fig 3 – Derivatives example

3. Maplets

![Maplet creation example](image2)

Fig 4 – Maplet creation example
Problems involved

There are, of course, some problems one has to face when introducing a CAS:

1. As a first remark, we often hear: “...it’s too complicated… students get lost...". We address this problem by presenting the students with a reduced set of instructions that they should be able to use: about 20 in the first year and 10 more in the second year. But, in principle, we allow them to use all of Maple. The following rule applies however, to Maple's output: "Don't use it if you don't understand the output".

2. Another problem is teacher training and the gradual introduction of such a complex system. We recommend going slowly with this to give the teacher the chance to experiment and feel at ease. It should be made clear to the students that sometimes the teacher has to be given time to check something out. Use of Maple induces a shift in paradigmata and calls for other approaches and methods.

3. Furthermore, since the advent of Maple 9, there is the issue of Classic (worksheet) versus New (document) styles. We concluded that it is better not to confront the students with this extra level of complexity.

A Call to Maplesoft

Finally, there are some important comments to be made in the margin... As a matter of fact it has not to be made in the margin but as a central issue.

I will not enter into details of prices, but Maple is expensive for many institutions. Only through an alliance with our Engineering Department INWE, were we able to afford Maple. These matters belong to the realm of decision-makers at Maplesoft.

There is however a question of responsibility: when scholars and universities are (sometimes rightly) asked to make strong alliances with industry and even make profit. Is it not reasonable to ask business to care about and invest in education and the future of our youth as well?

We have already seen that some of the reasons why we chose Maple, twelve years ago, no longer hold. I find this very regretful, as I believe in the power and capabilities of CAS and of Maple in particular in educational environments. If there are special costs involved, is it not possible to find other ways of financing? Maybe a "light" Maple version could be envisaged, where all the costly and commercially profitable numerical algorithms are left out?

I fear that in the future we who teach will have to face discussions with decision-makers in our institutions over the choice between Maple and, say, MS-Excel as a tool for empowering our mathematics classes. This would be like returning to the Stone Age.

Additional information

Anyone who would like to discuss this further can contact me at roland.maerivoet@hogent.be

More information (in Dutch) can be found at http://webs.hogent.be/~roma754

Information about Dokeos one can find at http://www.dokeos.com