

# Some Thoughts About the Use of Computer Algebra Systems in University Teaching

Helmer Aslaksen  
Department of Mathematics  
National University of Singapore  
Singapore 117543  
Singapore

aslaksen@math.nus.edu.sg  
www.math.nus.edu.sg/aslaksen/

## 1 Introduction

At the moment, the use of computers in mathematical research and teaching is getting a lot of attention. Many mathematicians seem to have caught a “computer virus”. Computers can be as addictive as alcohol to mathematicians, and a lot of us seem to think that computers are a panacea for both research and teaching. The bureaucrats prefer spending money on buying equipment rather than hiring people, and the vendors of the computer algebra systems bombard us with evangelism. The result is that a lot of people, especially outsiders, seem to envision that mathematicians will soon be made redundant by computers.

But computer algebra systems have their fair share of problems, too. First of all, there are intrinsic limitations to what these programs can do. For a discussion of such problems see [A] and [S]. In this paper I will instead focus on some of the problems related to implementing them in teaching mathematics at the university level.

At the Department of Mathematics at the National University of Singapore, we are currently in the process of introducing computer algebra systems (CAS) into our pure mathematics courses. There are many reasons for doing this.

1. **Exposure.** It is important for the students to be aware of and familiar with the tools that are available.

2. **Graphics.** The graphical components of CAS can be wonderful tools for visualizing complicated concepts.
3. **Numerics.** The numerical component of CAS allows for interesting combinations of exact and numerical methods.
4. **Applications.** Using CAS enables us to discuss more realistic examples, rather than the often artificial applications that abound in calculus textbooks.
5. **Concepts.** Using CAS allows us to focus on the concepts rather than the computations.
6. **Labs.** Using CAS, one can radically change the way mathematics is thought, by introducing a more experimental, lab-based approach.

One aspect that I feel is significant about CAS is that it helps bring pure and applied mathematics closer together. It becomes natural to use more numerical methods in calculus for instance, and one can introduce non-trivial applications. But that doesn't mean that applied mathematics will take over the whole field. In a different paper ([A]), I considered some problems related to elementary complex functions, and showed that it is somewhat of an Achilles' heel for CAS. It is interesting to see that what is needed is "esoteric" pure mathematics like branch cuts, demonstrating once again the centrality of pure mathematics.

But it is important to realize that introducing CAS into the classroom raises a lot of problems and questions.

1. **Cost.** These programs are quite expensive, and they put serious demands on the hardware, especially if one wants to take advantage of the graphical capabilities.
2. **Computer-illiterate staff.** There are still a lot of computer-illiterate staff in most mathematics department. Senior staff may feel threatened by plans to introduce technology and teaching methods that they are not familiar with.
3. **Demand on the students.** A lot of students are having a hard time with basic calculus. Do we really want to also teach them how to use a complex CAS?
4. **Time consuming.** If we want the students to use CAS, we will need to set aside time to help them with the programs. We will also need to write suitable teaching material and to maintain the software and hardware.
5. Which program to use? What if some people in the department want to use Maple, and some want Mathematica?

6. **Basic skills.** The students need certain basic skills in calculus, and some people are concerned that they will not master it if they have access to CAS.
7. **Exam.** Will the students be tested on the use of the CAS? Will they be allowed to use it during the exam?

In the US, many departments have introduced calculus labs with quite good results. But these programs are usually conducted at big schools where there are many graduate students who can supervise students during lab hours, and with adequate technical staff. If the professor has to install and maintain software and hardware and teach computer-phobic students how to turn on the computer, that might quickly become a huge burden.

I have come to the conclusion that a suitable compromise is to not go for the lab approach, but just use CAS as a demonstration tool during lectures. I have experimented with both bringing a notebook computer to class and printing the output on transparencies. The CAS was available on the campus network, and the students had access to my input files. In this way the students get some exposure, without having to worry about the idiosyncrasies of CAS input syntax.

This approach also allows different staff to use different programs. It is confusing for the students if they have to different programs in different classes, but if they are not required to learn the syntax, then that problem disappears.

I'm sure that experts in mathematical education will object to this approach. It is in fact a fairly conservative approach, that is quite compatible with traditional teaching. But it is a convenient way of getting started, and based on some limited experience, I feel it can be a good solution.

## References

- [A] Helmer Aslaksen, Multiple-valued complex functions and computer algebra, preprint no. 631, Dept. of Math., National Univ. of Singapore, 1994.
- [S] David R. Stoutemyer, Crimes and misdemeanors in the computer algebra trade, *Notices Amer. Math. Soc.* **38** (1991), 778–785.