Computer algebra systems in mathematics classrooms
Introduction

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Computer Algebra Systems (CAS), mathematical software such as Derive, Mathplus, Mathematica or handheld technology such as TI-89, TI-92, TI-92+, Voyage 200 are able to operate with symbolically represented mathematical objects in a way which equals the operating by rules in mathematics. Operating by rules means the transforming of mathematical representations in accordance with rigidly (clearly determined and without contradictions) formulated rules.

CAS (up till now) have not been able to master all the operational known and needed in mathematics by far, yet they do indeed master almost all operations dealt with in mathematics in schools and as well as a couple of operations not necessarily dealt with there. These materialized operative knowledge and skills are available for anyone at a current cost of approximately Euro 180,00. It therefore appears obvious to outsource algorithmic, numeric and symbolic operating to the machine also in mathematics classrooms.

Using CAS thus can and will change essential parts of the traditional (computerless) teaching of mathematics. With these changes not only innovative progress, but also undesirable developments can be expected. These changes offer chances as well as dangers; great hopes are linked to them but considerable fear also arise. So, some people see the use of CAS as a chance to relieve the teaching of mathematics of uncreative routine operating and finally to gain space for didactically more meaningful and, in many cases, mathematically (more) ambitious goals. Others state that mathematics teaching will be badly shaken in its foundations and basic values or fear that much doubt will be cast upon the validity of it and they refuse to accept what they assume to result in the "decline" of the Occidental Culture.

A similar ambivalence turns out in the role CAS are playing in view of the cultural coherence of the teaching of mathematics (cultural continuity and compatible links of different cultures and subcultures – cf. Heymann 1996): On the one hand, with regard to the paper-pencil calculations and manipulations, using CAS in mathematics classrooms means a radical break with the cultural continuity (conserving traditional mathematics in school and maintaining continuity in everyday mathematical culture). On the other hand, not using CAS also would lead to a break in the cultural coherence which in this case manifests itself as a denial of the technological development of mathematics and of the society.

Ambivalences like these are almost always present and markedly felt in discussions about the use of CAS in the teaching of mathematics and they are manifested in particular in various teaching projects and in teaching proposals for CAS-supported mathematics classrooms which were developed in great number in the last years all over the world.

Mathematics education research on using CAS in mathematics classrooms endeavours to offer orientations for global perspectives, for global goals and points of emphasis in CAS-supported classrooms and to do incorporations in comprehensive didactical conceptions and theories. It is intended to establish criteria for evaluating possibilities offered by CAS and for taking a decision on their use, research work in this field aims at identifying potentials and chances of using CAS in the teaching of mathematics as well as problems and limits and at offering critera for a reflective handling of those effects. In this way perspectives as well as undesirable developments and misinterpretations of using CAS in mathematics classrooms should be pointed out. The five contributions of this issue were selected accordingly. They deal with the use of CAS in mathematics classrooms with different focus and from different theoretical points of view.

W. Peschek and E. Schneider (*CAS in general mathematics education*) offer didactical orientations for global goals of a modern mathematics teaching which focus on the education of generally educated people. These orientations can be seen as guidelines for the exploring, classifying, reflecting and evaluating of the possibilities of using CAS in mathematics classrooms as well as for designing, developing teaching materials and performing CAS-supported mathematics teaching.

The great importance of which beliefs and knowledge of teachers need, with regard to changes in teaching goals and points of emphasis in CAS-supported teaching – in the field of contents as well as in that one of methods and social aspects – is discussed by M. Kendal und K. Stacey in their contribution *Teachers in transition: Moving towards CAS-supported classrooms*.

D. Guin und L. Trouche (*Mastering by the teacher of the instrumental genesis in CAS environments: necessity of instrumental orchestrations*) focus on the behaviour of students in handling CAS, on different categories of students' behaviour and on consequences that ensue from these analyses concerning the organisation of CAS-supported teaching environments ("instrumental orchestration"). Guin's and Trouche's investigations here are based on and refer to the theory of instrumental genesis.

Beyond the consequences for the behaviour of teachers and of students, using CAS in mathematics classrooms can also influence the point of emphasis in the field of teaching contents. In this case we have different opportunities, like applications, emphasis on the representation aspect and the interpretation aspect of mathematics, reflective consideration of limits and ranges of mathematical concepts and procedures, reflection about fundamental ideas of mathematical concepts, incorporation of historical and social-pohilosophical aspects, …. J. Berry discusses in his contribution *Developing mathematical modelling skills: The role of CAS* by means of modelling one of such points of emphasis. He analyses modelling with regard to its relevance for the mathematical education as well as with regard to possibilities of realizing it in CAS-supported mathematics teaching.

The final contribution of this issue should make clear that using CAS is not always as easy as and does not go off as smoothly as we are often lead to believe. Within his contribution *Learning mathematics in a computer algebra environment: obstacles are oportunities* P. Drijvers identifies „obstacles“ which students can encounter time and again in CAS-supported classrooms. He discusses the relevance of these obstacles for the learning of mathematics from the view-point of the theory of instrumentation.

References

Heymann, H. W. (1996): Allgemeinbildung und Mathematik. - Weinheim-Basel: Beltz (Studien zur Schulpädagogik und Didaktik; 13).

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