Introduction to the Special Issue on Computer Algebra in Education at ACA'2009

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Welcome to this special issue of The International Journal for Technology in Mathematics Education (IJTME), containing selected papers from the Applications of Computer Algebra (ACA) 2009 Special Session on *Computer Algebra in Education*.

ACA'2009 was held at École de technologie supérieure (ÉTS), Montréal, Québec, Canada. The conference was chaired by Michel Beaudin, Gilles Picard and Kathleen Pineau, with Michel Beaudin and Michael Wester acting as program chairs. ACA conferences have been held yearly in a variety of locales in North America, Europe and Asia since 1995. The ACA conference series is devoted to promoting all types of computer algebra applications, and encouraging the interaction of developers of computer algebra systems and packages with researchers and CAS-users (including scientists, engineers, educators, etc.). Additional information can be found at the website: http://math.unm.edu/~aca/

In 2009, the Special Session entitled *Computer Algebra in Education*, was chaired by Kathleen Pineau and Michael Wester, with assistance from France Caron, Daniel Jarvis, Bill Pletsch, and Bernhard Kutzler. Sessions discussing the use of computer algebra in education are traditional at ACA meetings. A non-refereed proceedings volume of the ACA'2008 educational session was published previously: Michael J. Wester and Michel Beaudin (editors), *Computer Algebra in Education*, Aulonna Press, White Lake, Michigan, ISBN 978-0-9754541-9-6, viii+134 pages, 2008.

There were 28 talks, a record for ACA conferences, including a session finale which summarised the previous presentations and asked the question *"What constitutes a good CAS task?"* Additional information can be found at the website: http://aca2009.etsmtl.ca/education/

The Education session at ACA'2009 brought together practitioners and researchers in order to exchange ideas, discuss classroom experiences, and to explore significant issues relating to CAS tools and use within education. Though open to all scientific fields, the majority of participants came from the fields of mathematics and mathematics education.

This special edition of the IJTME journal contains mostly practitioner reports, as opposed to research based reports, and thus mirrors the results presented in *Integrating Computer Algebra Systems in Post-Secondary Mathematics Education: Preliminary Results of a Literature Review* (Buteau et al.), the literature review pilot study that opens this special issue.

The authors of the second article of this collection witnessed firsthand the difficulties involved with the institution-wide integration of a handheld CAS. Indeed, in *Using Symbolic TI Calculators in Engineering Mathematics: Sample Tasks and Reflections from a Decade of Practice* (Beaudin and Picard), the authors voice their enthusiasm for, as well as their frustrations with, the integration of the TI Voyage 200 CAS calculator in their Engineering School mathematics courses. In an effort to encourage a more thorough integration of CAS in mathematics classes, they give examples of what they consider should be part of the common core of the mathematical curriculum of future engineers.

CAS syntax can often act as an obstacle to the integration of CAS in the mathematics classroom. Three articles of this collection present how the authors deal with this matter. The two papers, *Scilab and Maxima Environment: Towards Free Software in Numerical Analysis* (Mora et al.) and *Towards the Development of an Automated Learning Assistant for Vector Calculus: Integration Over Planar Regions* (Yaacob et al.), present the interfaces the respective authors have developed to existing computer algebra systems in order to eliminate the need for formally teaching syntax. By contrast, explicit teaching of syntax is addressed in the article, *In Getting from x to y without Crashing: Computer Syntax in Mathematics Education* (Jeffrey).

Syntax is only one of the issues that arise when automating assessment. As discussed in *A Comparison of Equality in Computer Algebra and Correctness in Mathematical Pedagogy (II)* (Bradford et al.), when moving beyond simple multiple-choice, automated grading of mathematical answers is far from straightforward. The authors highlight how difficult it is to use computer algebra to decide if an answer is correct, and how pedagogical objectives need to drive the classification rules when the notion of "right answer" is ambiguous.

As the selection of tasks tends to reveal what an instructor finds truly important, we asked participants, prior to the actual session, to send us samples of what they perceived to be good CAS tasks, along with some annotation that explained their choice. We received ten such sample tasks, and each one of these was presented to the larger group with a few comments from its contributor. This was followed by small group discussions around these CAS problems. A whole-group debriefing was then facilitated to capture and list the attributes that were viewed as important for the creation of a "good CAS task". These included the following:

- Requires the use of CAS at a given point; cannot be done strictly by hand;
- Maintains and develops autonomy of students, with a progression in the spectrum of involvement;
- Sets clear goals and expectations;
- Should include aspects of intrigue or even humour;
- Makes use of CAS power to tackle complex mathematics;
- Allows one to "scale up" or increase the order of magnitude of treatable expressions, beyond the limitations of pen and paper;
- Allows one to accomplish (or focus on) a task without getting lost in the computations;
- Raises the level of math and analysis;
- Addresses tool limitations (as well as students'!) and promotes critical thinking;
- Sparks curiosity or surprise;
- Results in new insight/intuition for students;
- Allows for patterns to emerge and opens to generalization;
- Helps develop mathematical creativity;
- Allows for several approaches (multiple entry points) and different ways to arrive at the "solution";
- Makes use of dynamic/visual/graphic representations;
- Builds on immediate feedback for graphs that can be easily manipulated;
- Requires a combination of the tool functionalities in the different registers (graphical/numerical/symbolic/programming) to accomplish the task;
- Appears immediately useful to student;
- Includes a real-world aspect which leads to mathematical analysis;
- Is not too limited and can be extended, may include a certain degree of open-endedness; and,

- Allows one to assemble pieces in order to construct/assemble a whole.

Note how technology and pedagogy appear tightly coupled in all of the above points.

As examples of good CAS-tasks, we include the article *Using Forensic Investigations and CAS to Motivate Student Interest in Mathematics* (Leinbach and Leinbach). Here the authors present student-centered activities from their collection of case studies in forensics as a means to provide students with interesting problem solving opportunities.

Giving a voice to students, the selection concludes with *Mathematics Education with a Handheld CAS – The Students' Perspective* (Schmidt). In this paper, the author presents the results of two surveys (one in 2002, and one in 2005) that were carried out to explore students' attitudes regarding the handheld CAS device they were using.

We organised the Education session at ACA'2009 with the hope that such an event would foster collaborations between practitioners and researchers in education. We view collaboration as a significant means of confronting the educational challenges brought forth by the introduction of CAS in the teaching of mathematics and science.

We greatly appreciated the ideas and the dialogue that emerged from such a diverse community of contributors. Finally, we would like to gratefully acknowledge Ted Graham's helpfulness in producing this special issue of IJTME.

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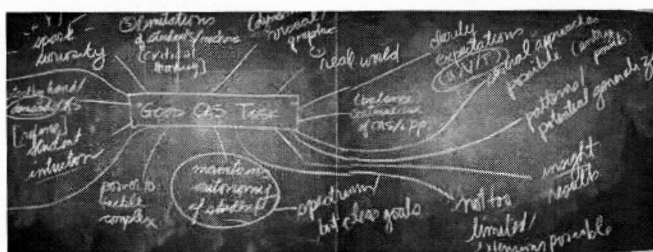
"What constitutes a good CAS task?": part of the resulting blackboard

The organizing team, from left to right:
Bill Pletsch, France Caron, Dan Jarvis, Kathleen Pineau, and Michael Wester