CAS in the Context of Methodology of Mathematics Education

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Extended Abstract

In this paper the components of the learning design process and methodological issues of integrating technology in mathematics education are considered. Three key questions are set up: Could the core principles of a methodology be invariant with respect to any particular technology? What to be taught: a particular CAS or its principles; only one CAS? Learning with technology only? The need of considering all the three components of the triad teaching-learning-assessment (TLA) in tandem and not focus on any one of them is mentioned.

Keywords

Mathematics education, methodology, learning design process, Computer algebra

1. Introduction

In 1994 the founder, Stanly Steinberg, and the co-founder, Michael Wester, of the "***Applications*** of Computer Algebra" Conference series foresaw that the basic ***principles*** of CAS allow multiple and multifaceted ***applications***. These principles are at the heart of the great potential and further development and enrichment of the CAS. The founders have been aware that the joint efforts of enthusiastic professionals with creative and innovative thinking will contribute to reasonable applications and large-scale development of CAS. And thus 20 years, since 1995, these professionals have created a great amount of original, useful and perspective applications of CAS.

Whether a certain computer algebra system would be classified as a rising or fading star, whether it is one of the commercial "heavy weights" or of the free software/open source systems a key question is about its application for achieving goals of interest. Concerning education educational goals need to be well-defined during the whole teaching-learning-assessment process (TLAP). According to the European Qualifications Framework of Education the results (not investments) have to be measured: knowledge, skills and competences of learners. CAS as an extremely powerful tool considerably can contribute to enhancement of these results.

2. Computer Algebra Systems (CAS) - a challenge for mathematics education

The most often used word (characteristic) associated with CAS is “challenge” - both as a verb and as a noun, with respect to mathematics education (ME). The interpretation of its meaning understandably depends on the context. In the context of mathematics education it seems that many of the meanings could be taken into account:

- as a noun: provocation, dare, doubt, invocation, exhortation, gage, …

- as a verb: provoke, dare, induce, rouse, raise, debate, require, bring on, engender, dispute, test of immune system (of ME), … .

Which of these possible interpretations or combinations of some of them are supposed to be taken into account by mathematics teachers? And concerning what: curricula, courses, learning environment, teaching-learning-assessment process (TLAP), teachers’ qualification, methodology?

It is out of question that CAS is the most thought-provoking tool we have ever had for the TLAP in mathematics education. But the great power and potential of CAS cannot automatically transfer mathematics knowledge to learners and enhance their appreciation of mathematics. Like any other technological tool, CAS requires a professional attitude in order to be converted into an effective instrument. The main point is to find a balanced combination of educational values and the power of technology.

At the beginning we implemented CAS as a symbolic, numeric and graphic instrument throughout the TLAP (in Calculus of one variable) in order to: challenge existing ideas; extend existing ideas; keep the rule ”work smarter not harder”, innovate not to imitate, facilitate problem solving and save time; make additional activities possible; assess student’s achievements. For each group of these activities well-defined didactic goals were formulated. They aimed at development of learner’s mental (cognitive) abilities: analytical thinking (processing knowledge and data, organising data) and conceptual thinking (recognising patterns in complex data).

Later we have embedded applications of CAS in the whole **Learning Design Process (LDP)**:

1) Define learning objectives

2) Define learning outcomes and appropriate instructions, student’s activities and products (to be assessed)

3) Assessment design (along with 2.)

We consider the assessment as an equal element of TLAP: it has also to be continuous - by means of formative, summative and final assessment. The assessment design gives the teacher an opportunity to improve the LDP. In this way LDP becomes an iterative process.

We have designed and developed a Lecture course and Seminar and laboratory exercises in Calculus of one variable. They support also self-directed (independent) learning. Computer algebra systems

serve in these books as a knowledge and collaboration instrument not restricted to any particular didactical model. Our methodology is based on the idea of blended learning: it combines traditional and technology-supported approaches. We recommend only core principles of CAS to be taught and the applied methodology to be invariant with respect to any particular technology. In our considerations we took into account the following

3. **Learning trends**

- Active-student-centered learning
- Collaborative education opportunities
- Less full-sized courses – more small learning chunks
- Less focus on delivery - more focus on learning design (incl. participation and interactivity)
- Less focus on speakers talking at audiences - more focus on the audience as learners
- Personalized learning and learning environments (a variety of approaches to support self-directed and group-based learning) designed around each learning objective/goal
- Assessment and feedback need to be embedded within activities.

We use Collaboration Platforms (Moodle, ILIAS) to get advantage of synergy of Knowledge Management, Learning Design and IT Tools as an opportunity for constructing learning environments for effective didactic models that can contribute to the changing face of mathematics education. This can be achieved because

- Teachers can create scenarios
- Learners automatically get access to content and knowledge resource
- Course material can be organized using learning objectives
- Self-directed learning is supported.

4. **Conclusion**

Mathematics teaching and learning is a skill-and-habit-forming process. Technology and tradition can go hand in hand to achieve a threefold educational goal: help students acquire a life long habit of doing things not just anyhow; make students think better than they did before; develop improved student understanding and the right appreciation of mathematics and of its role in the everyday life.

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