Supporting Mathematical Thinking with CAS: The Need of Epistemic Change among Teachers.

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The current abundance of educational technologies, and computer algebra systems (CAS) in particular, carry a promise: new venues for advanced mathematical thinking. This promise is a product of teachers' ability to construct and simulate mathematical ideas that are dynamic and constrained by the mathematical world (represented with the CAS). This dynamic attribute is considered to bring a change in the way mathematical ideas are thought of: instead of prototypical examples that are drawn with pen and paper, CAS such as Geogebra can provide a dynamic context for inquiry of a full range of examples for mathematical concepts. Ultimately the goal is to create cohesive mental models of mathematical ideas.

The promise for new mathematical thinking afforded by CAS, however, is impeded by several factors. For example, Anthony and Clark, (2011) examine key factors that cause teachers to refrain from using CAS in their classrooms, including dilemmas of misalignment with other curricular goals and limited professional development. My interest in this talk, however, is in the change of epistemic stance that is required by teachers; from static prototypes to dynamic and invariant objects.

I will examine this point with a case study in which nine in-service teachers participated in an activity, in which they were asked to construct invariant models of mathematical objects — right triangle — with Geogebra. This activity was a part of a course on methodological issues in mathematics education. The teachers were familiar with Geogebra as part of their postgraduate curriculum. An analysis of the activity shows that the mathematical objects that were constructed by the teacher, at first, neglected the much necessary "invariance" attribute of such object: in the case of the right triangle created in Geogebra should stay a right triangle even if one of its vertices or segments is moved by the user. Upon instruction and refinement of the objective of the activity, teachers were gradually able to construct objects that are invariant. However, the idea of invariance became what Cobb et al., (2001) would call "a socio-mathematical norm" among the teachers, only after two more similar activities.

I conclude that there is a need for epistemic change — even among teachers that are supposedly familiar with Geogebra — from seeing CAS as tools that afford static prototypes to seeing them as environments for building and simulating invariant-dynamic objects. For that matter, teachers need to participate in activities that would provide them with opportunities to make that epistemic change;

namely, they should be engaged in building such models as well as observing other who do so. These results has also carry a nesting effect: if a teacher is not familiar with the invariant principle, there are good chances that their students will not adopt this epistemic stance either. Moreover, the illustrated case also suggest that "frontal" teaching with CAS — without students' or teachers' hands-on experience and building of objects — will yield limited learning in terms of achieving advanced mathematical thinking.

References

[1] Anthony, A. B. and Clark, L. M., *Examining dilemmas of practice associated with the integration of technology into mathematics classrooms serving urban students*, *Urban Education*, **46**(6), 1300–1331 (2011).

[2] Cobb, P., Stephan, M., McClain, K., and Gravemeijer, K., *Participating in classroom mathematical practices*, In *A journey in mathematics education research* (pp. 117–163), Springer Netherlands (2010).