Introduction: the transformative nature of “dynamic” educational technology

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The presence and intelligent use of digital technologies in mathematics education has awakened an interest in understanding new ways of conceiving mathematics and mathematical cognition. Cognition, especially mathematical cognition, can be understood in terms of the emergence of successive and evolving representational systems (Kaput, 1991). As a consequence, the presence of digital technologies in education calls us to address this fundamental issue that curricular structures eventually will be inhabited by these technologies. It has already happened in the past: the technology of writing and the technology of positional notation of numbers are two of the milestones in the history of semiotic representations with a living impact on education.

However, we cannot forget that a school culture always leaves significant marks on students’ and teachers’ values. Artigue (2005, p. 246) states that “these [previous] values were established, through history, in environments poor in technology, and they have only slowly come to terms with the evolution of mathematical practice linked to technological evolution.” Thus, the school culture requires the gradual re-orientation of its practices to gain access to new habits of mind and to the new environments resulting from a serious presence of digital technologies. Consequently, this issue will offer a new perspective with examples from our research to approach the new *problematique* made tangible by digital technologies.

We particularly focus on the role of “dynamic mathematics” as an umbrella description of a certain technology (both software and integrated hardware) that opens up a new exploration space for learners. We present data and analyses of students working with dynamic geometry environments and software that links multiple representations of function in interactive ways across networks. We refer to these more globally as *Dynamic Technological Environments* or simply DTE(s). Within such environments, students are capable of exhibiting new forms of expressivity associated with their explorations and new forms of understanding based upon the capacity of the environment to react to the actions proposed by the students.

This special issue aims to analyze the impact of dynamic mathematics technologies on learning, didactics and curriculum development from multiple perspectives. Particularly, it will examine the differences between the phenomenological aspects of dynamism in the use of technology more generally—contrasting the use of technology as a temporary, engaging activity (the “field trip” syndrome) with more fundamental theoretical and epistemological dimensions of sustained uses of certain technologies. These focus on increasing accessibility of conceptually difficult mathematics through the transformation of mathematical ideas and experiences. A specific contribution of all articles in this special issue is the presentation of the paucity of research in the field from an interdisciplinary perspective, especially with respect to particular mathematical topics, and suggestions for programs of research that might attend to these issues.

When we thought about a title for this issue, the word *transforming* became our main focus of attention. Given the challenges of education globally, we prefer to think about “transforming” the very socio-cultural system within

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which our children are deeply embedded (both inside and outside the classroom) instead of “changing” it. Change is important, but often costly, as it can lead to deep infra-structural moves which can destabilize the status quo. With computers and wireless networks becoming standard in many modern schools today, we are no longer asking the question *why technology?* and *what do we need to change?* but instead, *technology, for what purpose?* How can it transform practice and hence learning? We believe that technology is here to transform thinking, and not to serve as some prosthetic device to prop up old styles of pedagogy or curriculum standards. In doing so, we potentially change the very nature of the subject matter on which we are focused. Many of the authors in this issue address the question of what is new in our classrooms and the affordances of certain technologies in the category of dynamic mathematics. Changes in school practices eventually will be transformed into epistemic changes.

So, if the very nature of our subject matter is being transformed, then we should begin to address what are the fundamental axioms or primitives of our mathematics education. One such primitive is a symbol. Now, crossing the semiotic border from the icon to the symbol, we see the emergence of a crystallization of intentional actions on the side of the symbols. This is why we ask ourselves in the presence of an artifact, material or virtual (e.g., a hammer or a law): What is its purpose? A deep novel, for instance, installs in our mind a virtual universe of human values, deep reflections on life and so on. Afterward, probably anything we conceive of in our own life will bear the mark of that symbolic artifact, the novel. That is its purpose. Thus, for us (the authors of this introductory article), a symbol is the embodiment of a dynamic complex of crystallized actions. There is intentional thought crystallized in the stone tools of our earliest age and these intentions are confronted with the possibilities of the tool. The legal system of a country is a more contemporary example.

Today, besides their traditional spaces, symbols are digital and that means that intentionality becomes blended with the executability of their digital representations. At this stage, we believe the notion of co-action becomes relevant in helping us understand the transformed role of symbols in our mathematical work. This is when someone,

say a student, guides an environment (e.g., software) with their actions on it, and at the same time is guided-by the environment through its resultant, dynamic, fluid reactions. The symbol becomes digital and the need for a new semiotic theory is necessary. The emergent knowledge from this digital medium is different from the knowledge emerging from a paper-and-pencil medium because the mediator is not epistemologically neutral. The epistemology of mediation is another primitive.

As the very nature of our subject matter is transformed or enhanced so must our theories of knowledge, pedagogy and education in general. Educational Technology is no longer “education using technology” but a metaphor for new cognition as described above.

Such dynamics are leading to new forms of interaction within DTEs and between students and teachers. With new modes of interaction that appreciate human users as multi-modal thinkers and enhanced forms of connectivity both inside and outside the classroom, we believe that students will seek a new form of education.

We expect the issue to be of value to educators and researchers in various fields of educational research and not just mathematics education. In addition, we believe the ideas set forth in this issue will be of great use to graduate students and because of this, we have established a blog site to facilitate and sustain continued discussion between readers and the authors. See <http://kaputcenter.blogs.umassd.edu/> for further details.

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