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TRANSFORMING MATHEMATICS LEARNING FOR STUDENTS AND TEACHERS WITH DIGITAL TECHNOLOGIES

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This presentation takes inspiration from the work of Seymour Papert and many others across the world (including Jim Kaput and our colleagues from Bulgaria) who have worked in the broad framework of constructionism and with whom we have been fortunate enough to collaborate in the area of mathematics education and technology over many years.

Drawing on the mass of evidence from research and practice, we will first set out our vision of the potential of Information and Communication Technologies (ICT) to transform the teaching and learning of mathematics. Among other things, it can offer:

- *dynamic & visual tools* that allow mathematics to be explored in a shared space – changing how mathematics is learned and taught;
- tools that *outsource processing power* that previously could only be undertaken by humans – changing the collective focus of attention during mathematics learning and with implications for the mathematics skills needed in modern workplaces;
- *new representational infrastructures* for mathematics - changing what can be learned and for whom;
- *connectivity,* opening new opportunities for shared knowledge construction and for student autonomy over their mathematical work;
- *connections between school mathematics and learners' agendas and cultures,* recognising the need to motivate students to see 'what mathematics is (*really*)about';
- *intelligent support* for the teacher and students while they are engaged in an exploratory environment, which is adaptive to students' needs and strategies, while leaving the goals to be set by teachers and control of the trajectory of mathematics learning with the students – in contrast to "Intelligent Tutoring".

We present research evidence and examples that illustrate this transformative potential, dwelling primarily on our most recent work.

First, we outline the research we have conducted into the mathematical needs of employees in technology-rich workplaces, where there is a ubiquity of information technologies and widespread automation of routine procedures. We found that there is generally little, if any, trace of the mathematical processes going on 'behind the screen', leading to a particular difficulty: widespread *pseudo-mathematical* interpretation of the symbolic output of computers. It was this lack of any appreciation of the mathematical models driving

the computer output that seriously impeded communication across different communities. We also report the potential for developing relevant "*techno-mathematical literacies*" among employees of co-designing (with employers), technology-enhanced boundary objects (TEBOs), which opened up what was delivered on the workplace computers, so the mathematical infrastructure could be glimpsed.

Second, we describe the *MiGen* system, a new software platform we have implemented. At the core of the MiGen system is a microworld, the *eXpresser*, which we have built to tackle the persistent difficulties that secondary school students have with the idea of algebraic generalisation. Our starting point is that *school algebra* (the rules for combining symbols) is not a particularly good way to express *algebraic thinking* (a way to think about the general). Our attention has primarily centred on characterise algebraic ways of thinking and then to design affordances of the system, along with task sequences and pedagogies, which together provide a substrate of activity and experience to underpin the idea of generalisation. In particular, we illustrate the *intelligent prompts* built into the system to support the student in the move from calculation to expression of relationships in a quasi-algebraic form. We also outline the *classroom dynamics and student tracking tools,* which provide teachers with key indicators of their students' activities; and a *grouping tool*, which supports teachers in forming optimal pairs to undertake collaborative tasks.

Finally, we argue that the overriding evidence suggests that in order for ICT to move from the periphery to centre stage in mathematics teaching and learning and for its potential for transforming mathematical practice for the benefit of all learners to be realised, *teachers* must be part of the transformative process:

- to do mathematics for themselves with the digital tools (before and during their thinking about pedagogy and embedding in practice) thus allowing teachers, regardless of experience, the time and space to take on the role of learner;
- to co-design activity sequences that embed ICT tools and make explicit appropriate didactic strategies;
- to try out iteratively in connected classrooms as a collective effort, in which students can debug together.

A major challenge facing innovations using ICT is *scaling up*, since, all too often, design experiments while reporting positive results wither away soon after any funding ends. One way we are working in England to break this cycle is through the *National Centre for Excellence in the Teaching of Mathematics.* The National Centre was set up in England in 2006 (see `www.ncetm.org.uk`, and the first author has been its director since June 2007). NCETM's major aim is to develop a sustainable national infrastructure for subject-specific professional development of teachers of mathematics that will enable the mathematical potential of learners to be fully realised. The NCETM offers a blend of approaches to effective Continuing Professional Development (CPD): national and regional face-to-face meetings, and tools and resources on its web portal designed to promote and sustain collaborative CPD among teachers of mathematics (for example through on-line communities). These networks and communities include the use of ICT in classrooms.

A major challenge faced by the NCETM is to reach out to all teachers of mathematics across all the phases of education (including university mathematicians) in ways that develop ownership of NCETM's CPD offer and, in particular, ownership of and fluency

with the tools available on the portal. If this ownership is achieved, the tools will grow with use, as teachers contribute to the content and to the on-line communities and in so doing support each other in transforming their practice. It is only through this process of mutual support that the potential of ICT will be realised - not only the potential already on offer, but also through new technological innovations such as personal and mobile technology, and all that will become available in the future.

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ТРАНСФОРМИРАНЕ НА ОБУЧЕНИЕТО ПО МАТЕМАТИКА С ДИГИТАЛНИ ТЕХНОЛОГИИ

Силия Хойлс, Ричардс Нос

Това представяне е вдъхновено от делото на Сиймър Пепърт и много други от целия свят (включително Джим Капут и наши колеги от България), които са работили и работят в духа на конструкционизма и с които сме имали щастието да си сътрудничим в областта на математическото образование и дигиталните технологии в течение на десетилетия.