Editorial

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Referring to the state of affairs in 1996, when the *International Journal of Computers for Mathematics Learning* was launched, its founding editor Seymour Papert wrote that the new generation of powerful computational environments “are stimulating new thinking about the content of mathematics learning, the way it is assessed, and the kinds of interactive settings in which it can be embedded. And the changes to date might be only intimations of what is to come” (Editorial statement). In many ways, he was right that the road ahead would be full of changes. The development of innovative computational environments was just at the beginning. The internet was in its infancy. Interaction was mouse- and keyboard-based. Logo was text-based and it would be nearly two decades before mainstream programming interaction escaped the keyboard. Dynamic geometry environments such as *Cabri* and *Sketchpad* had only been around for about 5 years and had still not gained the widespread support of teachers, students and researchers that they enjoy today. Yet, in 1996, Papert was already talking about radically new approaches to the teaching and learning of mathematics, in which “students are being actively challenged to investigate rich contextual problems; design, use and refine tools; model and construct mathematical processes and objects; and communicate mathematical ideas in the context of critique and debate” (ibid).

Nearly 20 years later, and despite the enormous developments in both hardware and software, in many classrooms around the world radical change has only occurred in very local and often short-term situations. This is not just because change is slow in education: there have been other changes in the technology of the mathematics classroom that have had a widespread impact, such as the blackboard and the use of graph paper (see Ruthven 2008 for a discussion of the latter). Indeed, Papert was prescient in saying that “the new visions and computational environments are not in themselves sufficient to engender deep changes in the teaching of mathematics”. He

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recognised important challenges in better understanding the nature of the social and cultural transformations required to maximise the potential of digital technologies in educational contexts. As such, at its launch, the editorial team of IJCML saw the journal as a forum for scholarly exchange devoted to the “ongoing debate on the nature of mathematical thinking, on issues of equity, cultural diversity, professional development, and the very nature of mathematical thought itself.”

In our initial call for papers for the launch of this journal, we asked potential authors for articles focused on a more *learnable* mathematics. For Papert, this meant, “‘reconstructing mathematics’ [...] in such a way that no great effort is needed to teach it” (1980, p. 53). This may involve extending the meanings given to the term ‘mathematics’, which could be informed by a variety of factors, including historical, philosophical, political and psychological ones. It may also involve challenging assumptions about meanings ascribed to the term ‘learning’. Around the time that IJCML was launched, the work of Jean Lave was raising deep issues about the relationship between situated and abstract mathematics—issues that became the focus of work by scholars such as Uri Wilensky, Richard Noss and Celia Hoyles, as well as a number of others. If certain types of learning involved a particular form of participation, as Lave and Wenger (1991) suggested, then part of what it means to learn mathematics would include learning to use mathematical tools. But mathematics has had, and perhaps continues to have, a habit of hiding its formative tools—and in its practice of detemporalizing, decontextualizing and depersonalizing (Balacheff 1988), the role of the tool in mediating mathematical conceptions tends to get lost—the tool becomes merely a pedagogical device for scaffolding learning temporarily. The on-going development of the field of experimental mathematics (including a Fields medal winner in 2014) may help in overcoming long-held assumptions about the role of tools as ‘crutches’ for those who cannot understand. If mathematical fluency were to involve expertise in using a compass to make congruent segments or in writing code to create a square—and not just in ‘knowing’ the concept of congruence or the concept of square—then the tool would no longer be the optional ‘extra’ it apparently represents in so many mathematics classrooms.

A more learnable mathematics should also be one that is worth learning. This leads to the question of what is worth knowing, and Jerome Bruner’s answer to the question would probably have been consistent with Papert’s own vision. Bruner argues for knowledge that “gives a sense of delight” and “bestows the gift of intellectual travel beyond the information given” (1969, p. 39). This ‘sense of delight’ seems tied up with many aspects of digital technologies that have been backgrounded over the past decade. With the desire to scale technologies and tasks at school district, state or provincial, and even country-wide levels, the technologies offered to students have become increasingly easy to use (change a parameter, drag a point) and the tasks much more goal-oriented toward the learning of particular concepts. While no one would advocate over-complicated technologies, it is evident that those which offer more expressiveness, though at times they might additionally require a steeper learning curve, also offer more potential—and expressiveness and potential are essential ingredients of both delight and intellectual travel.

As well as contributing to the rethinking of mathematics and its learnability, digital tools, along with the possibility of experiencing mathematics in multi-modal, multi-sensory ways, invite reflection both upon the learners themselves and upon the diverse range of means through which they interact with the world. In digital environments, visual, auditory and dynamic means of expressing and exploring mathematics can

increase the accessibility of mathematics to learners with (as well as without) disabilities. This too was part of Papert's vision, evident in his description of those involved in the early studies into relationships between programming and mathematics learning: "The children in these studies are not exceptional, or rather, they are exceptional in every conceivable way. Some of the children were highly successful in school, some were diagnosed as emotionally or cognitively disabled. Some of the children were so severely afflicted by cerebral palsy that they had never purposefully manipulated physical objects" (1980, p. 13). More recent research that has followed in this tradition concentrates on how digital tools can act as 'substitutes' for eyes, for ears, for memory and for other physical and cognitive functionalities. These 'substitutes', in the sense proposed by Lev Vygotsky (1978/1930) in his work with learners with disabilities, open alternative learning trajectories and, in turn, alternative meanings for mathematical objects that, while mathematically valid, do not always correspond to those emphasized in paper-and-pencil curricula.

In this inaugural issue

Our first issue contains three full-length research papers. Anna Baccaglini-Frank and Mirko Maracci provide a critical analysis of the educational potential of touchscreen tablet technologies. They draw on a wide variety of disciplines to inform their critique, including cognitive psychology and neuroscience, as well as on their extensive experience in working with pre-schoolers' development of number-related concepts. As with most innovations in technology, such as the personal computer or the internet, one can find a plethora of new programs and applications for tablets, many of which inherent much of the same pedagogical assumptions of older technologies. In their paper, Baccaglini-Frank and Maracci are careful to attend to what might be truly new in terms of a more learnable and teachable mathematics, which will inform not only other researchers, but also parents and teachers.

In their paper, Al Jupri, Paul Drijvers and Marja van den Heuvel-Panhuizen study a digital technology that has been available for a much longer time than the tablets, but in a context that is quite distinct. They examine the use of internet-based applets, as well as their accompanying tasks, which were designed to support the teaching and learning of algebra in Indonesian classrooms. They show that the classes in which the digital tools were used outperformed the classes in which only paper-and-pencil based algebra was used. Although such comparative studies are conducted less frequently, particularly since Artigue's (2002) argument that such comparisons are difficult if we assume that the digital tool changes the mathematics being learned, Jupri, Drijvers and van den Heuvel-Panhuizen complement their quantitative comparison—which are much more effective for policy-makers—with qualitative insights into the specific ways in which the applets allowed students to develop strategies that they could also use in the paper-and-pencil post-test.

Finally, Chiara Andrà, Nicola Parolini and Marco Verani explore the very important social issue of gambling, exploring how the use of a specially designed mobile App can help students understand the mathematical behaviour of lottery games. They focus not only on the importance of developing statistical literacy, but also on becoming aware of the emotional aspects of gambling. With respect to the latter, they show how the shock value of the App can help students overcome some of the emotional reactions that

frequently lead to gambling abuse. In addition to exploring a very important and novel situation, Andrà, Parolini and Verani also take into account the particular role that the touchscreen interface plays in students' interactions, drawing on theoretical insights into the role of gestures and touch in mathematical meaning-making.

The *Computer Snapshots* column in IJCML was a place where scholars could write about mathematical explorations in which digital technologies had figured significantly. These provided exemplars of 'mathematics' that highlighted the particular affordances of the authors with their tools, as well as possible starting points for this kind of activity in the classroom. Most significantly, the snapshots were designed to point towards ways that mathematical knowledge itself can be transformed with technology—not just mathematical pedagogy. We plan to continue this column in DEME, where we see it playing a similar role; and we would like to extend it to classroom situations so that we may learn more about how teachers manage to prompt and suitably constrain such mathematical activity. In this first issue, Rina Zazkis and Chanakya Wijeratne offer an engaging mathematical exploration of the period of the sum of two sinusoids, which brings together trigonometry and number theory using a dynamic geometry visualization.

Another column of early IJCML issues was entitled *Software Criticism*, edited by Al Cuoco and Celia Hoyles. Its mission was to “deal with the deep issues of designing and using software, the learning theory it serves, the discipline-based connections it can be used to make, and the kind of classroom culture that is needed for its effective implementation”. The editors saw this column as being somewhat analogous to literary criticism. Several scholars have proposed that some kind of aesthetic criticism deserves a more important place in mathematics, including Imre Lakatos (1976), who recognized choices and preferences at work in the making of conjectures and forming of concepts. But this column was to be devoted to criticism of software, criticism that is remarkably absent in our research community. Indeed, over the past decade, for example, researchers have begun to refer to, say, dynamic geometry software (DGS or DGEs) as a single entity, which has had the effect—particularly for newcomers to the field—of ignoring important design differences between them and the ways in which these differences as well as commonalities shape the learning of mathematics. There may be some good political reasons for this, and contexts in which such a blurring of difference is appropriate, but only if there exists a serious supporting discourse. We hope that in the pages of DEME, such a discourse can develop because we see it as crucial to the questions of understanding what might be meant by a more *learnable mathematics*.

Yet another column that was announced in the first issue of IJCML was entitled *Readers' forum*, which was to provide a space for intellectually engaging, shorter commentaries on articles published in the journal. In order to promote discussion amongst scholars, DEME will provide a similar kind of space, which we call *In briefs*, where we invite readers to comment on particular issues, including reflections on past contributions or commentaries on new ideas that may be of interest to the community. In this first issue, Jeanne Bamberger, an author from the first issue of IJCML, looks back on that first publication and discusses some new directions that research on music and mathematics education has taken over the past two decades.

In this journal, we also propose a new column, entitled *Digital Keywords: a Vocabulary of Technology and Education* and edited by David Pimm, which will

investigate the changing and interacting meanings of key words in our research, words such as *digital*, *dynamic* and *media*. Such terms have a history and change over time, often without our explicit notice. The inspiration for this column comes from literary critic Raymond Williams' (1976) collection of short entries on what he termed 'key-words' of culture and society, which included *art*, *alienation* and *aesthetics*. Later, Eric Love and Dick Tahta (1991) began a similar project for mathematics education with a modest number of entries (including entries for *number*, *concept* and *structure*).

These investigations not only help us to recall original meanings of our key words (for example, a computer or a calculator used to be a person who carried out computations), but in addition highlight the multiple and sometimes conflicting meanings that such words take on. In the title of this journal, the word *computer* has been dropped, largely because of the advent of more portable devices such as tablets and smartphones. With the word *digital*, we wanted to embrace the wider variety of tools that are now available and perhaps even leave the door open for new forms of hardware not yet available. As Williams (1976, p. 81) notes in his entry on *culture*: "The complexity, that is to say, is not finally in the word but in the problems which its variations of use significantly indicate."

We have also chosen a title for the journal that includes the *teaching* as well as the *learning* of mathematics. One claim that has been made by several scholars, including Colette Laborde, is that our understanding of the role of the teacher in the technology-based classroom is lagging woefully behind our understanding of the transformative potential of technology for mathematics and mathematics learning. While some focused research in this area is now emerging (see, for example, Clark-Wilson et al. 2014), it has often failed to reckon with the particulars of the mathematics and the technologies involved in teaching contexts. This may be due, at least in part, to the still-emergent theories being used or to the extensive need for professional development. But with a changing population of teachers, many of whom will have grown up with the internet and be comfortable with a more socially and materially fluid use of technology, some of the old barriers may be breaking down. In the future pages of DEME, we hope we will begin to see reports on work that focuses on a teachable–learnable mathematics.

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