The role of handheld technology in the mathematics classroom

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The last decades show a tremendously increasing presence of handheld technology in our society. Devices such as smartphones, palmtops, netbooks and laptop computers have contributed to create a “mobile” generation, enabling individuals to be constantly connected to each other as well as to the worldwide web, and providing the possibility to store and access personal data and other information at any time and in any place. How does this affect mathematics education? How can mathematics education benefit from these technological developments and how can we anticipate further developments in these directions? These are the issues that are at the heart of this volume.

In the early 1970s, the first digital handheld technology for mathematics—the *scientific calculator*—appeared on the market.¹ Compared to the four-function calculator, which is well established in society and in mathematics education in many countries, the scientific calculator generated a worldwide and intensive debate on whether these calculators should be allowed in mathematics classrooms and, if yes, in which grades they might provide opportunities or cause problems. Expectations on the benefits of such new tools were high; handheld technology was said to allow for

- extended experimental and discovering learning;
- concept formation on a broad numerical basis;
- more meaningful algorithmic calculations.

The introduction of *graphing calculators* in the middle of the 1980s² resulted in a change of paradigm concerning working styles in mathematics classrooms. These calculators were well established early in the Anglo-American world, but they were not widely used in other countries in

Europe or in the Asian world. The reasons are manifold. Using these calculators required some getting used to, the resolution of the display was low, and in addition there was a lack of knowledge and readiness on the teachers’ part to integrate this new tool into common lessons (which might derive not only from a lack of teacher training, but also from a sceptical attitude towards the new tool). Moreover, access to the newly developed personal computer provided a variety of mathematical software with a better graphical presentation than that of graphing calculators. Since 1980, many schools—especially in the developed countries—have set up a computer lab, and mathematics lessons with computers have to be done in these labs; a computer-supported lesson became an ‘excursion’ to another room.

The appearance of the first handheld calculator with integrated computer algebra system and dynamic geometry software³ caused similar great expectations as attended arithmetic calculators some years before. These *symbolic calculators* allowed working dynamically in geometry and doing all the algorithmic algebraic calculations many students were struggling with in mathematics. The new tool provided the chance to concentrate more on central competences in mathematics education, concept formation, problem solving and modelling competencies, and to out-source algorithmic operations to the machine. Some, like Jim Kaput, predicted that technology would become rapidly integrated into every level of education. Kaput also claimed that technology in mathematics education might work as a “newly active volcano—the mathematical mountain is changing before our eyes” (1992, p. 515).

¹ In 1972, the Hewlett Packard HP-35.

² In 1985, Casio produced the world’s first graphic calculator, the fx-7000G.

³ In 1992, the TI-92 appeared, followed by the Casio FX 2.0.

Nowadays, despite the use of digital technologies in the public and business world, despite the tremendous number of research and practical classroom papers, the use of technologies in mathematics education and their impact on curricula is still limited. This is quite often noticed in the current ICMI 17 Study, *Mathematics Education and Technology—Rethinking the Terrain* (Hoyles & Lagrange 2010), e.g. “... technology still plays a marginal role in mathematics classrooms” (p. 312) or “the impact of this technology (CAS) on most curricula is weak today” (p. 426). The reasons for this (non-)development are again manifold. Maybe the most important issue is the time factor. Educational change needs time, and requires an evolution rather than a revolution. Introducing new elements—such as new technologies—means developing new concepts, connecting these concepts to the old ones, doing pre-service and in-service teacher training, and testing and evaluating these new concepts in longitudinal empirical investigations.

Over the last 20 years, many new ideas have been developed in the area of working with digital technologies in mathematics education. Classroom activities have been designed, empirical investigations are carried out, different theoretical frameworks involving the student–tool relationship are developed, as well as views on teachers’ professional development, and on teaching and learning as a socio-constructivist process. In the meantime, technology is rapidly changing, both in its potential and in its dissemination. Symbolic calculators improved both their handling and functionality⁴; netbooks are small and—compared to laptops—cheap and give access to the Internet; mathematics programs can be installed on smartphones—such as iPhones and Android phones—as well as on tablet PCs. Pupils and students become more and more familiar with this kind of handheld technology in their everyday life.

The contributions in this issue focus both on lessons to be learnt from the last three decades and on attempts to look into the future to explore the possible use of up-coming technology in the mathematics classroom and its influence on future mathematics education. The opening article by Trouche and Drijvers provides a more personal look back on the past decades and tries to extrapolate these experiences towards the future. The contributions that follow show great variety on the type of technology, student age, nationality, etc. A central aspect in all papers is the focus on student learning and/or teaching and the role of the teacher.

Weigand and Bichler describe the development of a student competence model for using symbolic calculator in the domain of function, based on their longitudinal study in Germany. Robutti and Arzarello also focus on student learning, but now through the lens of multimodal production, including words, gestures, and actions with the

artefact, using technology both for representation and communication. The paper by Duncan addresses the topic of multiple representations that students are expected to integrate more fluently through the use of handheld technology. According to teachers’ reports, the use of dynamically linked multiple representations enhances the students’ relational understanding of the mathematics. In the contribution by Zeller and Barzel, the use of symbolic and non-symbolic handheld technology by young students is investigated, leading to the conjecture that symbolic tools offer better insights in the relation between arithmetic and algebra and in algebraic objects. A final contribution on student learning by Wijers, Jonker and Drijvers describes a pilot study in which a handheld device with GPS was used for a location-based out-of-school game, which invited geometrical thinking.

Of course, tools and tasks do not automatically lead to learning. The teacher remains crucial, and the availability of handheld technology challenges existing teaching practices and didactical contracts. The contribution by Pierce, Stacey and Wander illustrates how mathematics analysis software affects the didactical contract, with on the one hand a shared responsibility for learning, but on the other hand a different perception of the main points of the lesson. Aldon describes that while using handheld technology, teachers and students share being engaged in a process of documental genesis, but in different ways, so that the private character of handheld technology may even conflict with the teacher’s intentions. The contribution by Clark-Wilson shows how the use of technology leads to new emerging pedagogies, and explores the nature of these practices. The volume ends with a book review of the final report of the ICMI 17 Study on new technologies in mathematics education, edited by Hoyles and Lagrange.

Altogether, we believe this special issue offers a fascinating overview from multiple perspectives on research in the domain of the use of technology in mathematics education. It is evident that both the learning and the teaching perspective are crucial. Also, the contributions reveal a growing synthesis of theoretical knowledge and practical approaches and results. This being said, the quest for scientifically underpinned contemporary educational practice that is both mathematically sound and prepares for the students’ future societal and professional needs has not yet ended.

References

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⁴ Such as the TI-Nspire or the Casio ClassPad.