Essay about future directions – New Technologies in the next decade

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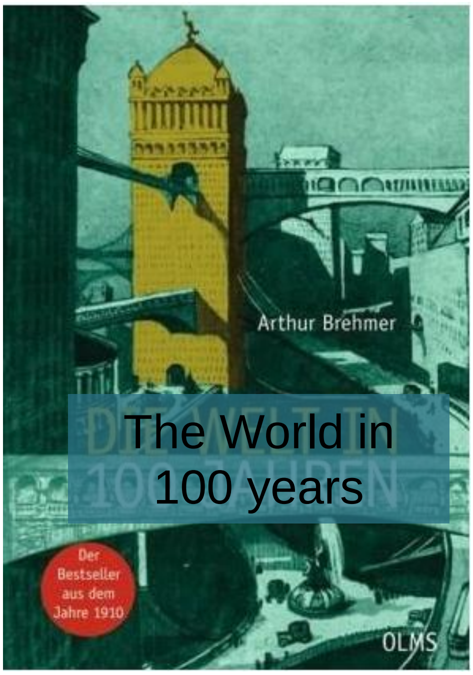
Abstract. Advantages and disadvantages of the use of digital technologies (DT) and especially of computer algebra systems in mathematics lessons are worldwide controversially discussed. What will be the meaning of DT in the next years or even decades? What is the basis for an answer to this question and how might it be possible to get a vision of the possible development?

A first aspect might be an evaluation of developments in the past. How was the situation, especially in the middle of the last century, when we introduced computers into mathematics lessons? Can we learn from the development of the past? A second aspect is the evaluation of the present situation. In the last year, the 17th ICMI Study "Mathematics Education and Technology – Rethinking the Terrain" was published by C. Hoyles & J.-B. Lagrange. It gives an evaluation of the present situation concerning the use of DT and it wants to give a basis or a vision for the development of DT in the upcoming years. The word "vision" is used quite often: a vision for the development of the software, the hardware, the pedagogical landscape, mathematics in the classroom, the learning and the teaching.

In the following, a critical reflection of the past and the actual development will give some hypotheses of possible, gainful developments in the future.

Visions

In the book „The World in 100 years" (German: Die Welt in hundert Jahren), published in 1910, the editor Arthur Brehmer asked important scientists of that time to describe a vision of the world in 100 years. One article in this book is about „The wireless Century", and its author Robert Sloss describes „The Telephone in the Vest Pocket "(S. 35ff).



„The citizen of the wireless century will walk everywhere with his „receiver" … On his way to work, in the underground, everywhere, he will listen to the „spoken newspaper" and he will get all the news he wants … And if he wants, he will be able to connect with every theater, every church, every concert hall and he can take part on the lecture, the sermon, the music session. …. The events of the whole world will be open to him …"

The vision of Robert Sloss became reality – in form „of the i-phone – 100 years later!

The NCTM standards of 1989 (and in the revised version of 2000) have been similarly visionary – concerning the field of mathematics education – by representing a vision for the future of mathematics education. This is especially true for the use of new technologies in mathematics classrooms, expressed in the "Technology Principle":

"Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning." (S. 24)

and:

"… Calculators and computers are reshaping the mathematical landscape … Students can learn more mathematics more deeply with the appropriate and responsible use of technology. …" (S. 25)

Also, the first ICMI study in 1986 “The Influence of Computers and Informatics on Mathematics and its Teaching” (Churchhouse) has been affected by a great enthusiasm concerning the perspectives of mathematics education in view of the availability of new technologies. Many mathematics educators, for instance Jim Kaput, forecasted that new technologies would change all fields of mathematics education quite quickly.

“Technology in mathematics education might work as a newly active volcano – the mathematical mountain is changing before our eyes” (1992, p. 515).

Expectations - Calculators

In 1972, the first pocket calculator – the HP 35 – appeared on the market. Between 1976 and 1978, it was permitted in most (or many) states all over the world. In Germany, its use in general started in grade 7. In the late 1970s and in the beginning of the 1980s, there have been many expectations going along with its use (e. g. GDM 1978): E. g. Calculators

- allow experimental activities in the frame of discovery learning and problem solving;
- give a numerical basis for concept formation;
- allow the integration of authentic real-life problems into the classroom;
- release students from algorithmic calculations, which do not have a central meaning for the solution of the problem;
- allow problem-adequate exercise phases.

However, the question “How might the aims of mathematics education to be better reached?” was posed in the centre of the discussion at that time. And already in those days, some or many (mathematics educators) thought that calculators will bring far-reaching changes of the goals of mathematics into the classroom (e. g. Winkelmann 1978).

Surely, it can be stated today that these hopes, demands and objectives were too extensive and have probably only been reached to a small part. Different reasons can be given for this development: Missing concepts for the use or introduction of calculators, the lacking of professional development for teachers, the resistance of many teachers, the belief of many teachers that paper and pencil abilities will be lost by using calculators are different reasons for the mentioned development.“ (see Weigand 2003).

Expectations and Disillusion

There are only speculations upon future development of the use of DT in mathematics classrooms. The use of hand held technology will especially increase in the next years (Guin et al. 2005). In the meantime, euphoric initial expectations are supressed by pragmatic attitudes. Despite of the use of digital technologies in the public and business world and despite of the tremendous number of research and practical classroom papers, the use of technologies in mathematics education and the impact on a change of curricula is still limited.

In the current ICME Study 17 “Mathematics Education and Technology - Rethinking the terrain” (Hoyles & Lagrange 2010), disappointment is quite often expressed that - despite of the countless ideas, classroom suggestions, lesson plans and research reports – the use of SCs have succeeded, as many had expected in the beginning of 1990s. Some quotations from the ICME Study:

“Technology still plays a marginal role in mathematics classrooms” (S. 312)

“The impact of this technology (CAS) on most curricula is weak today” (s. 426)

“The situation is not so brilliant and no one would claim that the expectations expressed at the time of the first study (20 years ago) have been fulfilled.” (S. 464)

This study gives a good overview of the numerous activities of the last years concerning the use of new technologies in mathematics education (see also Weigand 2010). But the book is not a vision, it rather poses questions, which are, however, quite similar or very similar to those 20 years before. One may interpret that as - partly - resignation, but one can see it also as an indicator of how hard these questions are to be answered. Finally, one can also understand it as a request and as a challenge to develop new ideas - visions - in order to make progress with the integration of new technologies in mathematics education.

It is surely crucial whether these tools are allowed in examinations and, above all, whether they might be used in final or state-wide examinations. World-wide most diverse models can be found. In the last years in Germany, there is a tendency to allow graphing calculators, however, the use of symbolic calculators is only voluntary.

In the following, three theses are set up, which are more strongly a pragmatic view than a vision to strengthen the influence of new technologies on mathematics education.

Concerning the Future

Central questions concerning the use of new technologies and concerning a change of teaching and learning have been posed for a long time and they can be answered – of course – not in a final way (Trouche & Drijvers 2010). With new, always changing media, „old “questions arise in new ways: What is mathematical basic knowledge and how can it be saved? How can traditional working styles and mathematical thinking (proofs, arguing) be preserved and further developed? How can digital tools support the protection of the basic knowledge?

The following is based on the hypothesis that an only isolated point of view of mathematics education and mathematics instruction will not lead to a sustainable basis for future developments. Those isolated points of views could be views only on certain subfields of mathematics, an evaluation of the current situation without seeing the relation to its development, a view on pupils without the view on teachers and contents, a view on technologies without a view on pupils, contents and teachers.

Thinking in relations and connections will be the central condition for changes (improvements) in mathematics education. Connectivity will be a key word of the future.

Three theses are set up concerning the use of new technologies and a further positive development of mathematics education. These are not the only aspects which will be important in the near future, but maybe these are the most crucial ones.

1. Thesis: The use of new technologies requires a global concept of teaching and learning

An integrated global concept of the use of new technologies has to follow different aspects: It concerns

- the interaction of different digital components such as laptop, netbooks, the Internet, pocket computers under technical aspects.
- the use of class room materials. It is crucial to build the relationship between traditional and digital materials, between paper-pencil and digital tools, between schoolbooks and (interactive) e-books and worksheets.
- internal-school aspects. The cooperation of all groups represents the school: pupils, teachers, the head of the school and parents.
- over-school aspects such as the cooperation between teachers of different schools, between school and school administration as well as between school and university.

The following collage shows these connections and relationships of new technologies (computers and hand held technology) – starting in the middle and going clockwise from down left – with computers, laptops and notebooks, smart-phones, whiteboards, a navigation system in the classroom, the Internet (and the necessity of technical support), traditional books, teachers, head of the school, parents, other schools and professional development.

Future developments and the question of a wider integration into classroom technology have to be discussed in the context of an extended mathematical learning environment (classroom, home, digital learning environments). But over all, we will not forget that a change in teaching and learning does not automatically mean a change to a better learning and understanding.

Example: A current example of the effectiveness of the use of new media and the necessity of a global concept is the use of interactive whiteboards. It is surely a surplus that interactive acting is possible with this technology in a direct dynamic way, like it is not the case with traditional presentations. However, only presenting contents with an interactive whiteboard will not lead to a provable increase of pupils' knowledge. The use of this medium must be integrated into a global concept of new digital media usage. If all pupils have laptops or netbooks available in the classroom, and if there is a class-internal digital wireless navigation system, the interaction between pupils and teachers might change. Interactive whiteboards can support this change: The work and the acting of an individual pupil can activate – supported by the whiteboard presentation – a whole class discussion at any time. Moreover, if there is a digital communication system in the classroom, and pupils also have access to a learning platform over the internet at home, in class developed whiteboard sketches can be given to the students for working on them at home. Homework can already be made by pupils under the aspect that it will be presented interactively and dynamically.

Technology and whiteboards can be catalysts for a change in the classroom. But they have to be integrated into a global concept of learning and teaching in school.

2. Thesis: While using new technologies the important "traditional" goals as well as basic skills, facilities and knowledge have to be preserved.

It is sufficiently well-known that effective learning can only develop on a solid basis of knowledge and abilities. Knowledge is cumulatively acquired. A good structure and network of already existing knowledge is the basis for the acquisition of new knowledge. It gives the learner security and acquaintance, it develops meaning by connecting contents and showing a common thread in the learning process. You may talk about a "genetic learning process"

There is especially a need for

- preserving a flexible availability of basic arithmetic, geometric, algebraic and stochastic knowledge, and
- preserving and developing mathematical working styles like proving, arguing, constructing.

There are two important questions for the future: What is the basic knowledge, what are the basic abilities, the basic skills pupils and students should know or should be able to do

- without the use of technology?
- as the basis and condition for the (later) use of DT?

There is a variety of answers to these questions. But they cannot be answered in an absolute way, like Herget et al. tried in 2001. The questions always have to be answered in relation to the goals and aims of learning and teaching.

Example: There are many examples concerning the success of this kind of networked learning. We quote Philipp Melanchthon (1497-1560), who demanded „ad fontes" (lat.: back to the sources) in his inaugural speech with the topic „Concerning the improvement of the studies of the youth"in the year 1518 in Wittenberg. At Melanchthon's time,, "ad fontes" meant studying the ancient Greek philosophers. Today, "ad fontes" can also be regarded as guidance for working with digital tools. The "sources" are knowledge and the basis of a more than thousand years old mathematical knowledge. New technologies give new possibilities for an access to these sources.

3. Thesis: The effects and the results of the use of digital technologies in mathematics classrooms have to be continually evaluated, new concepts have to be developed and integrated into professional development.

Mathematics education, regarded as an "engineer science" (Freudenthal 1978) or a „design science" (Wittmann 1995) has to develop and evaluate appropriate teaching and learning concepts. The basis for these concepts are firstly existing empirical results, secondly theoretical analyses of existing concepts and thirdly creative ideas and visions of a new kind of learning. Concerning the use of new technologies, there exist many theoretical concepts and classroom suggestions, but there still is a lack of especially long-standing empirical investigations. To collect personal meanings of teachers concerning existing lesson plans and contents is for sure important. But only a reflected (scientific) evaluation gives a basis for a specific and aimed development of new teaching and learning strategies in the classroom.

Developing and evaluating concepts is one aspect. Another important aspect is to spread the existing ideas into the classrooms. Especially schoolbooks are crucial for this process. But moreover, without permanent teacher education and teacher training, new ideas will not come into the classrooms.

Example: The EdUmatics-project (European Development for the Use of Mathematics Technology in Classrooms, see Bardini & Bauer et al. 2011) aims to increase the integration of ICT in European mathematics classrooms. An online training course is constructed to provide learning and teaching material for in-service and pre-service secondary teachers.

Conclusion

It is one or even the central goal of mathematics education to develop – based on theoretical considerations and empirical evaluations – concepts for future developments in mathematics classrooms. It is important to have visions and develop visionary concepts, but you also have to take care that these visions will not be illusions. Connectivity will be a key word of future developments to avoid disillusions.

The meaning of hand held technology will increase in the next years. "Ad fontes" gives the security of having a basic ground, new technologies can be catalyst of coming a little bit closer to the old – but still important – goals of mathematics teaching.

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