MULTIMEDIA TEACHING AND LEARNING ENVIRONMENT[*]

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Facing the challenge and potential modern technology offers for mathematical education means to strike out in a new direction. In this article, we give information on the dynamic mathematical software GEONExT and its integration and application in school. As a methodical basis, we use the concept called *I – you – we*. Technical realization is done in form of learning environments and dynamic worksheets.

1. Introduction. Undoubtedly, modern technology has found its way to the classroom. Hence the question we have to face is not *whether* to use computer and internet at school but *how* to do it. In mathematics there is quite a long tradition to use technology in form of pocket calculators. Even the use of software is not a new topic (see [2]). But still, a lot remains to be done. Considerations have to be done on several levels including both the technical side as well as the methodical side. We start this article by giving some information on the dynamic mathematical software GEONExT. Then we introduce the concept *I – you – we* and present a way to combine technics and theory in practice: Learning environments and dynamic worksheets proved as an appropriate means for this purpose. We will finish with reports on a practical one year's experience at school and on the initiative GEONExT Goes East.

2. Some remarks on GEONExT. The dynamic mathematical software GEONExT has been developed by the chair of Mathematics and Mathematics Education at the University of Bayreuth. Let us briefly state some characteristics of this program:

There are two ways to use GEONExT: either as a tool for geometrical construction or as part of HTML documents. In the latter case it is easy to connect the dynamic construction with text and graphics.

All the standard constructions from school geometry can be done. You can draw points, lines and circles, but more complex constructions as well, e.g. bisectors of an angle.

A special feature is given by sliders. These are points that are connected to other objects, e.g. a slider that can only be moved along a distinct line or a circle.

Going beyond the field of geometry, graphs of functions can be drawn as well. Furthermore, the integrated algebra system allows computations.

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The menu can be customized. This allows to adapt the use of GEONExT to special lessons and their progress.

Technical requirements are just a few. You may use the program both under Windows and Linux as long as Java 1.4 (or higher) is installed.

GEONExT is GNU General Public License software. Hence it is available for free. For download, go to the internet site .http://geonext.de (cf. [4] or [5]). There you may find further details as well.

3. I – you – we. The question now is of course, how to use mathematical software like GEONExT at school in a reasonable way. It is obvious that the traditional way of teaching at school has to undergo substantial changes.

Let us explain a concept that enables a new way of performing a lesson. In basics, it goes back to Gallin and Ruf (cf. [1]). We sketch the principle and then go into details with some points we would like to emphasise. For further reading, cf. [3]. A practical example will be given in section 5.

In short, there are three steps:

I	individual work of the single student
you	cooperation with a partner
we	communication in the whole class and additional teacher's instructions

- I – individual work of the single student

  Compared to the traditional passive attitude of a student, active learning definitely is the better choice. Furthermore, learning itself is a very individual act, new knowledge has to be incorporated into the net of existing knowledge which is different for everyone. Hence in this step the student is encouraged to behave actively and discover mathematics on his own.

- You – cooperation with a partner

  Competency in communication and cooperation are topics that are widely neglected. Nevertheless they are essential both for a better understanding of a specific subject as well as for social behaviour. The aim of the second and third step is to improve the student's competencies in that respect. In the second step, communication with a partner (or within a small group) is meant to help the student to improve his understanding of a mathematical situation. Discussing a problem with the neighbour can help to fill gaps in understanding and to deepen the understanding.

- We – communication in the whole class

  First of all, this step is devoted to the presentation of results. This offers the opportunity to compare and complete own results. Moreover, communicative skills are trained. It is only at this point that the teacher restructures and completes – if necessary – the results that were obtained by the students. (This shows the contrast to traditional teaching where the teacher's explanations are the first step.)

This detailed look at the three steps shows that teaching is much more centred at the student. His role becomes a very active one. Of course, this requires a change of the

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teacher's role as well. Instead of being an instructor, he becomes a tutor. His task now is to accompany the student on his discovering journey into the world of mathematics. In order to meet the demands connected with this new role, both mathematical as well as didactic competency is necessary.

4. Learning environments. Let us now come to the question how to realize the concept *I – you – we* together with the use of technology.

Dynamic worksheets are an appropriate way to foster active learning. Following the idea of the traditional printed worksheet, which is rather common in German classes, a dynamic worksheet is a document written in HTML and including dynamic applets to be viewed at the computer monitor. This choice of technical basis enables the integration of texts, graphics and dynamic constructions. There are several possible scenarios for its use:

- use in classroom
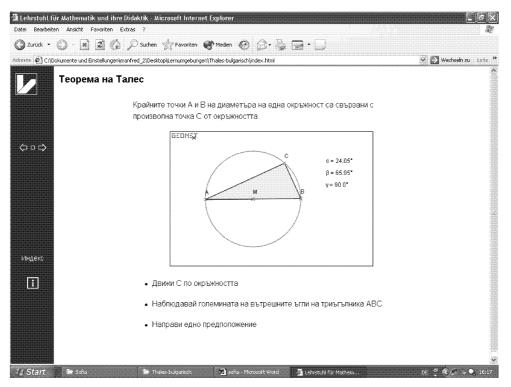
- supplement for lessons

- repetition

Obviously, in all these situations, the active and individual use by the student is emphasized. For example, it is the student who determines the speed of processing

Learning environments finally can be viewed as an aggregate of several multimedia units dealing with the same topic. Their modular structure enables the user (may be both student as well as teacher) to select single components and (possibly) adopt it to his own needs. The technological requirements for this are very low.

As a final remark let us point out that learning environments with GEONExT may be used both online and offline.

5. Examples. As mentioned before, GEONExT has been developed at the Chair of Mathematics and Mathematics Education at the University. The same effort is made to provide learning environments and dynamic worksheets. Several examples can be found in the internet on the homepage of the chair [6]. Besides German versions, some examples already exist in other languages as well. Concerning topics related to curriculum, the variety of topics includes

- Pythagoras

- reflection at a line

- Platonic bodies

- geometry of a triangle

- golden section

Even examples of learning environments can be found which establish the opportunity to connect different subjects such as mathematics, art and history (e.g. *Dürer's Melencolia I*).

Page 1 of Thales learning enviroment

As one example, let us go into more detail with a learning environment which deals with the so called theorem of Thales (cf. [4] and [5]). Originally written in German, this learning environment is available in English, Russian and Bulgarian language as well.

Besides the title page, there are four pages. They reflect the concept *I – you – we*.

- page 1 (experiment): The student is confronted with the starting situation. In the dynamic construction, three points are on a circle. Two of them are on the diameter, the third one can be moved along the circle. There are some guiding proposals what to do. Finally, the student is asked to formulate a conjecture, which is to be written in his study journal.

- page 2 (conjecture): Now, the intended formulation is given together with a historical remark. The student is supposed to compare with his own results. This gives an opportunity to discuss with the neighbour. The next aim is to prove the statement. Some hints are provided, but it is up to the student to ask for these hints.

- page 3 (proof): In this page, a proof for the statement is given. So at this stage the student is given all the information about the theorem of Thales. Note that the student was active during that process!

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- page 4 (converse) A natural question in the course of this proceeding is to ask for the converse. This is supplementary. However, when using the learning environment in classroom it may be convenient to make smart students deal with this page while other students are still working on the previous pages. It may also be given to interested students as a supplement.

Additionally, there is one page in pdf-format which is meant to be printed and added to the study journal. This page contains the main results of the learning unit.

6. In practice. So far about theory, let us have a look at practise now.

If GEONExT or any other software is used in lessons, a certain amount of time has to be invested in order to get acquainted with the program. Hence, on first sight, this means a loss of time and there has to be a good reason why one should get involved in all that.

As a reply, we would like to point out two aspects: On the one hand, several supposed drawbacks go back on short time use. On the other hand, there are some positive effects that result in the regular use of dynamic mathematical software, and hence this should be worth a consideration.

In order to give you a hint on evidence, let us briefly report on an experiment. The interested reader can find more details in [7].

In the school year 2001/02, for a whole year GEONExT was used in mathematics lessons. The class comprised 31 students, 28 of whom where female. Based on the regular 8th grade curriculum, the aim was to implement the concept *I – you – we* as well as dynamic worksheets in the lessons. The only deviation from normal operation was the fact that the class was divided into two parts for the time when the computer was used. This was due to the size of the computer room with only 22 working places, whereas every student should have the possibility to work on his own.

The experiment was evaluated. To a large extent, the results had been used to improve the program. In our context, the more interesting conclusions are those concerning the new elements of teaching. Let us list just a few observations.

- The size of the class set limits to the realisation of the student's liberty in exploring a mathematical subject on his own. Many learning units were rather strictly directing to the desired result of a lesson.

- Though an "average" class, most of the students were very motivated and appreciated the use of computer.

- GEONExT was not used in examinations. This might be a reason for the widespread students' opinion that the use of software is "not a regular lesson".

- Improvement in traditional constructions with compass and ruler was observed.

- If there were negative attitudes towards the use of computers, two main reasons were mentioned: a) Difficulties with the use of GEONExT. These problems, however, were due to a lack of general computer literacy independent of GEONExT. b) Weak students were afraid that basic manual skills were to become less important in assessment.

- The aim of improved communication was hard to realise. Students are not used to communicate in the intended way (discuss problems, present results). It turned out that help with computer problems was a possible catalyst to encourage this new element in lessons.

7. GEONExT Goes East. GEONExT is available for free and there are only few requirements with respect to the operating system of a computer. In view of the distribution and application of the program, possible problems like licensing do not exist. On the other hand, teachers are provided with the program and – even more important – examples of dynamic worksheets and learning environments. Much depends on the activities of teachers in practise. They have to adapt existing materials to personal needs, to develop material on their own on the given basis as well as to create new materials.

A lot of response in this respect came from Eastern European countries. Hence, the initiative *GEONExT Goes East* was founded in order to encourage activities in this direction. For example, in Ukraine existing material has been used in school lessons (at schools with German lessons).

However, material to be used at school definitely should be available in the respective native language. A language interface for the program GEONExT is now available. This, together with the use of HTML for learning environments, makes it easy to adopt materials to any language. Everybody interested in participating is invited. Please contact the appropriate address indicated below.

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[2] H. HEUGL, W. KLINGER, J. LECHNER. Mathematikunterricht mit Computeralgebra-Systemen, Bonn, Addison-Wesley, 1996
[3] V. ULM. Ich, Du, Wir – ein Lern- und Arbeitsprinzip im Mathematikunterricht. Praxis Schule, 5–10, Heft **4** (2002), 30–34.

INTERNET RESOURCES

[4] the GEONExT internet site: `http://geonext.de`
[5] the Russian GEONExT internet site: `http://did.mat.uni-bayreuth.de/ru`
(email: `goeast@geonext.de`)
[6] internet site of the chair of Mathematics and Mathematics Education at the University of Bayreuth: `http://did.mat.uni-bayreuth.de`
[7] W. RITTER. Ein Schuljahr dynamische Geometrie mit GEONExT in der 8. Klasse: `http://www.mwg-bayreuth.de/geometrie8/`

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МУЛТИМЕДИАЛНИ УЧЕБНИ СРЕДИ

Манфред Й. Баух

Да се отговори на предизвикателствата и потенциала, които модерните техноло-
гии предлагат за организирането на урока по математика, означава да се поеме
по един нов път. Настоящият материал съдържа информация за динамичния
математически софтуер GEONExT, за неговата интеграция и за неговото прило-
жение в училищата. В методическите основи на GEONExT, лежи концепцията
Аз – Ти – Ние. А техническата му реализация се осъществява основно чрез из-
ползването на виртуални учебни среди и на динамични учебни страници.