USE OF MATHEMATICAL SOFTWARE IN PRE-SERVICE TEACHER TRAINING: THE CASE OF DGS

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Use of mathematical software in pre-service teacher training for preparing students to become mathematics teacher has two aspects:

- *Using mathematical software as a support for pre-service teacher training*
- *Preparing the future teachers for using mathematical software for their teaching.*

In the presentation theory and practice of the second item will be discussed: what are the pedagogical benefits of the use of mathematical software in mathematics teaching.

Different types of mathematical software will be introduced and discussed towards their use in mathematics teaching.

INTRODUCTION

Preparing the future teacher for the appropriate use of technology in their teaching has to be one of the main issues in today's mathematics and science pre-service (and in-service) teacher training.

The appropriate use of mathematical software in mathematics teaching can greatly support the teaching and learning of mathematics. On the one hand mathematical software can be supportive for using mathematical knowledge and in learning how mathematical knowledge can be used. On the other hand mathematical software offers valuable support for the appropriate development of mathematical concepts.

Therefore the use of mathematical software should not be ignored in pre-service teacher training.

The use of mathematical software in teacher training comprises two aspects:

- Using mathematical software as a **support for the training** itself (e.g. for doing the mathematics, that the future teachers need, with the help of computers or hand held technology).
- Teach the future teachers **how to use** mathematical software **in teaching** (eg. how to analyze the benefits of the use of mathematical software in teaching mathematics, according to the respective teaching goals).

How to use different types of (calculators and) mathematical software in the classroom has become a central topic in mathematics education research during the last decade. Researchers focused on the use of numerical and graphical calculators, as well as on computer software like Computer Algebra Systems (CAS) and Dynamic Geometry Software (DGS). Based on empirical research about the use of such tools in mathematics classrooms and on recent theories of mathematical learning, some theoretical models about the use of technology for mathematics teaching were developed. Most of the research projects are centred on the use of CAS for mathematics teaching (Kutzler 2000, Artigue 2002, Cuoco 2002, Ruthven 2002). But more and more attention is also put on the use of DGS in mathematics classrooms.

DYNAMIC GEOMETRY SOFTWARE

Dynamic Geometry Software (DGS) - a group of programs for doing "dynamic geometry" - is from the didactical point of view the most appropriate tool (group of tools) for supporting the development of geometrical concepts, in particularly concepts of Euclidean geometry, which are developed in the frame of teaching elementary mathematics.

The main characteristics of A DGS are:
- a dynamic modelling of the traditional paper and pencil (blackboard and chalk) teaching environment through the drag mode
- an option to condense a sequence of commands to form a "new command", a macro
- an option to visualize the paths of the movements of geometrical objects, a locus

These features allow a great support to the development of geometrical concepts, when the programs are used appropriately in the classroom.
How the use of DGS influences the teaching and learning of traditional Euclidean geometry was investigated and analyzed by many researchers during the last decade (Hölzl 1996, Straesser 2001). Results from a large number of research projects, looking at different aspects of the use of DGS for teaching and learning Euclidean geometry and focusing on changes in the teaching and learning of geometry (Hoyles & Jones 1998, Kokol-Voljc 1999, Laborde 2003) back up the hypothesis of a positive influence of DGS for teaching and learning geometry:

> "from being a visual amplifier or provider of data towards being an essential constituent of the meaning of tasks and as a consequence affected the conceptions of the mathematical objects that the students might construct" (Laborde, 2001, p.283).

One of the most powerful and the most widely recognized didactical components of DGS is visualization (Kadunz, 1998). Numerous theoretically justified teaching suggestions are offered for using DGS on different levels of geometry teaching (Weigand 1988, Kokol-Voljc 2000).

When comparing algebra and geometry as two fields of school mathematics, DGS offer a quite comparable alternative to CAS (Laborde, 2003).

DGS offer tools and possibilities, which can considerably improve the teaching of basic geometrical concepts in the primary (as well as in higher) grades.

DGS-TEACHING EXAMPLES

Concerning the power of visualization and the mathematical background of the respective software features, DGS can be used as tools for developing the theoretical meaning of geometrical concepts already in very early phases of introducing geometrical concepts.

In the following we give examples for early development of some geometrical concepts.
We use DGS GeoGebra and Cabri Geometre II to show, discuss, and analyze examples on how DGS can support the development of generic geometrical concepts in the first years of learning mathematics.

Example 1: Line, ray and segment

When introducing a ***line*** in the first year of primary school, the students has to draw a straight line using pencil and ruler. Using these tools, the students don't need to think much about prerequisites for the line (such as that the ruler must not be moved, and that the line can be drawn) - only the direction can be pointed out, but the importance of a "starting" point is not so evident.

When using GeoGebra for drawing a line, one first has to choose a point. Then the line appears, but the direction changes with the cursor. Hence, the direction of the line has to be fixed. The direction is chosen by selecting a second point of the line. Consequently, for having a line on the worksheet, one has to select exactly two pints (Figure1).

"*Two points determine a line*." says an axiom of Euclidean geometry - and this is the fact, which is practiced/learned when drawing a line using GeoGebra.
A very important aspect here is a *dynamic aspect* of the activity: the line changes its direction until the second point is fixed.

Using appropriate features of GeoGebra, students can similarly learn and visualize the characteristics of ***segments** and **rays*** and they learn about the differences between a line, a ray, and a segment (Figure 2).

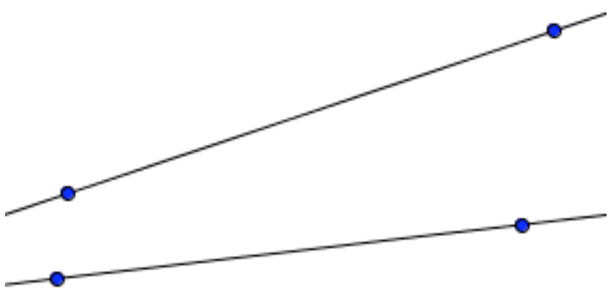


Fig. 1

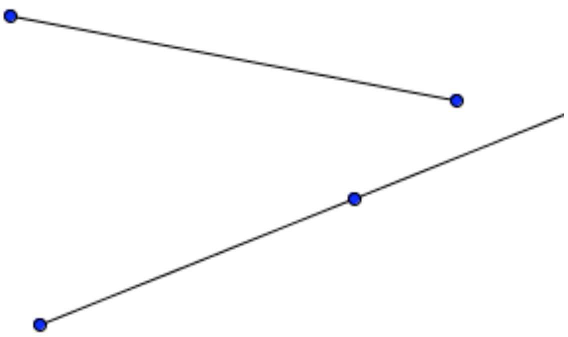


Fig. 2

Example 2: Plane figures

How do we draw a ***triangle*** with pencil and ruler? We hardly do it by choosing the three vertices ...

If we use the respective feature of GeoGebra for drawing a triangle, we **must** select three points to obtain a triangle (Figure 3). Basically, a triangle is determined by three vertices - and this is the fact we learn when using DGS for drawing triangles.

The same is true when drawing a ***circle***.
The first GeoGebra-tool for drawing a circle demands to choose a point (the centre point) and a distance from the centre point to a point on the circle (e.g. the radius) to draw the desired object (Figure 4). The other GeoGebra-tool for drawing a circle requires choosing a point and the radius explicitly.

Therefore, through the use of GeoGebra, the students learn the essential conditions for a circle: to have the centre point and the radius. The activity using GeoGebra requires/supports being aware, that a circle is determined through a point (the centre point) and a constant distance of the points on the curve (radius) - and through this supports a mathematically adequate development of the respective concept of circle.

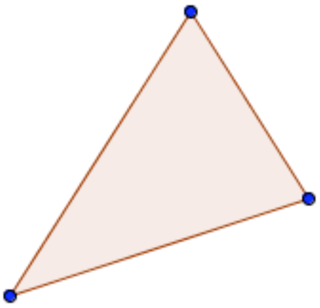


Fig. 3

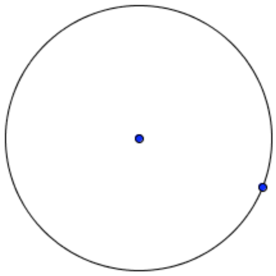
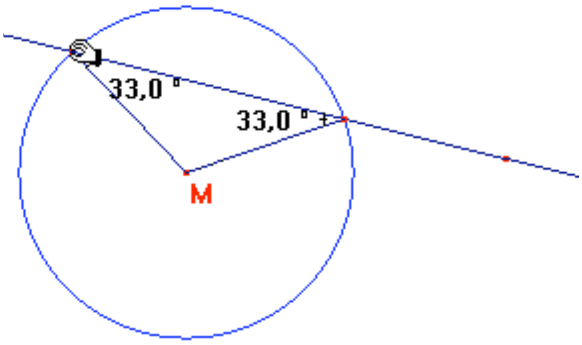


Fig. 4

Example 4: Tangent

As an example for early middle grade mathematics teaching, we take the concept of a ***tangent***. The definition of a tangent requests: *"The tangent to a circle is a line having only one point in common with the circle."*. Through appropriate activities, performed with DGS (Cabri Geometre II), where the *dynamic aspect of the activity* is of great advantage, the students can develop the concept of a tangent, connecting the above definition with the main characteristic features of a tangent (Figure 5 and



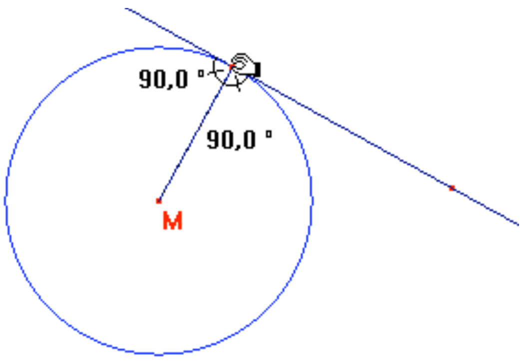


Figure 6).

Fig. 5

Fig. 6

The defining relationship between a line and a circle can be **visualized** when **experimenting** using drag mode. At the same time the student can observe one of the characteristic features of a tangent: „*The tangent line is perpendicular to the radial segment in the point where line and circle touch*."

DYNAMIC SCHEMATIZING

One of the main common characteristics of the examples shown in Section 3 is the *dynamic aspect* of the performed activities - we call this ***dynamic representation***.

In a traditional ruler/compass (or pair of compasses) geometry the sketch represents a *static representation* of the respective geometrical concept. The *dynamic aspect* of the concept (which represents the relational aspect of the concept) remains hidden in a construction process when using a paper-pencil environment. And it is lost when looking only at the final product of the constructing/drawing activity.

The use of DGS changes the situation fundamentally: In the sketch itself and in the construction process, the *dynamic-relational aspect* of the respective concept retains (it would be kept through the drag mode). This is the main difference between a DGS produced sketch of a geometrical figure/object and a paper&pencil sketch of the same object.

A ***dynamic representation***, i.e. the ability of a DGS to represent dynamic processes and to make them an object of research, can be used for a dynamic construction (drag mode) or for the process of constructing (macro, locus). The dynamic schematizing (Kokol-Voljc 1999) of geometrical objects can significantly improve the development of geometrical concepts at all levels of mathematics teaching.

CONCLUSION

DGS bring a new dimension into the teaching of geometry. Through making use of the dynamic features of DGS (*dynamic representation*), the geometrical concepts can be developed more efficiently and the graphical representations of the concepts - sketches - can be even more representative for the respective mathematical characteristics compared to doing the same in a paper-pencil environment.

The use of DGS should not replace the use of ruler and compass, but enrich and complement it.
There are great advantages of "ready-made" macro constructions - but for the students, an important part of the respective activity (the construction) would be lost. The concrete constructing activities are important part of the concept developing process as well in a DGS as in a paper&pencil environment.

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