IMPROVING GEOMETRICAL SKILLS BY USING COMPUTERS TO CREATE SIMPLE MECHANICAL MODELS

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ABSTRACT
Interactive geometry software is mostly used at schools as an environment for solving traditional geometrical examples. Students' skills, which have been learned in classical geometry and by constructing classical figures in the computer, can be improved by creating dynamic geometrical figures as they look and behave in reality, for example, with models of real movable subjects that are simple engines, apparatuses, people or vehicles. Working on open ended exercises and projects as well as publishing final figures on the web can attract students who can feel themselves as being web programmers. In fact, they do not make any programs, but discover the geometrical character of movement and test their hypotheses by creating models in DGE software, for example Cabri.
This article deals with an in-service teachers' preparation project currently running at the University of South Bohemia. The main goal of the project is to prepare future mathematics teachers to the changes in education style and curricula, which should reflect by using computers as educational tools in many school subjects.

KEYWORDS
Dynamical geometry, computer assisted instruction of mathematics, geometry education, Cabri Geometry

INTRODUCTION

The changes of the setting in the Czech School System, based upon the new school law, the trend towards key competency-oriented curricula, including cross-disciplinary activities i. e. using computers. The interest of teachers to use computers as tools for teaching standard geometrical topics by standard "paper and pencil" methodology (which uses this software only as a tool for exact and quick drawing) can be exhausted in a relatively short time if they don't practice searching mathematical patterns in the real world instead of orientation on knowledge of mathematical findings.

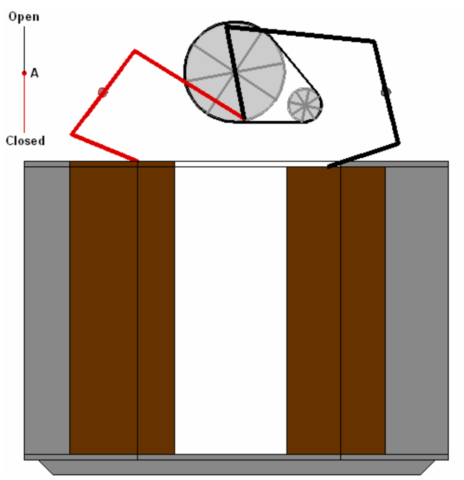

Figure 1. Lift door opening mechanism as a movable geometrical model made in Cabri

Searching for a new approach as to how to let children get geometrical skills leads to using educational projects and open-ended tasks. There is some understandable resistance of mathematics teachers for the project-oriented education across school subjects. These teachers don't see concrete application and practice of learned mathematical knowledge in just such activities.

DYNAMICAL GEOMETRICAL FIGURES

One of the main features of the dynamical geometry environment is the possibility of creating movable and interactive pictures using geometrical objects, which can be dragged with a mouse or moved automatically according to given paths (Vrba, 2000). Users can see an internal geometrical mechanism there which can move the whole figure by dragging one point and can create graphical figures without the necessity of knowing special commands or language which allows for its creation, unlike other computer environments which allow for the creation of graphics, like graphics editors (GIF Animator) or programming applications (programming languages). Dynamic geometry allows children to apply skills and knowledge related to the geometry and elementary mechanics learned by the traditional way through the construction of movable models of real things or situations, as simple engines, the moving of figures, animals or vehicles. Visualisation of the situation releases a part of actual memory capacity, which allows the learner to use other mental functions, i. e. analysis or comparation, which has a big demand in a conceptual learning (Hejný, 1990).

Unlike the construction of basic geometrical solids, dynamical figures evoke the real world and can better motivate children. As a geometrical basis is less visible in these pictures, pupils use their knowledge subconsciously as they would by creating conventional constructions (Henn, 1993). They practice their geometrical imagination and intelligence by searching for invariants in movement and appearance of geometrical projections in the world around unwittlingly. On of the example is a parallel wire on front and rear wheel of a bicycle (see Figure 4) must always keep parallelism, if wheels are the same size. Then the rear wheel could be made as a picture of the front wheel in a translation, because of parallelism is retained during translation. In another case, if two wheels have to turn in opposite directions, they can be constructed using axial reflection.

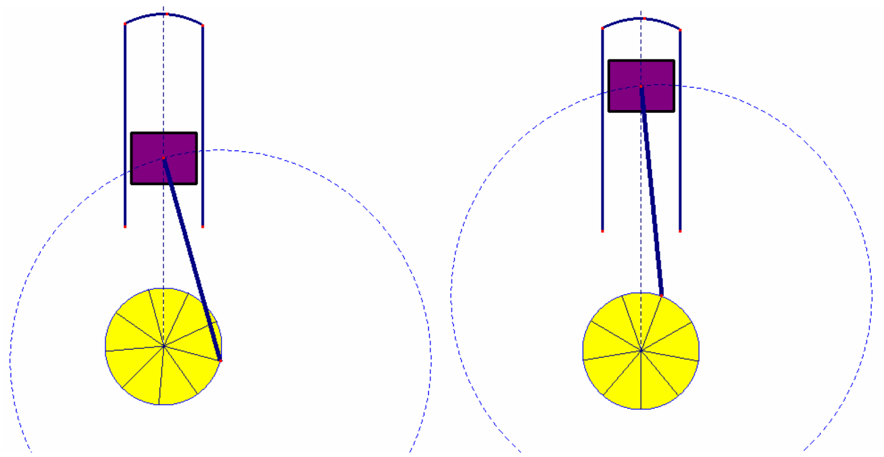

Figure 2. A model of an engine is an example of using locus. A centre of a piston lays on a big dashed circle with constant radius and the centre moving along a small circle.

SIMPLE MECHANISMS

In this project, we have created not only models of engines, cars and other mechanical equipment, but also animals or people in motion as well. Every dynamical figure which can model some real objects moving in agreement with mechanical rules is called a simple mechanism. Simple mechanisms are suitable objects for creating dynamical figures, because their movement follow only several simple rules which can be recognized easily (Laborde, 1996). Dynamical geometry tasks can be transferred to tasks using locus. For example, an interactive model of a combustion engine is built on the piece of knowledge that the piston rod has constant length and then a segment representating this piston rod must not change its lenght by moving. The centre of the piston (represented by a point) must have a constant distance from the other end of the rod. Thus a locus of centres of the piston is a circle going through the point representing the other end of the rod and which radius is equal with length of the rod.

Dynamic geometry software is able to create a microworld, so it is suitable to use learning strategies which are successful in working in the microworld environment. Pupils react better when they are allowed to create their first animated figures exactly according to the directions and presentation of a skilled user, i. e. the teacher. Later, they mostly create their own figures using analogy, not only constructional, but also topical similitude. As lately as they get a lot of experience, they become courageous enough to start an adventure of creating a completely new animated figure. They usually don't have enough practical experience to discover the special behaviour of objects by moving and to finish the construction correctly. They need the presence of an experienced tutor which can help them to realize their ideas directly in the dynamical construction.

The universality of sharing finished interactive geometrical models, via the Internet, is an additional motivating factor. Movable pictures can be placed into web page as an applet. The content of the applet can be displayed in every web browser (with installed Java support)..

LEVELS OF CONSTRUCTION DIFFICULTY

Dynamical constructions can be sorted by the dependency of moving objects to four difficulty levels:

Level No. 1 Objects move simply on basic lines (straight lines, circles), objects usually move independently of each other.

Level No. 2 One object in the construction exists there, usually a point, which controls movement of the others objects that are constructed by the geometrical way (as perpendicular, parallel, image in translation or symmetry – see Figure 3).

Level No. 3 Some of movable objects are created using intersection points. Some objects are created as an intersection of temporary overlapping objects. This technique allows hide and show these objects depending upon actual situation on a sketchpad.

Level No. 4 The figure allows for the acceleration or retardation of speed of some moving object unlike just steady running (f. e. swinging of pendulum, falling of objects).

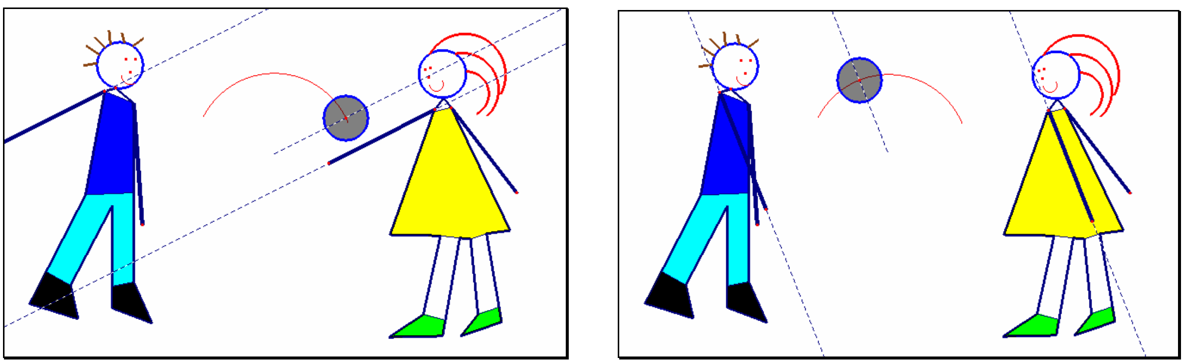

Figure 3. Playing children, level No. 2. A centre of a ball controls the whole dynamic construction. Both moving arms lay on the lines parallel to the ray going through the centre of the ball.

The chosen level of movement difficulty in the mechanical model depends upon the author's mathematical skills. It is interesting that this level does not correspond with author's creativity rate of dynamical figures. Very creative movable figures often contain very simple movement of objects. A lot of authors realize their creative potential more so in drawing plentiful static parts of the figure and colouring objects.

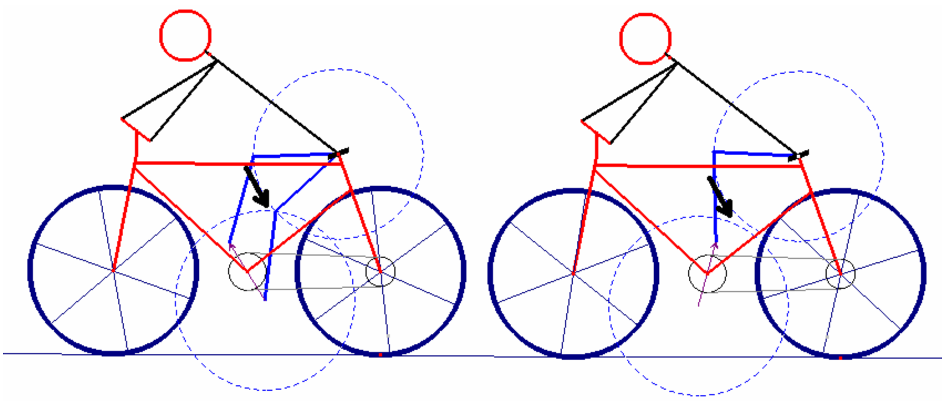

Figure 4. A cyclist's knee is made as an intersection point of two dashed circles. On the right figure, the intersection does not exist (arrow), so the whole leg is off.

EXPERIENCE WITH TEACHERS PREPARATION

If pupils are able to create dynamic models at schools, they need prepared teachers. The main goal of the modelling simple mechanisms project which has been currently proceeding at the University of South Bohemia, Pedagogical Faculty for more than five years, is to prepare future mathematics teachers. Because a part of our students are enthusiastic about this type of mathematics, we hope that it could be a way of how to change their meaning of what is important to teach in schools.

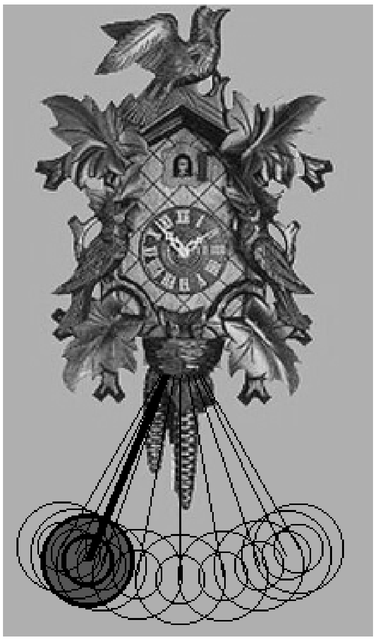

Figure 5. Level No. 4, phased figure of realistically behaving pendulum against a bitmap background of a clock. A definition of the complicated movement is hidden in the invisible part of the construction.

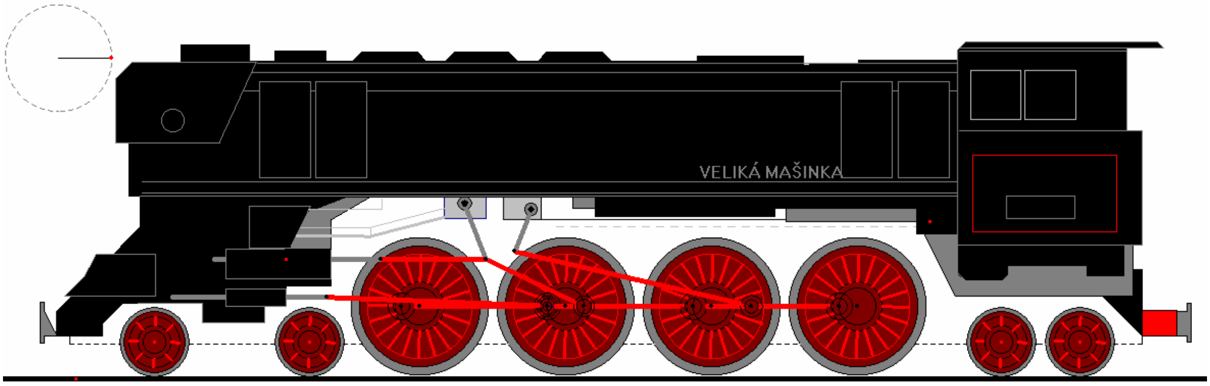

Figure 5. A big model of steam locomotive transmission as a student's work in Cabri

CONCLUSION

According to our experience, only less than half of participating students are enthusiastic over these activities, they have to be forced to work in a creative way. At first not only pupils, but also pre-service teacher students, cannot imagine which technique to use to manage nice and correctly behaving animated figures. A big surprise is that most clever students are not the most successful ones. More often, the ones who are ready to communicate with the teacher are more successful because, as we suppose, they can get a lot of skills by studying the work of the tutors and following the tutors' recommendations.

University students also are more anxious than secondary school pupils. They are very rarely open towards creating a picture without exact knowing the whole construction process. On the other side, pupils rarely realize projects with construction steps of the levels 3 or 4 (described above) because these geometrical constructions appear to be too difficult for them.

We can say, that this way of improving dynamical geometrical and computer skills together can improve constructional skills and thinking and it will give students another example of usable application of school geometry in the world of mechanics. Creating simple mechanisms can lead project oriented and open-ended tasks education into Czech Schools and direct mathematics teachers to the key competencies instead of learning content oriented education.

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