ICT in Technical Subjects

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Abstract

ICT have currently spread almost into all areas of human interests. These technologies accompany us during our rest and entertainment and enable fast and easy communication across vast distances. Moreover, they are used in education and science and control systems around us allowing easier design and construction of these systems. However, they cannot be taken as the only one perfect and best technology. Our research and experience in education of technical subjects shows that they cannot replace the work with real systems and models. In fact, no simulation or animation, even the most perfect one, can fully replace reality. Nevertheless, reality properly completed with animations or simulations offers many possibilities that were previously unthinkable. It is very important in education to show proper interdisciplinary relationships which are the true image of the real world. Also, it is essential for pupils and students to acquaint themselves with the practical problems from their practice. They have accustomed to computer design and project and assembly documentation and they understand technical documentation. Further, they have realized that these are direct images of real systems and they have learned to create and use them. At our department, we have focused on those issues. Students profit from acquired knowledge and skills in one subject that can be used in other subjects. This contribution aims to summarize up to now experience and show some practical results of research that have been conducted.

Keywords

Introduction

It is well known that ICT in education has replaced education aids and practical activities with real systems. However, the situation in technical fields is critical. Our research and experience show that not only pupils of primary schools but also a large number of technical university students do not have good craftsmanship. In fact, a social prestige of crafts is extremely low and it results in a very little interest in them. Knowledge can be stored in books and other media but experience and skills cannot be preserved like that. They are handed down from a master to

an apprentice and this transmission takes from several years to decades depending on the field. Unfortunately, masters able to pass experience are slowly disappearing. In general, demands of technical fields require a high level of quality secondary and tertiary technical education, which seems to be a global problem as shown in a report for President Obama (Holdren, 2010) where recommendations to change education in the United States are. Nowadays, mutual natural authority based on skills, not only for pupils in primary schools, does not practically exist. In today's society more and more emphasis is put on the idea of freedom and democracy and the authority together with the discipline are considered inadmissible (Vališová, 1999). At the same time, to educate an individual does not mean to take him the opportunity to be himself or to restrict his abilities and to operate in an authoritarian way. In our society, freedom and authority are not mutually exclusive opposites but complementary aspects of formative action (Vališová, 2005). In such a social climate it is very difficult to educate young people and motivate them to diligence, consistency, ability to solve problems or to cooperation and consideration.

Our research and experience with technical courses at basic schools show that practical activities naturally create space for cooperation. During them, a natural authority is created based on handicraft or technical skills. It can often happen that students with worse results but with skilful hands and technical thinking can be an authority for other pupils. Generally, practical work requires patience and the ability to face difficulties when obtaining skills and abilities. It is the dependence of the current generation on ICT that can be used in a positive way to bring young people back to the practical work, and to suppress the negative impact of ICT and improve the employability.

## Creation of technical documentation drawings, diagrams and their use

Basics of education for the design and production of technical documentation have been developed in primary schools and subsequently technical schools and technical universities. Creativity and imagination are the basic requirements related to the construction and design of products and technical devices (Driver, 1994). Thus, preparation of a technically oriented young person should include: the basics of technical graphics, practical activities and work with the material, installation and maintenance, self-control, quality, health and safety at work (Kočí, 1994).

Technical documentation is crucial in the fields of mechanical engineering, electrical engineering and electronics, civil engineering and architecture. The basis is the technical documentation or a draft, a scheme of circuit board in electrical engineering and electronics or an assembly plan. Technical documentation currently includes everything from technical standards to design using computer technology – CAD (Svoboda, 2011). The area of primary education needs to focus on the basics of technical documentation and its creation, reading and use within the various practical activities.

Technical drawings used to create technical documentation and ICT are linked over CAD. The issue of CAD is currently represented by two main fields of use (Freedom, 2011):

- 2D CAD;

- 3D CAD.
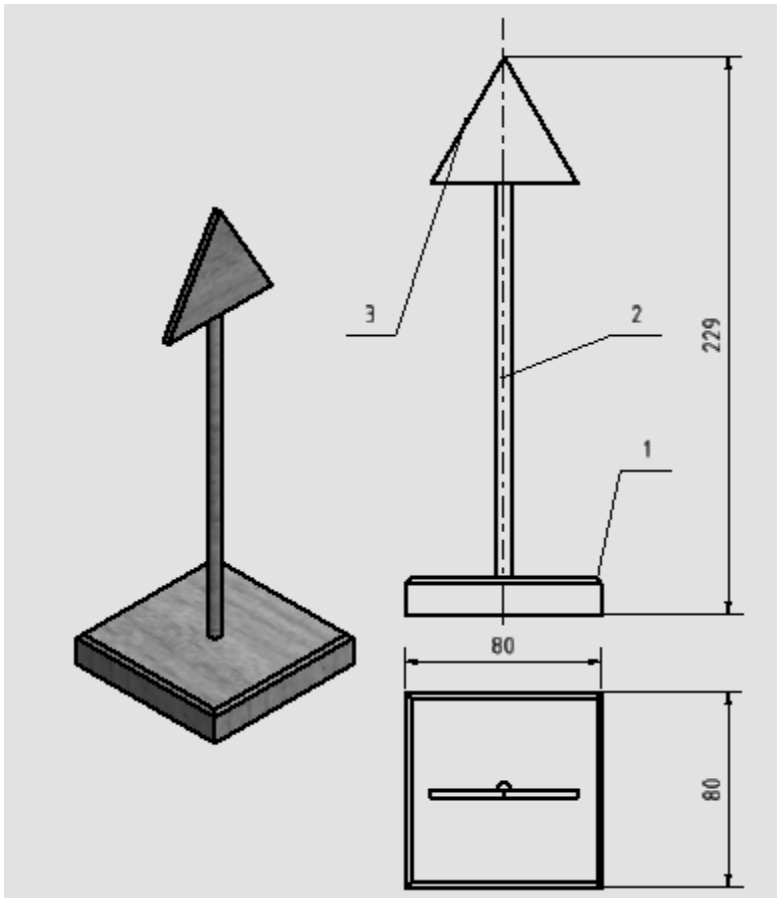
Fig. 1: Design of a simple road sign – Autodesk Inventor

In practice, modern methods of 3D design are promoted at universities and secondary schools and they are based on the parametric modelling - 3D CAD (Svoboda, 2011). The core of this design is the creation of a 3D model of an object (component) on the computer screen. The model is mathematically described by the variables and parameters. In the process of construction, these parameters can be flexibly changed with the immediate effect on the subsequently created technical documentation (Svoboda, 2011). The indisputable advantages include the fact that the transfer of 3D objects into technical documentation provides the program itself and the creation of technical documentation thus becomes more creative (Hodis, 2012).

Primary schools are mainly focused on simplicity and mastery of basic manufacturing operations such as sawing, filing, etc. When making a draft, it is therefore important to pay attention to its visualization (Hodis, 2012). This can be very effectively done with 3D CAD solutions - Autodesk Inventor. An example of using this design system to create a simple product for a primary school is in Figure 1.

ICT are linked with the creation of technical documentation over CAD in the design of schemes in electrical engineering and electronics. Specialized software such as AutoCAD, progeCAD (Figure 2) or Eagle is suitable for schemes or PCB design (Eagle).
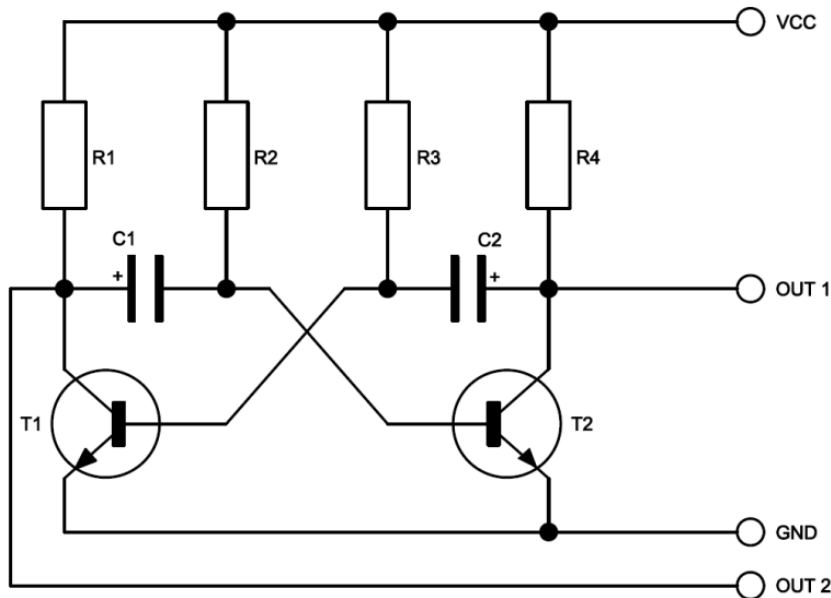

Fig. 2: Scheme of multivibrator – progeCAD

Mastering the basics of technical documentation is an important condition for the use of basic graphic communication in technical fields. The creation of technical documentation and diagrams is linked with ICT and is currently ensured by using specialized software - CAD. New CAD systems are prospective graphical software for creation of technical documentation. It is especially 3D design based on the parametric modelling - 3D CAD which is an area with a great potential that leads to visualization of the proposed design solution. The essence of this design is the creation of a 3D model of the object on the computer screen. The undeniable advantages include the fact that the transfer of 3D objects into technical documentation provides the core of the program itself. In fact, the work with these new systems is becoming a creative activity and it is much more attractive than the older method of 2D imaging. However, 2D imaging method with CAD is still irreplaceable in the concept of the graphical display and especially in the schemes creation in electrical engineering and electronics.

3D models, animations and interactive simulations

Use of e-learning and multimedia study supports is growing not only in technical fields. Benefits can be seen not only in distance education, but also in the support of full-time education. The importance of multimedia and their dynamic elements (animations, graphics, videos, interactive features, audio, online applications, etc.) rises. Multimedial study materials

provides a more effective preservation of knowledge of taught study matter (Klimeš, Svoboda, 2009) because of better clarity and possibility to involve more senses.

The use of 3D graphics and demands for it has significantly increased in recent years. This happens due to the increasing power of computers and accessibility of 3D modelling and animation applications. The best-known application for creating 3D models and animations are Maya, 3ds Max, Cinema 4D (figure 3), Blender and others. In terms of using 3D applications in the school environment, we conducted a comparison of two commercial and one "open source" product (Maya, Cinema 4D and Blender). Due to the low cost of school licenses (Cinema 4D Academy Program), easy control, Czech localization and availability of materials for self-study, currently the best product for the use in the school environment is Maxon Cinema 4D (Babb, 2004).

There are new and new areas where 3D graphics can be used – for example movies and television, computer games, multimedia, 3D GUI applications on the Internet, e-learning and multimedial textbooks with visualizations of objects, processes and principles. In the field of technology, 3D can be used engineering or architecture, where we can visualize models of buildings or devices, their design and transfer into the technical documentation.

We can use the term CGI (computer generated imagery) for the image created on the computer using graphics software. CGI is often used in the field of 3D graphics (Derakhshani, 2006), but the output can also be a 2D image (render).

The creation of 3D graphics is very similar to the creation of vector graphics. In the case of 3D graphics, the vector graphics is extended to the third dimension (coordinates X, Y and Z).

The model is then created from polygons (defined by points and lines). A polygon is composed of at least three vertexes and form a triangle or a polygon ($n > 2$, $n \in N$). By combining multiple polygons, we create the surface of the modelled objects using the selected modelling techniques. After modelling the object, we apply materials and textures, lighting and animations. The we can render the scene, which means converting the scene into a 2D bitmap as a single image or image sequence (jpeg, tiff, avi, mov, ...). This procedure is the middle phase of a three-phase process consisting of preproduction, production and postproduction (Baaba, 2004). Production of CGI can be summarized in the following steps (Derakhshani, 2006):

- modelling;
- shading and texturing;
- animation;
- lighting;
- rendering.

It should be noted that the classic 3D applications (such as Cinema 4D) are not the only possible way to create a 3D model. Another way, frequently used in engineering, is volume rendering. Unlike "classic" 3D graphics, where polygons are formed in the process of coverage to a 2D image consisted of pixels, volume rendering works with the so-called voxels (volume element).

The data sources can be various types of measurements or scanning (CT, MR…). 3D data are stored and then it is possible to re-create the image.

When we are animating 3D models, we are not limited only to keying of basic parameters (position, size…), but we can animate any parameter. In addition, using tools such as Xpresso, we are able to influence the behaviour (animation) one object by the behaviour/state of another object. If we include the dynamics of solid and soft bodies, or particle effects, we expand the animation possibilities by a variety of possibilities usable for modelling of physical properties in technology.
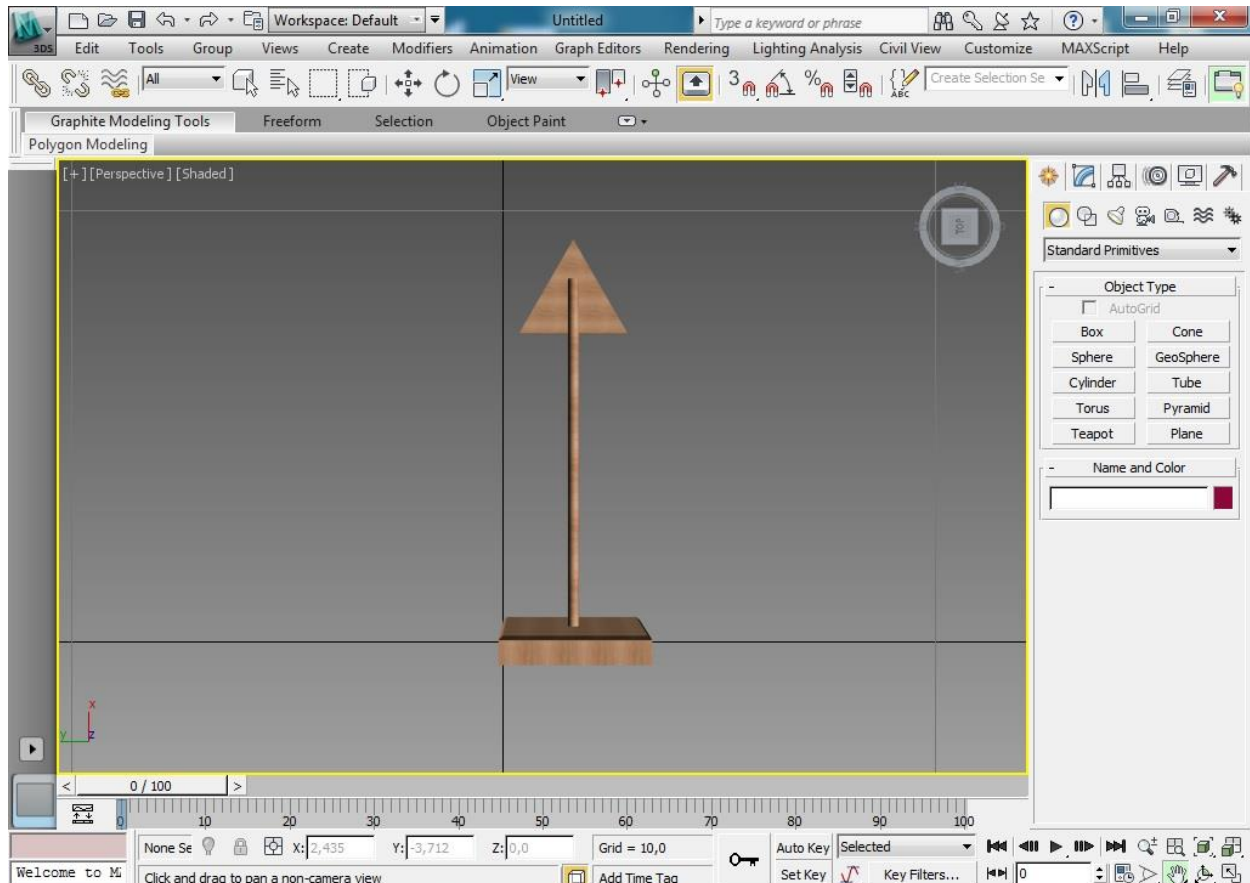

Fig. 3: Example of a 3D model of a technical product

The use of 3D graphics in education of technical subjects helps to develop the perception of principles of the world around us. Thanks to the clarity of 3D graphics, models and animations, pupils and students are more aware of the laws of physics and the interaction between bodies. They perceive different behaviours of materials, lights, shadows, geometry objects and other aspects. By simple rendering of image sequences, we can create an illustrative animation. If we need interactive simulations, we are able to export for the web environment in VRML format, or use other technologies (such as Adobe Flash) and thus widen the interactivity of models suitable for education in technical fields.

Interactive whiteboards in education

Interactive whiteboards can be currently considered a standard among education devices that schools normally have. With them, the teacher can easily create an active and creative environment. In fact, the hardware or software of an interactive whiteboard does not matter because the current boards are practically comparable. Furthermore, larger software differences only provide a different level of user comfort, which is an important fact to consider when choosing an interactive whiteboard, but it is not a prerequisite for the creation of the aforementioned creative and active environment in the classroom. Thus, board itself is not a guarantee of interactive education. However, it enables extension of the standard teacher – student and student – teacher interaction. As for student – interactive whiteboards and interactive whiteboard – teacher see Fig. 4.
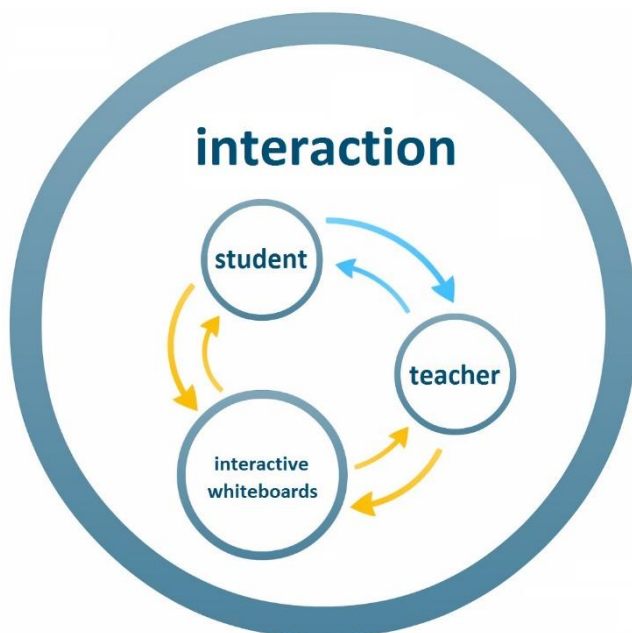
Fig. 4: Interaction between participants in the educational process

It is therefore essential to change the attitude of teachers towards students. Experts (Fidedor, 2007) agree that quality interactive education lies in the involvement of pupils directly in the process of education so that they become part of it. As reported (Rack, 2007), an interactive whiteboard is not a punishment for teachers but a great help during a lesson. Yet many teachers hold the opinion that the energy spent with the creation of interactive materials using a new technology is not directly proportional to the increased efficiency of education. However, working with an interactive whiteboard does not necessarily mean hours spent on creating materials. An interactive whiteboard can be used as a classic board and also have the comfort in the form of tools and software applications of the interactive whiteboard. An example of such use is shown in Figure 5, where a teacher of technical education illustrated an interconnection of modules of robotic kit H&S electronic systems through block diagram.

Pupils can also elaborate other suggestions for robotic system activities on the board. Due to the automatic recording of each page, a few suggestions became available and can be worked with.
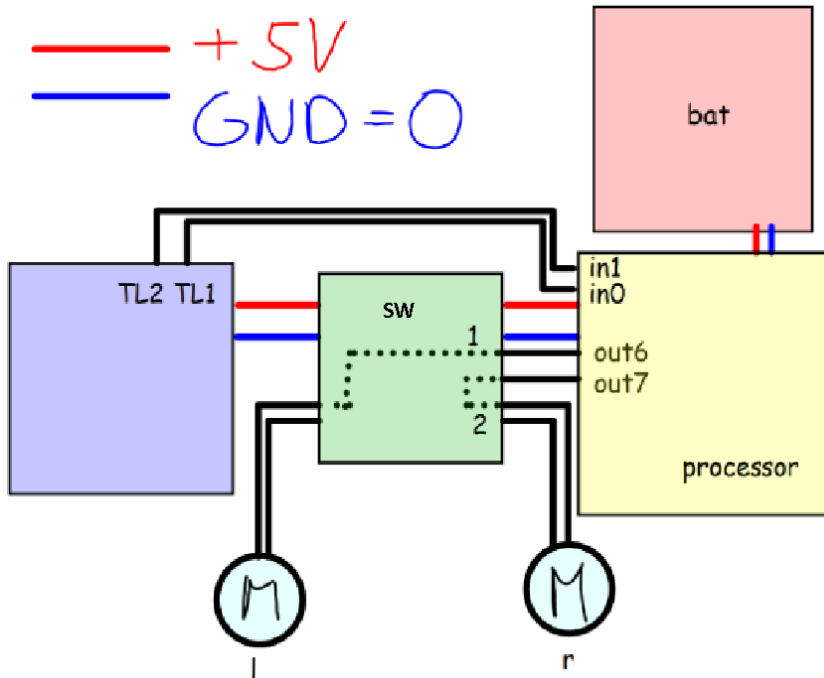

Fig. 5: The use of an interactive whiteboard as a classic board

Another option for the creation of interactive materials is the use of PowerPoint presentations. Currently, many teachers have plenty of PowerPoint presentations that were created in the past for the explanation of a new subject matter. One of the ways to integrate these materials into new interactive materials is a transfer using OpenOffice Impress into the SWF format, which can be easily inserted into most of the programs provided with interactive whiteboards (Stojanová, 2008). This way, it is possible to insert several pages into one interactive page (Figure 6).
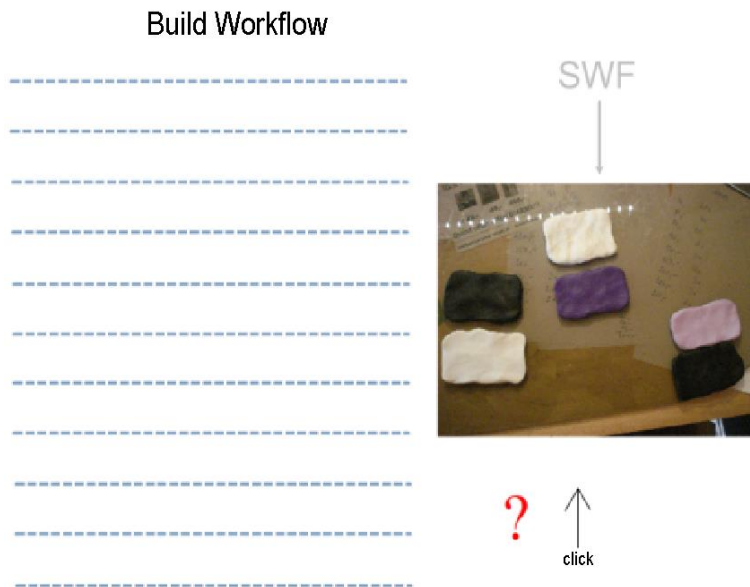
Fig. 6: Integrating PowerPoint presentations into interactive materials

The above examples can be useful especially for beginners that are already familiar with working with basic tools but have not created their own interactive materials yet and would like to start using interactive whiteboards. As Stojanová remarks, it is all about people. The implementation of changes is a long-time and difficult process. Eventually they will become a normal part of our lives and nobody even think that it should be otherwise.

Use of external systems connected with interactive animations

Other important areas in technical fields where ICT are used is programming of drivers and firmware for various devices, programming of systems operating in real-time, such as robotic systems, PLC control systems of technological processes, intelligent homes or industrial robots. These areas are very interesting and require entirely different programming approach than what we know from programming of desktop applications. For this reason, it is necessary to teach subjects related to these fields in a different way since they also require a different way of thinking. As our researches suggest, it is optimal to begin education these subjects in the third year of primary schools. This requires the maximal pupil motivation and direct connection of external systems with interactive study supports.

Thanks to Adobe Flash, it is possible to directly connect interactive multimedia study supports with external systems. A system which enables the creation of dynamic study supports with internal intelligence directly connected with external system has been developed at our department. This system is called MyIMLE (My Interactive Multimedia Learning Environment) and allows connecting interactive multimedia animations running in web browsers with desktop applications running on client computers and connected to external systems. There is also no need using servers as in the case of remote laboratories.
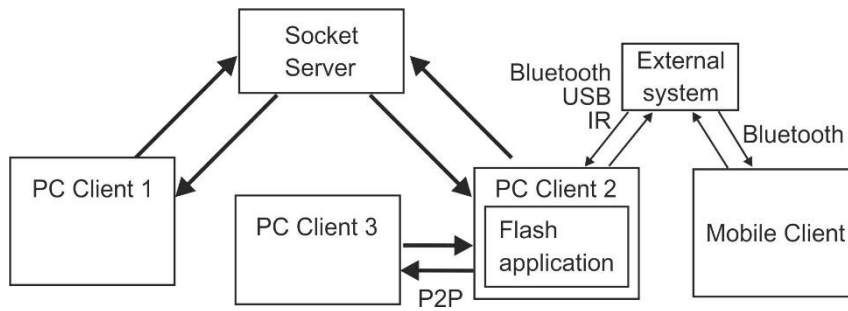
Fig. 7: Demonstration of the possibility of connecting client computers with an external system

Figure 7 shows the most common connection possibilities of client computers to the computer where is running a Flash application directly connected to an external system. The Flash applications can be executed from a Web site, or can be run as a desktop application (Adobe AIR, ZINC, Flash EXE, etc.). Even these applications can mutually communicate.

We have been searching for several years in order to find a suitable device operating in real-time for education of programming. Based on various tests and analyses "H&S electronic systems" were designed. The development of these systems is still in progress, but there are currently available basic electronic modules for custom construction of external devices and robotic systems, which can be used also for educational purposes. In the education of robot design, we use a robotic kit H&S that can be used even in the third year of primary schools. The core of the kit is processor board PICAXE 20M2. Programming of the board is realized using flowcharts. We use a professional programming editor that is free for educational purposes.

The robotic kit can be extended by using new modules and the programming of the processor board can be realized in Assembler. The education can gradually continue from primary schools, over secondary schools, to universities.
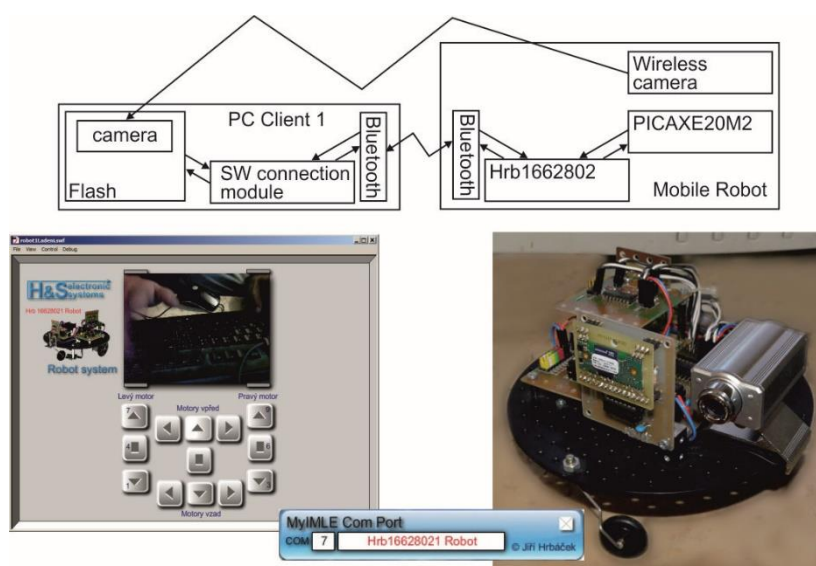

Fig. 8: Example of a wireless control of a robot from a Flash animation

If we need to use a robotic kit together with MyIMLE system, we use Hrb1662802 module that communicates with Flash animations by speed 115200 Bd via USB, TCP IP (Virtual COM port), or Bluetooth. A simple class Robot1662802 for Flash is available for this purpose. The module controlled from this class enables to control both motors of the robot, wheel synchronization, PWM wheel speed control and motion by a set distance. In addition, the module has four other IO pins, through which it is possible to communicate with the board PICAXE20M2 to create a multiprocessor system control. An example of such a robotic system with a wireless USB camera is shown in Figure 8.

In the education of creation of interactive Flash animations in OOP, students learn to create intelligent graphics and to use already existing classes. There are several classes available for external systems connectable to MyIMLE that allow, for example, as was already mentioned, to control a robot or other models, to create cheap measurement system or adjustable sources (modules containing a 10-bit AD converters with conversion time 25µs or 10-bit PWM sources with a period of up to 20 kHz, etc.). External systems (HW modules) can be also used with another control programs, for example based on Java, etc.

The great advantage of the above mentioned systems is that even common users without any previous experiences are able to create simple applications. On the other hand, advanced users can use these systems in special applications.

Conclusion

New information technologies have spread into the all fields of science, technology and our lives. One of the important parts in technical fields is Computer Aided Design (CAD), which shifts towards parametric modelling. This method of creating technical documentation is very interesting and suggestive for students. Together with 3D graphics, animation and interactive education, we have a powerful tool for visualization in other study subjects and visualization of technical devices. Moreover, together with electronics and robotics, we are able to link the virtual world with the real world. By combining all of these areas, we gain a complex concept. We are currently verifying our conception by using surveys and interviewing students.

Information and communication technologies have brought many positive aspects into our lives, but they have brought negatives as well. History already showed that whenever a new technology enabling unprecedented possibilities appeared, we attributed it more importance than it deserved. It is wise to examine such technologies and use them, but we can't forget the technologies used before, as it happened when computers appeared. Now we have come so far that we are not able to manage the euphoria of their possibilities and gave them the place they actually deserve. We hope that the contribution showed some possibilities and connections of ICT and technical fields and we believe that the usefulness of ICT will increase, if we use it together with real systems or if we use them together with practical activities.

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