

Research of the deployment of tools of computer modeling for design and simulations in technical education

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Abstract — Procedures applied in the current industrial engineering practice put new demands on knowledge and skills of graduates of technical schools, connected with a significant proportion of using of tools for design, simulation, production technology and data management solutions for the design and technological tasks. Computer-aided engineering activities open up new approaches to creation and analysis of designs and also for creation of processes of manufacturing and assembly. A large number of data sets, the complexity of procedures and the need of sharing of information in various points on the planet with adequate check and security of shared information required the deployment of data management systems and processes.

Keywords — computer aided design, vector models, model simulation, model verification, model validation,

I. INTRODUCTION

TODAY, programs for technical modeling used in almost every field or industry. We see them in technical industries as well as in our everyday life and even in areas where we would never expect to see them. It generally replaces the creativity and imagination of the designers, and in many cases it helps determine collision situations and points during the creation of new products. Programs for technical modeling we used in almost every field or industry. We see them in technical industries as well as in our everyday life and even in areas where we would never expect to see them. It generally replaces the creativity and imagination of the designers, and in many cases it helps determine collision situations and points during the creation of new products.

Procedures applied in the current industrial engineering practice put new demands on knowledge and skills of graduates of technical schools, connected with a significant proportion of using of tools for design, simulation, production technology and data management solutions for the design and technological tasks. Computer-aided engineering activities open up new approaches to creation and analysis of designs and also for creation of processes of manufacturing and assembly. A large number of data sets, the complexity of procedures and the need of sharing of information in various points on the planet with adequate check and security of shared information required the deployment of data management systems and processes. Features of tools deployed in industrial practice and also in the school sector are

known and have already been mentioned in many publications, intended for training of technical personnel in industry, but particularly in preparing of students at all levels of technical schools. Verification and optimization of teaching methods takes place within the long-term research conducted in the teaching of engineering-oriented projects Survey is focused on the increase of knowledge of technicians with the use of visualization and simulation possibilities of computer applications. Implementation of project procedures and results of undertaken experiments are presented in the text. The focus of research activities is the depth analysis of projects in progress and completed projects of virtual prototypes. The data sets represent an important carrier of information and, in addition to communication medium by the process of design and technical preparation of a specific products, it allows an insight into the thought processes of a technicians. By default knowledge and skills, their expansion and especially consolidation of cross-curricular links can be expected. Since it is a specific industrial sector and the priority is to prepare graduates for success in the field, the content and form of teaching must be based on the requirements of industrial practice.

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II. SCIENTIFIC MODELING

Modeling we use not only for solving problems of practice. As in this article we solve computer modeling of virtual prototypes. Scientific modeling is intended also to perform various studies and experiments or simulations of phenomena and processes. It is important to note, however, that the model can in no way cover the actual reality, but a simplified view on a certain part of the real world [1]. For the successful creation and exploitation of the model is necessary to understand the problem we want to model, capture, have a pre-specified target and simultaneously use a good quality source data. Modeling is a multidisciplinary activity, since it can contribute to knowledge of mathematics and physics, systems theory, probability theory, computer science, cybernetics and cognitive science, operations research and others. In practice, we encounter a great variety of different types of models [2]. Only some of them can be understood as models suitable for use in scientific work. Models can be categorized according to

the following criteria [3]:

- semantics - what the model represents and acts as such;
- ontology - what means models can be heard;
- gnoseology - both models used to develop knowledge;
- philosophy - both models reflect reality, what are the implications of the model approach to science and reality, both models can explain by natural laws.

III. THEORY OF MODELING

Modeling is a method that is often used in professional and scientific practice in many fields of human activity. The main goal of modeling is not only describing the content, structure and behavior of the real system representing a part of the reality but also describing the processes. The process can be understood as series of transformations that changes the input values to output values. From the system point of view the process is dynamic system in which the values of the characteristic of the system elements are changed under the influence of the external elements. The models are always only approaching of the reality, because the real systems are usually more complex than the models are. The system homomorphism is applied in the process of modeling, which means that each element and interaction between the elements of the model corresponds to one element and interaction of the modeled real system or real process, but the reverse is not true. The model is always to be understood as simplification of the original. If the relation of isomorphism is between the model and real system the original model we could not distinguish between the model and the original, which is discussed e.g. in [4].

The first step in the process of computer simulation is creation of conceptual model of the studied real system / real process. Conceptual model can be represented in different way. The most used representations are:

- Mathematical equitation;
- Process charts.

Mathematical equitation establishes mathematical model of the studied real system. The model can be obtained either theoretically based on basic physical properties of the system, or numerically by means of the measured values. Determination of parameters of theoretical model developed from empirical data is called system identification.

IV. APPLICATION IN PARAMETRIC MODELING

Parametric modelers may use different environments and user interfaces, but the general principles of parametric modeling are similar. The relevant software application is mostly used as another creative tool. Models are created through sketching and through volume or spatial constructional elements. They must be clearly defined, without any redundant or contradictory information. There are always several solutions. Students must be able to deal with difficult and demanding logical tasks and must be able to use spatial

imagination. This offers many opportunities for the application of alternative teaching methods, problem and project teaching techniques and the development of creative teamwork [4]. The art of learning to solve problems lies in the fact that the student acquires the ability to independently seek solutions and strategies and to make decisions in alternative situations. Information technologies offer many opportunities for the application of alternative teaching methods, such as the problem and project teaching techniques and the development of creative teamwork [5]. In order to strengthen cross-curricular relations, the Secondary School of Applied Cybernetics in Hradec Kralove introduced project teaching classes. One of the projects realized by the school is called the Virtual tour of objects. The technology of virtual reality is based on various fields such as programming, computer graphics, mathematics, but also on various artistic fields. Therefore, the above-mentioned project involves students focused on these fields of study. Students of the Computer Graphics class undergo classical art training and courses, which teach them the basics of computer graphic technology. Participants in the project are organized into two groups including future experts of various disciplines. Some are technically oriented programmers and others are artists. To achieve creative cooperation between these groups of students is not always an easy task. For practical example we describe with mathematic tools body. We use concepts such as topological spaces and topological views and n -manifold in E^m . Topological space is a set of subsets X with τ . System τ must satisfy axioms:

- 1) $\emptyset \in \tau, X \in \tau$,
- 2) the intersection of a finite number of sets of τ must be back in τ
- 3) the union of any number of sets (and innumerable) of τ is τ again. The system sets τ must be closed to the final penetration and any sum (even with the countless number of elements). File name the topology τ on X . The sets in τ are open sets and their accessories in X closed sets. Topological space is denoted (X, τ) .

Subset $U \subset X$ topological space (X, τ) is a neighborhood p point, when there is an element $O \in \tau$, so that $p \in O$ and apply $O \subset U$. Neighborhood of a point will be denoted $p \in U(p)$. View f topological space (X, τ) into a topological space (X', τ') is continuous if each image in the neighborhood of p (X, τ) is at the same time point f surroundings (p) in (X', τ') . If f is a bijection and f and f^{-1} are continuous maps, then called f homeomorfizmem, a topological view. Two topological spaces are topologically equivalent if there is a homeomorphism between them. Homeomorphism is mutually unambiguous mapping between topological spaces that preserves the topological properties. In terms of topology, these two rooms the same properties are the same. Homeomorfismus for the definition of an essential element.

In describing the body and its boundaries, we introduce the notion of manifold- n E^m N -manifold in E^m where $m = n$, such E^m subset which is homeomorphic with E^n . It is a

manifold without boundary. N -in manifold with boundary $E m$ is then $E m$ subset which is homeomorphic with a positive half-space $E n + = \{(x_1, \dots, x_n) \in E n \mid x_1 = 0\}$. In practical implementation modeler to check the calculations correct topological elements. To check you can use Euler's formula, this is a necessary condition for correctness. Formula says that the number of walls, edges and vertices is given by the body. We solve first the bodies that have only one surface does not pass by them any holes. They do not contain any internal cavity and the wall is homeomorphic with a circle. Such elements are topologically simple. They are all homeomorphic to the ball. When we describe V number of vertices, edges E number, number of walls F . You can then Euler's formula for this element can be written as:

$$V \cdot F + 2 = E \quad (1)$$

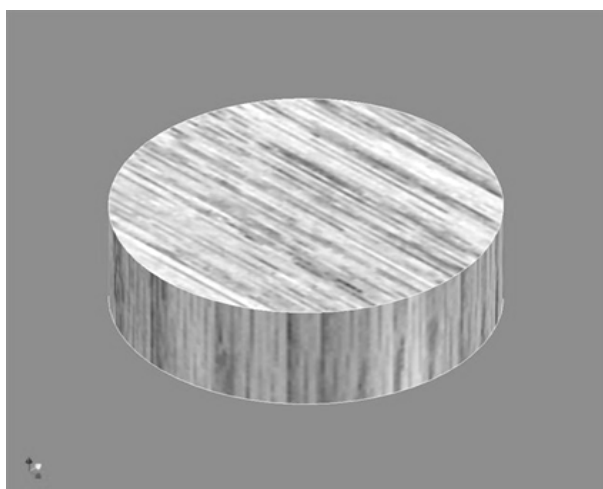


Fig.1 Topologically simplest element (body) with one surface

Body on fig. 2 is body with a whole (not the internal cavity) is bounded by a single continuous surface, while each wall element is homeomorphic with a circle. This mass is homeomorphic with a sphere with a certain number of closed units. Number of holes is a genus. For the body whose genus is G . The Euler formula here is:

$$V + F = E + 2(1 - G) \quad (2)$$



Fig. 2 Example of real technical body with the whole (not the internal cavity).

For housing with an internal cavity, the body is bounded by several separate closed surfaces. Denote the number of surfaces S . It is not necessary that every body panel is homeomorphic with a circle. Each wall is bounded by a single loop edges. L the number of loops on surfaces of solids G genes and the sum of the individual surfaces. Euler's formula has the shape:

$$V F = E + (L - F) + 2 (S - G). \quad (3)$$

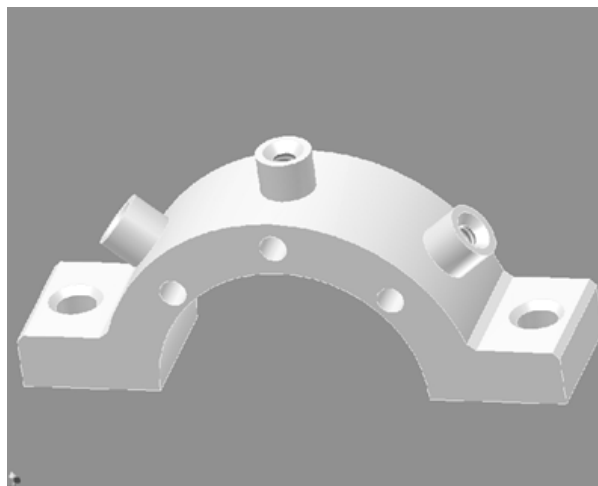


Fig.3 Example of real technical body with the internal cavity

Process charts establishes process model of the real process. The process models can be described by different way; the most common are flowcharts that described the algorithm of the modeled process. The conceptual model must adequately describe the dependency system outputs on its inputs. Models of real process system will be shown in the following paragraphs of this paper.

V. THEORY OF SIMULATION

The process of modeling is closely related to the simulation. Simulation can be understood as process of executing the model. Simulation enables representation of the modeled real system or real process and its behavior in real time by means of computer. The simulation enables also visualization and editing of the model.

A typical simulation model can be written both through specialized programming languages that were designed specifically for the requirements of simulations, or the simulation model can be created in standard programming languages, spreadsheets (MS Excel) or other application (CAD systems). From the above considerations, it is clear that simulation is a process that runs on the computer. In some publications, therefore, is called "computer simulation". It generally is valid that computer simulation is a computer-implemented method used for exploring, testing and analysis of properties of the conceptual (mathematical or process) models that describe the behavior of the real systems or real process which cannot be solved using standard analytical tools [6].

The simulation models represented by executable computer program have to be isomorphic with the conceptual model that is a representation. It means that the mathematical model and simulation model have to represent the real system, its elements, internal interactions and external interaction with the environment in the same way. In our paper the parametric simulation realized in CAD application will be presented.

Significant function of the simulation

Simulation has from the scientific point of view several functions, [6]. We will focus in this paper two of them and they are:

- replacing the real process;
- development of study process.

This is an important and indispensable feature of simulations and simulation model because it allows realize a situation of the process that cannot be investigated conventionally.

Computer simulation of real systems and real processes is one of the most effective methodological tools, especially for the following reasons [7]:

Computer simulation of real systems and real processes is one of the most effective methodological tools, especially for the following reasons [7]:

- It allows study models of reality that are not analytically solvable models, especially dynamic.
- Process and allows qualitatively and quantitatively classify a large amount of experimental data.
- Allows general theoretical models of experimentally confirm or disprove - validate.

The process simulation follows the process of creating a conceptual model of a real system under study and the real process. The simulation can be understood as a process of transformation of a conceptual model describing the real system simulation model [8]. A typical simulation model can

be written both as specialized programming languages that were designed specifically for the requirements of simulations, both for programming can use simulation models and spreadsheets, or standard programming languages. In the literature, therefore, often found the term computer simulations. It is also the basis of our virtual prototypes. From the above considerations it is clear that simulation is a process that runs on your computer. In some publications, therefore, present the concept of computer simulation. Advantages and disadvantages of computer simulations are defined as in [9]. Briefly summarize the main benefits of simulations:

- Simulation allows study systems and processes described by mathematical equations or graphical formalism, but these are solvable only in a certain approximation. Transformation of this conceptual model into a computer program (simulation model) can be obtained from numerical solutions.
- Provides validation and testing a conceptual model.

Simulation of shortening or lengthening the time interval - can speed up or slow down the behavior of processes and phenomena in order to expedite or facilitate research. Exploration and identification process using simulation to optimal setup and management of real process without disruption of this process. Simulation allows you to diagnose problems and understand the complex interactions between the characteristics of a real system. The main disadvantages of simulation include the following [9]: Numerical, discrete solution simulation model is not fully analytical solution - there is some discrepancy between the conceptual model. There is a risk that the simulation model will be "at all costs" accepted as a model of a real system, even though this model is not based on actual real reasonable and generally applicable theory - generally as a conceptual model. In some cases it is easier, less time-consuming and cheaper to use a conceptual model analytical solution than to carry out the transformation of the model simulation. CAE - Computer Aided Engineering are tools for implementing of simulations and engineering calculations on 3D digital models and assemblies created in the CAD module. Computational algorithm works based on Finite Element Method - FEM. In connection with the design of structural design out strength calculations to determine the stress and strain in the loaded part of the structure is usually carried out. A network of elements is defined on a 3D digital model or assembly. Geometric and structural boundary conditions are specified according to functionality of construction. After completion of the calculation the quantitative results for selected construction sites, or qualitative visualization of the monitored parameter on the surface and inside the volume element is to evaluate. Based on the obtained results the construction can be considered as properly designed, undersized or oversized, which is the basis for further editing and optimization of the model. Introduction to CAE module in teaching is possible through case studies and examples of the topics taught in technical mechanics and physics, initially without further theoretical knowledge of

finite element method. It enables a gradual transition from analytical solutions to computer-supported technical calculations. Gradually full use of the work on their own educational projects is expected

VI. VISUALIZATION

The concept of visualization is closely related to the concept of simulation. Visualization is a technique that transforms, selects and shows the output data and data obtained from the simulation allows the investigation, analysis and interpretation. Among the commonly used tools in scientific visualization, simulated data are 2D and 3D charts, tables, flowcharts, animated diagrams and more.

Visualization of 3D data of the completed project of a virtual prototype of a model for pressure casting of aluminium alloy is shown in Figure No. 4. General principles of engineering design, rules for creation of tools and technology issues of inlet and solidification of the casting material in the actual process of casting were applied for the development of the project. A project of this type was processed by a student in a period of three months.

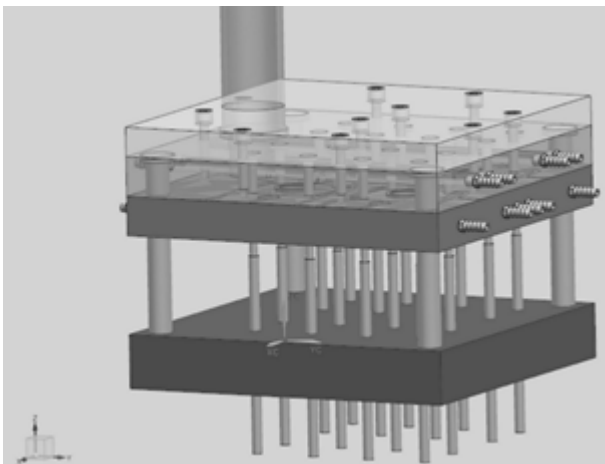


Fig 4 3D virtual prototype of a model for pressure casting of aluminium alloy.

The main advantage of simulations is that simulations model allows providing rather big number of the process steps in relatively short time, changing of input parameters and its visualization and optimization of the process. The simulation and visualization is very useful from study point of view. Using the simulation model and visualization of simulation results on the screen, students can better understand the basic features of the processes and systems and develop their intuition. It is also essential that the teaching by means of simulation is much cheaper and faster than the teaching carried by real experiment. In some cases providing the real experiment cannot be feasible.

VII. MODEL VERIFICATION AND VALIDATION

Verification and validation are important aspects of the process modeling and simulation. They are essential

prerequisites to the credible and reliable use of a model and its results [5]. In modeling and simulation, verification is typically defined as the process of determining if executable simulation model is consistent with its specification: conceptual model. Verification is also concerned with whether the model as designed will satisfy the requirements of the intended application. Verification is concerned with transformational accuracy. It takes into account simplifying assumptions executable simulation model. Typical questions to be answered during verification are:

- Does the program code of the executable simulation model correctly implement the mathematical model?
- Does the simulation model satisfy the intended uses of the model?
- Does the executable model produce results when it is needed and in the required format?

In modeling and simulation, validation is the process of determining the degree to which the model is an accurate representation of the real system / real process. Validation is concerned with representational accuracy, i.e., that of representing the real system / real process in the conceptual model and the results produced by the executable simulation model. The process of validation assesses the accuracy of the models. The accuracy needed should be considered with respect to its intended uses, and differing degrees of required accuracy may be reflected in the methods used for validation. Typical questions to be answered during validation are:

- Is the mathematical model a correct representation of the real system?
- How close are the results produced by the simulation executable model to the behavior of the real system?
- Under what range of inputs are the model's results credible and useful?

Validation and verification are both ultimately activities that compare one thing to another. Validation compares real system / real process and conceptual model. Verification compares conceptual model and executable simulation model. Sometimes validation and verification are done simultaneously in one process. [6].

The whole process of transformation from a real system, the simulation model and its visualization is shown in Fig. 5.

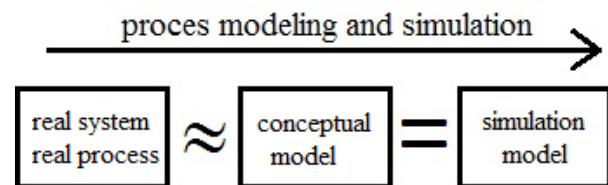


Fig. 5 Process modeling and simulation

Here again let us summarize that the mathematical model that reflects the real system / real process has some limitations and simplifying assumptions (the real system / process and

conceptual model are in homomorphic relation).

In contrast, the simulation model is only the computer expression of the conceptual model (the conceptual model and simulation model are in isomorphic relationship).

VIII. APPLICATION OF THEORY OF MODELING IN PARAMETRIC MODELING

Parametric modelers may use different environments and user interfaces, but the general principles of parametric modeling are similar. The relevant software application is mostly used as another creative tool. Models are created through sketching and through volume or spatial constructional elements. They must be clearly defined, without any redundant or contradictory information. There are always several solutions. Students must be able to deal with difficult and demanding logical tasks and must be able to use spatial imagination. This offers many opportunities for the application of alternative teaching methods, problem and project teaching techniques and the development of creative teamwork [10]. The art of learning to solve problems lies in the fact that the student acquires the ability to independently seek solutions and strategies and to make decisions in alternative situations. Information technologies offer many opportunities for the application of alternative teaching methods, such as the problem and project teaching techniques and the development of creative teamwork [10]. In order to strengthen cross-curricular relations, the Secondary School of Applied Cybernetics in Hradec Kralove introduced project teaching classes. One of the projects realized by the school is called the Virtual tour of objects. The technology of virtual reality is based on various fields such as programming, computer graphics, mathematics, but also on various artistic fields. Therefore, the above-mentioned project involves students focused on these fields of study. Students of the Computer Graphics class undergo classical art training and courses, which teach them the basics of computer graphic technology. Participants in the project are organized into two groups including future experts of various disciplines. Some are technically oriented (e.g. programmers) and others are artists. To achieve creative cooperation between these groups of students is not always an easy task.

IX. VIRTUAL PROTOTYPES

Digital model or assembly of a general object created by CAD (Computer Aided Design) applications serves not only to assess the visualization of a design and for a creation of a technical drawing. A wide range of activities associated with the analysis of design and technical preparation of production can be carried out on curve and plane 2D and 3D models. In the industrial and the educational environment, creating virtual prototypes is based on the principles of working with CAD tools and on the use of knowledge gained in the field of basic engineering subjects. As shown for example in [11].

This paper is focused on the area of engineering. However, any object of a different area of interest can be a virtual prototype. Apart from engineering design, virtual prototypes

can be created and analyzed for example on building construction, but also on living organisms, or physical processes. The virtual environment enables to carry out simulations and the related focus on objects that could not be realized in a lab environment, in an office or in a small workshop.

In particular the following operations can be performed on virtual prototypes during its formation and after conduct:

- Visualization of models and assemblies.
- Kinematic analysis of mechanisms.
- Strength control of stressed parts.
- Spatial assessment of components.
- Check of collisions of components.
- Measurement of models and assemblies.
- Determination of volume and cross-sectional characteristics of solids.
- Check for smooth surfaces.
- Angle analysis of difficult cast and molded components.
- Draft angle analysis of difficult cast and molded components.
- Analysis of flow and solidification of the casting.
- Creation and validation of machining technology.
- Technology of assembly of a kit.
- Determination of thermal processes in the structure.
- Progress of the electromagnetic field in the device.
- Analysis of fluid flow.

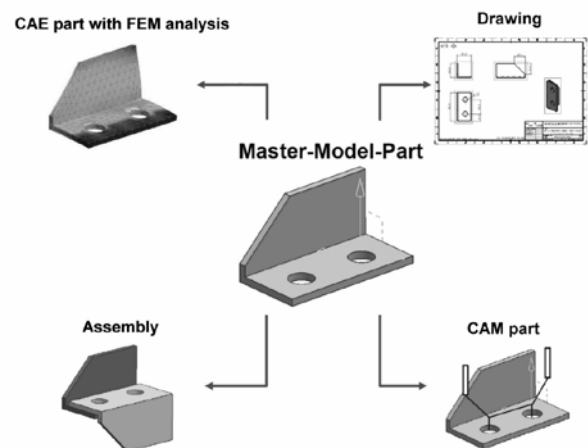


Fig. 6 Link objects using virtual prototyping method
"master model concept"

Data models and drawings are created in CAD applications. There are a number of tools of different levels. The issue of preparation of projects and their solution is not tied to a specific brand. In spite of the fact, that professional tools are very expensive in practice, there are academic licenses for a symbolic price. Functions for basic analysis and measurement models are integrated in CAD tools. Demanding calculations and simulations are performed by modules CAE (Computer Aided Engineering). Calculations in the structure of models

are carried out by finite element method (FEM - Finite Element Method). Generation and verification of the machining process is performed by the CAM module (Computer Aided Manufacturing). Phenomenon of contemporary design and technical preparation of production, including upstream and downstream processes, is management of data and information flows within projects and between projects deploying systems of administration and management of product data - PLM (Product Lifecycle Management). A characteristic of these applications in this category is the integration of CAX data and data file with common formats. A special feature is the ability to define processes and information flows on data and communication within the system. They can form a system of data of developed projects, of standardized parts, of all related documentation and, ultimately, distribution of educational materials, sample CAX solutions and test applications. An example of a structure of a virtual prototype is shown in Figure No. 1.

All of the above modules CAX / PLM tools are available within the installation sets. The skills acquired with experience working on complex projects using the above applications are crucial for adaptation of graduates in professional practice.

The current prevailing and rather traditional concept of e-learning provided in virtual university projects is limited to discussions, research and to the evaluation of the LMS environment. Typical examples of the LMS in our universities are environments such as Moodle or WebCT. Today, e-learning is viewed as a rather simple remote administration tool for student projects, remote communication between teachers and course participants, or as a mechanism for external expert supervision focusing on the professional level of individual courses [11]. Professional discussions are still focused on unclear results, while trying to demonstrate the benefits and disadvantages of off-line and on-line learning, in which each approach has its proponents and opponents, both on the student, tutor and course administrator sides. So far no unanimous agreement on what would offer the optimal solution has been found. The reason is not the helplessness or insufficient professional knowledge of people participating in these discussions. Variability of contents plays a role and the specialization of university courses in combination with the individual learning styles of participants in a specific environment of the virtual learning method. Currently, only some projects take into consideration the comprehensive view of digital learning offered by a virtual university, as a functional unit or as a model, which assumes a thorough system analysis of all solid, obvious and useful functionalities of the virtual university, which is necessary for successful implementation. Only very rarely do we find the concept of a modern educational institution as an integral unit combining the advantages of today's hi-tech technology with a common point of interpersonal communication, where personal relations and relationships between teachers and students are created and where valid and strong intergenerational experiences are shared as part of the educational or study process [11].

X. MULTIMEDIA SUPPORT OF PARAMETRIC MODELING

The progress in information technology has been changing the forms and methods of education. Application of multimedia supporting elements has improved the quality of the educational process. For example graphical symbols representing sketch links or values of parametrical dimensions are relatively small and usually it is not possible to magnify them together with other entities on the desktop. Therefore, for a visual and schematic job description and to display individual details, it is necessary to record the picture in high definition. Due to the high bandwidth, the use of online technologies is limited by the speed of the relevant Internet connection. Today's lifestyle requires speed and clarity.

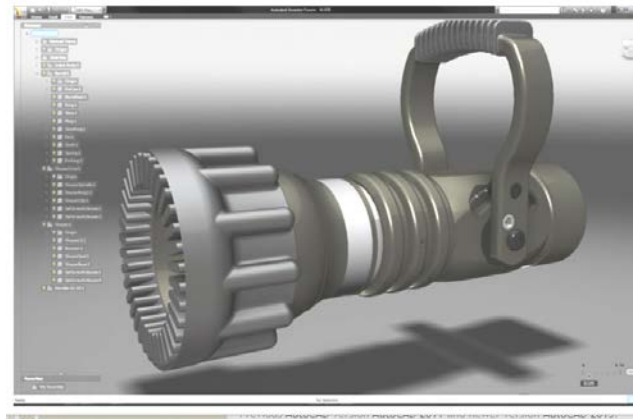


Fig. 7 Example of a working environment modeler
Inventor

From this point of view, various tools used during the education process which use clear and demonstrable samples are very useful and beneficial. That is why many software applications that use an interactive environment - and which work with real programs, are being developed (e.g. Microsoft Office - Word, Excel, PowerPoint, Access and others). Countless programs are used for this purpose. The main producer and developer of these applications is the well-known and recognized company Adobe (Adobe Systems Incorporated). Software produced by Adobe, such as Captivate, Director, Authorware, Robohelp etc. shares one common disadvantage. It is not free. Plus it is rather expensive, because it was mostly developed for companies. However, thanks to their valuable parameters and high quality, these programs are considered the best in the interactive multimedia education field. At the same time, there is also free programs/software available in the interactive multimedia education field. As an example, the most important free software is a program called Wink. All software offers format conversion as required by the final product. Applications produced by Adobe are able to create multimedia presentations but procedures and manuals I required use Flash, for animation, interactivity, and accompanying audio and video. Of course, the follow-up creation is a very time-consuming task for a person who also administers regular

classes at the university. Further, the larger the project is, the greater are the hardware requirements. This creates another financial burden for workplaces and classrooms that use these modern methods. The author must be able to process several types of activities at the same time, unlike with other common programs messages (Microsoft Office PowerPoint, Publisher, Adobe Flash Professional, Replay Screencast, RoboDemo, CamStudio and many others). High speed computer networks enable continuous high definition video streams between the source and the end user. Another alternative is video transfer using a "video on demand" system. Digital technology also enables reproduction of audiovisual recordings stored on optical disk recorded by a computer, TV or player. As we see, the applications of these technologies are very broad-ranging. For example, transfer of a picture/image of a multimedia disc (usually ISO format) between the client and FTP server is also possible, which is very useful for example for distance learning students. Audiovisual recording may be done with a video camera, and with other necessary technical devices [12]. An alternative solution is the application of a system used to record meetings or to make them accessible, for example Sonic Foundry Mediasite. However, this system is more suited to recording meetings during which a computer presents static images only or recording meetings with animations or video sequences or performances that contain a demonstration of computer software, it is better to use other technologies. The important issue is to select the correct lighting intensity of the person doing the presentation in order to achieve high quality recording, but at the same time, this light may negatively affect the recording of the visual presentation happening at the same time. I consider the use of shortcuts inappropriate. The situation may change when we begin to use multimedia teaching materials. In order to implement and use multimedia teaching, it is not important whether this process involves integrated multimedia or individual tools/aids in different formats which enable the user to present the relevant information. The important issue is that these tools activate more of the students' senses simultaneously multimedia materials. When we are working with a parametrical modeler, the image of the computer desktop is recorded as well as actions and events occurring due to the use of the keyboard or mouse. Then, using the editing mode, the user may add to the picture of the recorded desktop voice commentaries, text descriptions, raster images in various formats, audiovisual sequences in AVI format (audio video interleave), simple vector graphics, presentations in Microsoft PowerPoint or possibly other interactive elements (e.g. press buttons, links, etc.). The finished work may be stored as a self-executable file (Windows executable), Microsoft AVI or in a format supported by Macromedia Flash (SWF, FLA, FLV). These may be shared via web interface or FTP server (file transfer protocol). The advantage of this option is that the user needs only a minimal knowledge of computer graphics, multimedia and video programming. The desktop of a computer may be recorded using other software tools as well (e.g, TechSmith

SnagIt, Hyperionics Hyper-Cam Technology LLC, etc.) and compressed visual sequences in Microsoft AVI format created without needing large available storage on your hard drive. Audio commentaries may be stored individually or simultaneously. The quality of the audio recording is based on the quality of the sound card and the external microphone. The workplace where the audio recording is done should be well prepare for acoustic recording because background noises negatively affect the recording quality and may destroy the entire work. The picture and audio recordings may be synchronized by using tools for processing audiovisual materials such as programs belonging to the software suites Adobe Premiere, Sony Vegas or Canopus Edius. You may also use multiple audio and video tracks and perform various editing operations. For example you may change the speed of the playback of individual sections, or apply various transition effects or filters, insert subtitles, etc.

XI. RESEARCH OF THE USE OF TOOLS IN THE EDUCATION OF TECHNICIAN

Progress of project work can be assessed both in the classroom observation, and by analysis of ongoing status of projects that listeners process outside school lessons. Final outcomes of completed projects can be also analyzed. The structure of CAx data enables to assess the level of technical thinking of a student, his spatial imagination and creativity. From this point of view, the most suitable are CAx applications that allow you to achieve the same result in different ways. Due to the material possibilities of schools and to different licensing strategies for different providers of these systems, this requirement is difficult to reach [13].

Despite this fact CAx data created in any application are a carrier of sufficient amount of information to produce partial conclusions and for subsequent optimization of the concept of teaching, including teaching supports in the form of text and animated electronic materials. Animated materials are created directly through animation and visualisation tools of a used CAx application. They contain procedures of 2D and 3D design and setting up of corresponding simulations. Increase of knowledge and skills is verified by an experiment on two parallel groups in education. Sub-thematic unit is in the experimental group demonstrated with a use of a CAx tool. A classical method without the use of CAx applications is used in the check group. In both groups there are the same initial knowledge and skills, as measured by a pre-test. A post-test is entered and evaluated in both groups at the end of the learning process and this post-test is also repeated in a period of 1 month after completion of the interpretation of the topic. The results of the first post-tests of three final experiments are shown in Figure No. 8. In all cases it was a demonstration of the cutting tool geometry using a CAD model. Several so specified experiments were carried out throughout the research. Selection of pupils to groups was made according to organizational options and criteria, which do not affect the examined parameters. Independence of choice was assessed on

the basis of pre-test results. Numbers of pupils in each group were 15 to 30. An experiment was performed repeatedly with an emphasis on ensuring of the same conditions, consisting of the initial knowledge of students, course work, testing and evaluation.

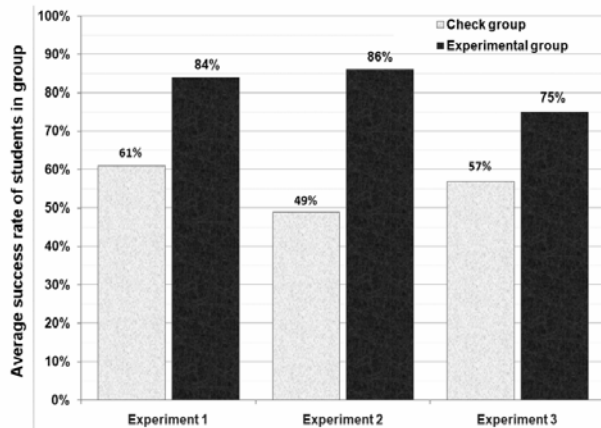


Fig 8: Verification of deployment of a CAD tool in education - students' success in posttest.

Research of attitudes of students and graduates to CAx technologies and to the teaching supported by these instruments is carried out using a questionnaire and an interview. A web questionnaire for obtaining the necessary number of respondents also from remote locations was created for this purpose. Selected results of positive responses, which have a significant influence on the creation and optimization of conception of computer-aided education is presented in the graph of Figure No. 9.

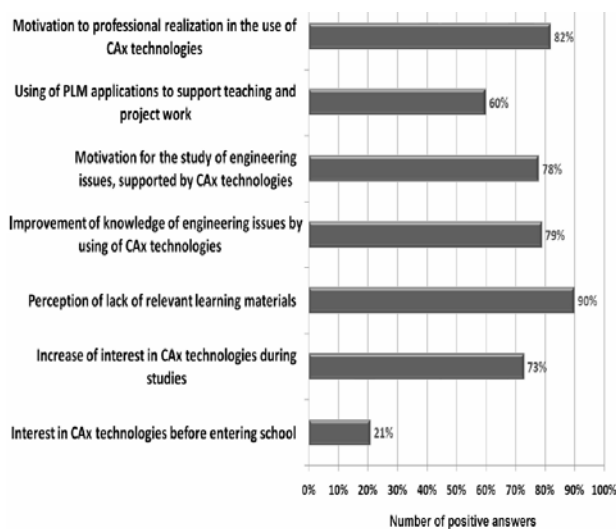


Fig 9 Results of the survey of attitudes of students and graduates of technical schools to CAx technologies.

XII. CONCLUSION

The perception of visual information represents largest share of the entire perception done through all our senses. Visual presentation catches the attention, awakens interest and helps with conceptualization. Presentation together with

practical demonstration is much more effective. Many terms and thoughts may be understood through visual methods rather than through verbal methods only, for example, practical skills. They should serve to help to expand the visual image. Therefore, it is necessary to keep in mind during the creation of a multimedia teaching educational application to add voice commentaries only to information that is not clear from the presentation itself. Regardless of the applied technology, it is clear that the creation of multimedia teaching supporting elements, and not only in connection with parametrical modeling, may be done by one person/teacher only and therefore it deserves a bigger share of our attention.

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