

Knowledge of mathematical foundations of the modeling as a condition effective deployment CAx technology

Josef Sedivy

Abstract— Significant part of scientific research is carried out using models. Study your own reality and real systems are often transferred to the study models. In some case, we only using model to discover their properties. We can find out facts about the real system, the model represents. As an example, let us study the dynamics of planetary systems, study the nature of the hydrogen atom, or the study of population dynamics. Real systems represented by the above models can't study directly. One way to represent models, especially in physics, mathematics and economics, the equation of these models is, as well as the theoretical structure, referred to as mathematical models.

Keywords—mathematical models, topological space, computer models, computer simulation, CAx technologies.

I. INTRODUCTION

ONE way to represent models, especially in physics, mathematics and economics, the equation of these models is, as well as the theoretical structure (see above), referred to as 'mathematical models. The problem to be included as representatives of equations models is similar to the linguistic models. First, here is the same situation, same model, expressed by different equations. Furthermore, the model has different characteristics from equation (oscillator has mass, moves, etc., while the number of equations has the characteristics of symbols, fonts). In this case, the equation must be understood in terms of meaning of the symbols and their arrangement into a whole [1]. We use to describe a higher level of abstraction than the basic description of the stage. At this stage there is a reformulation of information about the content and structure of the system. Determine the characteristics and values of the characteristics of elements of the system. The values and characteristics of the system are transformed into parameters and variables of the model. It is the most important step and in terms of the modeling process and is the most problematic phase. The introduction of variables and parameters, remove ambiguity and increase the accuracy of the model. At this stage is model in mathematical forms, which mean:

- dealing with the idealization of the model, define parameters is negligible;
- define the inputs and outputs;

- define the dynamics of the system, the time dependence of the characteristics of system elements;
- determinate behavior of links between elements (feedback, etc.), how changing the values of characteristics of elements affects other elements.

II. MATHEMATIZATION OF MODELS

Intuitively, we consider the body as a whole - three-dimensional object inside and with a boundary. The boundary representation of solids, as we shall see, but we have limit is therefore necessary to study the relationships between the characteristics and properties of solids its boundaries. Strictly speaking, we assume that we work with bodies 3-manifold in E^3 with the boundary. The boundaries of such a body are a 2-manifold in the third E . We want to find out what properties that can be practically used for implementation on a computer, a 2-manifold (In E^3), which forms the boundary element. Important features are as follows. The property "to be oriented" is the ability to "be focused in through the manifold triangulation. The concept for this property 2-manifold E^3 can thus be explained by orientation set of simplexes, which is a triangulation manifold. 2-simplex oriented cyclic ordering of vertices. For example simplex $\langle p_0, p_1, p_2 \rangle$ can be oriented in two ways, either p_0, p_1, p_2 or p_2, p_1, p_0 first orientation 2-simplex also induces the orientation of each of its walls, in our case 1-simplices. Let S and S' are two adjacent 2-simplex in the set of simplexes C . We assume that both are adjacent to a 1-simplex S'' . We say that S and S' are oriented consistently, if the orientation induced S'' orientations and S and S' are opposite. Set of simplexes we consider two dimensions oriented if all each adjacent 2-simplex can be oriented consistently. The finding that file and 2-simplices in manifold 3 E bordering body is oriented practically significant. If not, would not be possible the boundary representation in solid form, how to learn about it later. Based on yet that would also be possible to construct an algorithm for testing oriented set of simplexes. The algorithm begins by selecting an arbitrary orientation 2-simplex [2].

In this section we describe body with mathematics tools. 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 $p U (p)$. View f topological space (X, τ) into a topological space (X', τ') is continuous if each image in the neighborhood of $p (X, \tau)$ is at the same time point f surroundings (p) in (X', τ') . If f is a bijection and $f f^{-1}$ are continuous maps, then called f homeomorphism, 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. Homeomorphism is required 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:

$$V + F = E + 2$$

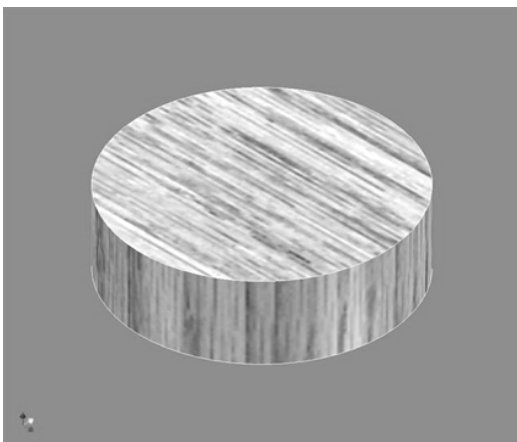


Fig.1: Basic example of body.

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



Fig.2: Body with the whole (not the internal cavity) CAD assembly of basic components of a technological process.

For housing with an internal cavity, the body is bounded by several separate closed surfaces. Denote the number of surfaces \square . It is not necessary that everybody panel is homeomorphic with a circle. Each wall is bounded by a single loop edges. L is the number of loops on surfaces of solids. G is sum of genus and the sum of the individual surfaces. Euler's formula has the shape: $V + F = E + (L - F) + 2(S - G)$.

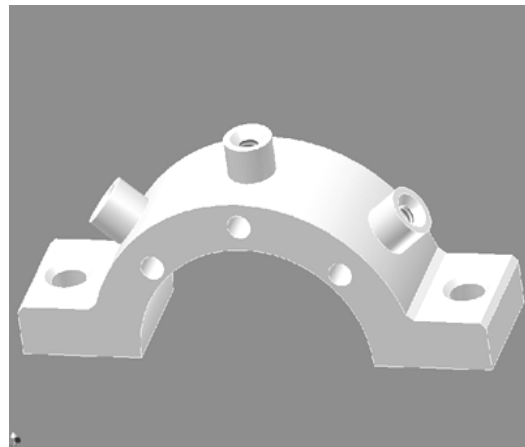


Fig.3: CAD assembly of basic components (with an internal cavity)

Maybe orientation tetrahedron: All triangles (2-simplex) are oriented so that edges (1-simplex) run against him and orientation is consistent. There are two possible consistently oriented. If you are in the process of "spreading orientation" to hit the 2-simplex, which is already oriented and the orientation of which was to be reversed, then the set simplexes is "to able oriented". But we now know that this situation would not in normal specimens occur. It is easy to show that 2-manifold in 3 E bordering to able oriented body is just two ways. That I will use in the practical implementation. We choose the orientation so as to looking inside body on his wall (2-simplex) shows their peaks in order counterclockwise.

Furthermore, let us reverse the problem when we want to formulate the requirements that must be met for a continuous and oriented 2-manifold in E^3 without boundary can be considered as boundary elements (more precisely, a continuous 3-manifold in E^3 with boundary). The interior of the body: Let's M oriented, connected 2-manifold in the third E Point p is called an internal point if it satisfies the following conditions: 1) Is there a 2-simplex S file C that its peaks p_0, p_1, p_2 at observation p appear in the order counter-clockwise, 2) the S there is a point q so that the line intersects $p q M$ elsewhere than in q . 2-manifold and divides E^3 , two open sets. One contains all the points inside the body (inside). The second contains points that belong neither inside nor M part, outside the body. For body type manifold with one continuous surface, we consider the 3-manifold with boundary E^3 . Its boundary is a compact connected 2-manifold without boundary in E^3 with limited variation. The body consists of the points inside and points on the boundary. The boundary is oriented so that the focused correctly determine which points lie inside the body, which lies outside [2].

III. MODEL AS A COMPUTER PROGRAM - A COMPUTER MODEL

Unlike the previous models, is type of model differ in their format. This model consists of computer program instructions and its own model behaves as an executable file [3]. The model is specific in that a computer program provides a means for the actual implementation of dynamic experiments. A computer program as a model is to be understood as a system. This system expresses the dynamic behavior of the realities and time provides information about the behavior, properties, and changes to the system to its environment. One reality can be described using various computer programs, all programs must be isomorphic to each other, ideally should give the same results. This type of model is known as a computer simulation. In our reflections on the handling of models with detailed focus on a group of models that are mathematical in nature. They are mathematical models (theoretical models, and symbolic - conceptual models). In some cases it is possible to interpret these models analytically. We derive the results of the theory, solving mathematical equations, or trace the process. Often, however, analytical solutions can't be achieved. A major benefit is the use of computers. These allow for analytically unsolvable equation and tracing complicated process addressed by computer simulation. Current research in both natural and economic, social and medical sciences is without the use of p-counter simulation unthinkable Computer programs that work with the models are usually equipped with a simulation module. Simulation is normally used in conjunction with dynamic models, as one of the characteristics (variables) include time, are time dependent. The aim of simulation is to solve equations of the model or process model links, particularly with regard to the time evolution of the model and the target system. In terms of the system, we can say that simulation is homomorphic replica (model) of a dynamic system (model) [2]. If we understand the model as a system is obvious that the simulation itself can be understood as a kind of fictional model that represents the model. Computer simulation can be understood as new methodology

knowledge. Sometimes even the computer simulation is viewed as a new scientific paradigm [4]. Although this claim does not meet the explicit consent, computer simulations have the potential-errors great practical importance. If standard methods fail, namely, computer simulations are often the only way to study and interpret the dynamics of mathematical models to help describe the complex dynamic processes with many input and output information. The current trend in the design process not only technical subjects is the application of parametric modeling, which provides a means of expression. Using advanced computer graphics technology can be difficult to realize the design phase, while the body shows its real form. Efficiency of parametric modeling results from its philosophy. Description of the model as technical parameters and components by means of mathematical expressions allows for immediate modification, then the automatic projection of such modifications to the reports, drawings and related controls and instruments of production. This leads to reduction of production costs at the design stage of future product[5].

IV. IMPLEMENTATION OF MODELS IN COMPUTER PROGRAMS

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 [5]. 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 essential factor for the realization of the introduced concept is the availability of suitable 3D CAx applications, which have a sufficient portfolio of functions applied to the project. CAx applications used in an industrial practice are generally very expensive. Even now, when the market offers a large number of competing products, a complete installation represents costs

comparable with a hardware equipment of the school computer lab. Part of the business strategies of majority of software vendors in this category is opening of use for the educational sector with regard to the material possibilities of schools. There are academic licenses, fully functional and for a symbolic price. Often it can be installed on home computers of students and teachers. This important fact gives students space for individual development and learning outside a classroom. It allows teachers to work continuously on input, optimization and evaluation of pupils' work. Costs of academic licensing may be included in grant programs, or industrial enterprises in the region of schools can participate [6].

Experience and research among technical specialists show that there is a high demand for licenses for academic purposes. The possibilities to work with CAx technologies increase the motivation of candidates to solve large-scale projects. Individual work, supported by regular consultations in education has a great influence on the growth of professional competences of students in the field of CAx applications. In connection with the attitude of the current generation of potential engineers to information technology there is no exception discovering new methods and ways to solutions while working with CAx tools, and also individual creative activity at work by improving the efficiency by adaptation of application and its expansion through the possibility of additional programming of functions and macros. A specific example is the possibility to control parameters of the CAD model by linking to external applications, particularly spreadsheet. This feature allows you to achieve highly advanced skills and is one of the ways how to implement teamwork on a project when not all team members can work directly with CAx tools, or their specialized interdisciplinary focus is not CAx applications. The results of their work can be integrated in a CAx project without the requirement of knowledge of tools for design and simulation. Graduates and students often find employment in these companies. Financial aspect is not a barrier to the use of this category of software [6].

V. IMPLEMENTATION OF MULTIMEDIA EXPLANATION SUPPORTS 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.

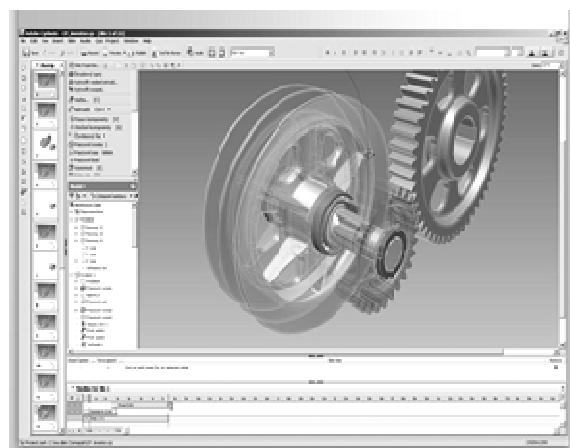


Fig.4 Sample of Adobe Captivate work environment

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 are 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 [7]. 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. During the creation of the presentation the author becomes the graphic designer, animator, film editor, etc. To follow this development and to be able to visit the number of training sessions and courses is an impossible task for a university professor. Preparation of presentations used in classes and preparation of multimedia applications usually involves several people or a work team. Thanks to integrated functional guide modules, a basic version of this method is available for the ordinary user as well. There are many programs focusing on this topic. There are basic and well-known applications used for the creation of instructional presentations and webpage contents, such as non-commercial

programs offering the user basic and quick tutorial messages (Microsoft Office PowerPoint, Publisher, Adobe Flash Professional, Replay Screencast, RoboDemo, CamStudio and many others). However, today's multimedia applications require a certain degree of professionalism and specialization. Samples of applications used for the creation of interactive multimedia presentations, which the teacher should be familiar with are: Wink, Camtasia Studio, Adobe Director, Adobe Authorware, Adobe RoboHelp and Adobe Captivate [8].

VI. SIMPLE AND EFFICIENT SAMPLE, DEMONSTRATING THE CREATION OF MULTIMEDIA SUPPORTING ELEMENTS

Not all tools require professional knowledge. An example of a very efficient environment used for the creation of multimedia supporting elements without the need for extensive professional knowledge is the software Captivate. The web page of Digitalmedia server (a part of the Adobe server), describes the use of the Captivate software. Only three learning stages should be sufficient and the user should be able to create highly efficient instructional presentations or simulations in the Captivate program. Captivate automatically records all actions you perform on the screen. 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. 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. However, for the visual description of work done in a parametrical modeler, the recording quality of the person doing the presentation is not as important as the recording of the computer desktop. Usually, every move of the mouse cursor is crucial. Uncertain or jerky motion of the mouse cursor or searching through drop-down menus during the presentation is confusing for technical candidates [8]. The same is true for the use of shortcut keys, which cannot be seen on the computer desktop. Only a few systems used to record the computer desktop enable the user to visually display activated sections of the keyboard or mouse. The majority of parametrical modelers enable the user to work efficiently with shortcut keys; however, during a presentation 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 are elements of the so-called educational process supported by technology (technology-based training), which provide information, tutors education materials and educational content through different forms of electronic media; therefore they are part of e-learning. Detailed results of the research are available in a book called Alternative technologies used for the creation of multimedia teaching supports. Adobe Captivate is a potential tool for the creation of interactive multimedia educational methods and for simulations of the functionality and control of various software applications. While 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 (TechSmith SnagIt, Hyperionics HyperCam, 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 prepared 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 [9]. 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.

VII. PREPARATION OF RESEARCH PROJECT

Project preparation is based on the possibility of procedures referred to in the previous lines. When preparing the project is necessary to take in mind the following factors:

- Specialization field
- Existing knowledge and skills.

- The time allotment for work on the tutorial project.
- Availability of relevant educational supports and information sources.
- The disposition of software applications for project preparation.
- The assumption of independent work.

The project aims to create conditions that simulate as closely as possible the real case in practice. Small-scale projects, which are dealt within a specified task, represent a case study in order to penetrate into the issues of the solved problem. The basis of skills acquired in related fields, at schools and studying professional publications, used and attached on the project. A related effect is a strengthening of interdisciplinary relationships of related areas and gaining more skills using design tools and simulation. Preparation of small projects is sufficient with developing of enter and validation of the model and alternatives. We can prepare CAD models, use CAD data of standard components, or parts of previous completed projects for specific cases. Items, including all documentation to work on the project, can be established in a PLM tool. Case study of small-scale project is presented in [9]. Projects of this scale are usually solved by individuals.

A share of self-work is already expected by large projects and the activity of a coordinator is input, consultation activities during the project and its evaluation. The project can be solved by an individual or group, but not more than 3 members of balanced performance. Acquisition of teamwork is one of the objectives of project work of virtual prototypes. It is necessary to specify the scope of the assignment according to the number of team members. The criteria for the entering of the virtual prototype of a specific project scope are following parameters that are designed and optimized based on long-term research investigations in the educational environment and industrial practice:

- Complexity of modeled parts.
- Request of specific modeling procedures.
- The number of components of the final report.
- The range of calculations and simulations.
- The volume of the required drawings.
- Application of standard parts from the available database.
- The complexity of the chosen technology and related processes of production preparation.
- The assumption of non-standard choice of design and technological solutions.

The complexity of the modeled components depends on the desired outcome. If the report is composed of the parts, containing the basic elements of Mechanical Engineering, we can expect much lower intensity than for example in the design of cavity injection molds for plastic parts of complex shape. Solution of this group of projects is appropriate in the higher years of study, where the assumption of a certain level of knowledge, skills and independence. Extensive projects are the culmination of study and lead to the use of knowledge of default subjects, but also of the experience of previous shorter-term projects. Degree thesis of the given study level can be processed based on these extensive projects. Alternatively, they may be solved in parallel with other objects of study. The outputs are supported by extensive calculations and

simulations, it is necessary to pay attention to the organization of data. If the goal of the project is the development of a new product, there is a prerequisite of change management in the process of development, therefore the older versions of outdated data must be available. Given to the scale and often also complexity of the assembly, it is necessary to design and follow the naming convention of individual components and documents. A project can be solved individually or in groups. Independent work of individuals or groups is mainly expected. The role of the coordinator is significantly consulting. Nevertheless it requires adequate preparation. [9]

VIII. WORKFLOW OF A PROJECT

Part of the project preparation is a supposed plan of activities and important points, set into the forward plan of the project. After entering of the project, investigator draws his forward draft plan based on his experience, which is a part of the initial presentation. The presentation is introduced and the term plan is discussed with the teacher or with other investigators of other projects before the official start of work on the project. Actual situation is recorded to the original term plan. Failure to plan must be justified. Comparison of the plan and real process is a part of the presentation of the final project. This information is a strong feedback for planning of other activities, and assessment of new projects entered in the school environment and in professional practice. The role of a teacher in the process of work on the project lies above all in the non-standard solutions consulting, availability of relevant information resources, supports with the implementation of complex modeling or simulation techniques. Check activity of a teacher is focused on a monitoring of project status and appreciation on of the relevance of noncompliance with the planned course. Input presentation, activity of a solver, compliance with design and technological processes are evaluated. In the final stage, the researcher introduces the completed project and the data are examined for accuracy of processing.

IX. CURRENT CONCEPT AND STANDARD EXPLANATION TOOLS

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 [10]. 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 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 process [10].

X. RESEARCH ON THE EFFICIENCY OF PROJECT WORK

Optimizing of the process of project to achieve high efficiency is an important activity, which is primarily based on the experience of specialists preparing projects. All findings should be recorded and evaluated in long-term context. Each project or group of projects can be considered as an experiment with all attributes. Testing of knowledge of issues with regard to the nature of the treated topic is performed during work. Test results can be quantified, statistically evaluated and the validity of hypotheses can be assessed to increase knowledge and skills of technical candidates and graduates for solving tasks of engineering practice.

Efficiency of intensive complex use of virtual prototypes for technical preparation of production, compared with the method of partial use of individual modules with no reciprocal links is verified by research on control and experimental groups. The efficiency, based on the execution speed of various activities and also correctness of technical documentation, calculations, final reports and analysis and quality of process technology are measured by the research. Interim results of the research are shown in Fig. 5.

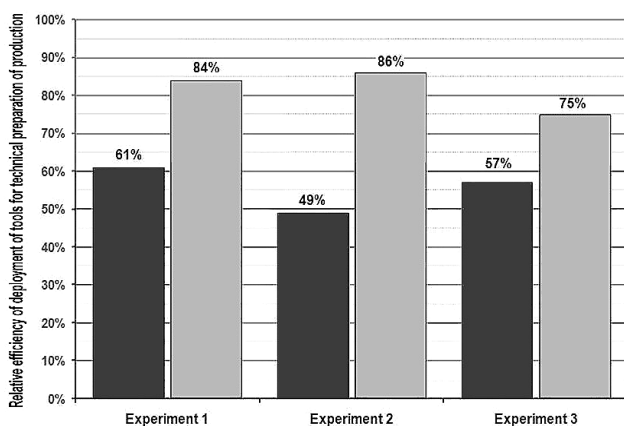


Fig.5 Effective deployment of research results

XI. CONCLUSION

Modeling objects in computer graphics is the role of fundamental importance. Working with ensembles (albeit a different technical meaning) is also a common feature of many CAD systems for engineering, construction, etc. The existence of three-dimensional model allows obtains any information about creating a geometric object. You can obtain such information for any display object, including cuts. Such characteristics can be calculated as volume, mass, center of gravity, moments of inertia and radii, etc. In addition, three-dimensional model can be used for automated preparation of input for finite element calculations. Using three-dimensional model can also be considered an automated pattern recognition arising in the modeling of the geometric models. It can become the basis for CAD systems with certain elements of intelligence. Modeling of secure systems or bodies subsystems, are called modelers volume (solid modeler). Problems of modeling objects (objects in the computer representation) and the corresponding implementation modelers is a significant area of computer graphics, which developed in the independent sector. The beginnings of the development of this region fall approximately to the seventies of the twentieth century. It has since been achieved remarkable results, which to a large extent the development of CAD systems. However, no development in this area yet be considered completely closed. Work on projects of virtual prototypes, created by CAX / PLM tools is one of the most comprehensive uses of IT in industry and in the educational sector. Quality of preparation of projects, involving the specification of the scope of the project, setting the forward plan and determining categories of applications that will be used for project development are very important. We also should take into account specific tools such as all macros, external interface for managing parametric object data models and software applications that extend primarily utilized tool. Another specificity of project work is the organization and management of data. Virtual prototypes include a wide range of data files, from CAD formats via CAE solution to the related documentation in standard formats for office applications. This fact requires a robust tool for organizing of data and defining processes between them. PLM tools enable teamwork, independent of the site of investigators. So it is possible to create an international team of specialists with equal dispositions. High-quality preparatory work of projects leads in the final stage to the minimization of problem events during solving in terms of technique and knowledge. [11]

Work on the projects motivates researcher to independent activities, often even beyond the requirements. Skills and knowledge are successfully applied not only in professional activities, but also in further follow-up study or during the processing of theses of appropriate levels. Experience with the preparation and application of educational projects can be summed up in the manual for consultants and coordinators. A key aspect of project preparation of virtual prototyping is the knowledge and skills of investigators. In addition to

knowledge of technical issues, corresponding to specification of input, skills to work with CAD tools, experience with the use of CAE tools and ability to prepare technical processes through CAM tools are important too. Cross-section of all activities is the administration and data management, integrated in effectively customized PLM tools. The project prepared according to the criteria listed in the text achieves a high degree of efficiency and simultaneously leads to the acquisition and consolidation of other knowledge and skills of investigators. CAx conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

computers science in 2002 on University of Hradec Kralove. He has Doctor of degree in theory of technical education in in 2008 both on University of Hradec Kralove, Faculty of Education, Czech Republic. He works as assistant professor on University of Hradec Kralove. His scientific activities are statistics tools for modeling and simulation.

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Josef Sedivy, PhD., was born in 1963 in Czech Republic. He obtained master degree in education of physics and technical teaching science in 1987 and