Solution of technical projects using computer virtual prototypes

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***Abstract*—** Tools for design, simulation and engineering technologies used in industrial practice have a strong potential for visualization and simulation options. Their systematic use especially in the project education is the subject of the research aimed at increasing of knowledge of engineering issues and increasing of skills of work with applied information technologies. Development of creativity of technicians and faster adaptability of graduates in their professional practice is expected. This text presents the concept of understanding of engineering methods, supported by deployment of these instruments, the issue relevant materials and the conclusions of investigations. Research question and hypotheses are introduced in the paper.

***Keywords*—** 3D data model, assembly, design, engineering, manufacturing, virtual prototype.

I. Introduction

CAx technologies represent a portfolio of applications to support engineering activities, focusing primarily on a suggestion of designs of parts and assemblies, verifying the functionality of constructions and determination of technology of a manufacture or an assembly. Basic tools in this category of information technology are:

- CAD - Computer Aided Design, creation of 3D data models and 2D drawings.
- CAE - Computer Aided Engineering, simulation and analysis on models created in CAD.
- CAM - Computer Aided Manufacturing, creation of technology, usually machining process in 3D or 2D data product model.
- PLM - Product Lifecycle Management system, philosophy of design data management and control of processes associated with the life cycle of a product.

Procedures to 3D data models will be presented and considered in the text. Current trend in industrial practice, technological possibilities of IT equipment and dispositions of the new generation of engineers require creation of compliance with methods of understanding of system [1]. Current situation calls for a widening of application of procedures using digital 3D presentation of products in a virtual environment. Properly planned learning on projects of virtual prototype should lead to strengthening of cross-curricular links and to increasing of knowledge and skills matching the profile of a graduate of the corresponding engineering field.

In the project, the emphasis is put on the comprehensive use of tools for design, simulation and data management. Experiments of use of tools for data management of a proposed product, in case of school environment, CAx data virtual prototype and all related documentation are carried out besides the traditional use of CAx applications. The use of PLM system brings the possibility of greater monitoring of work on a project and continuous access to analyzed data, which is beneficial especially in the view of the research conducted. A significant benefit of a use of PLM tools is also a possibility of configuring of processes of a system for the use in the role of study management system. We can this way not only distribute educational materials and sample solutions, but it also enables technicians to participate on the development of these materials, to check their work and communicate within the system. All procedures outlined in this study are designed without the requirement of specific CAx / PLM tools. Universal use is one of the prerequisites for the successful deployment of engineering education.

II. Projects of virtual prototypes

Digital data files represent models of components and assemblies, whose wide range of activities to examine the quality and functionality design can be exercised through appropriate CAx tools [2]. Undertaken analyses of models enable to understand behavior of specific design solutions and their variants more efficient. These include above all following procedures:

- The actual creation of 3D models.
- Compounding assemblies of components.
- Visualization of models or assemblies.
- Kinematic analysis of mechanisms.
- Strength check of the stressed parts.
- Spatial assessment of the elements.
- Measurement and analysis of models and
- Design and verification of technology of production.
- Design and verification of assembly technology.

Benefit of these activities in industrial practice lies especially in reducing of time needed for design and technical preparation of production. Reduction of costs of material, logistics and manufacturing of a real prototype is also significant. Another benefit is for example a more efficient process of a change management for the development and testing phase of a real prototype, or making adjustments to the finished product.

All listed procedures can be realized within a reasonable range in a school environment thanks to mentioned properties of virtual prototypes. Technicians can not only design but also simulate the operation of their projects, which would be practically because of the high costs of real operations. Projects outcomes are also portable, presentable, enable archiving and their possible use in subsequent continuing education is easy [3].

Creating of a database of completed projects is one of the preconditions for a more efficient way to approach of project teaching of technical subjects. Projects can be continuously expanded, or their component parts used to present specific approaches to solving similar types of tasks. In industrial sector, even in the school environment, finished successful projects can be a motivation and an inspiration for future solvers. By an analyzing of a large number of completed projects, approaches to solving can be quantified and the specific features that may be a subject for optimization of learning processes and the preparation of subsequent projects can be characterized.

III. CAx technology in the school sector

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.

Experience and research among technical specialists show that there is a high demand for licenses for academic purposes. The possibility to work with CAx technologies to increase the motivation of candidates to solve large-scale projects. Individual work, supported by regular consul ions 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.

IV. Project education using engineering tools

The aim of the project-oriented methods, supported by the use of CAx applications is to increase knowledge and improve skills of students in subjects of the curriculum field and related employability of graduates in professional practice. Theoretical foundations obtained in "classical" understanding of individual projects are applied in the design of structural and technological solutions in the course of the project [4]. Starting points is knowledge of the subjects:

- Engineering technology.
- Technology of assembly.
- Technology of specialization field.
- Machinery and equipment.
- Design of tools and products.
- Technical documentation.
- Mechanics, elasticity and strength.
- Information and communication technologies.
- Fundamentals of CAD, CAE, CAM.

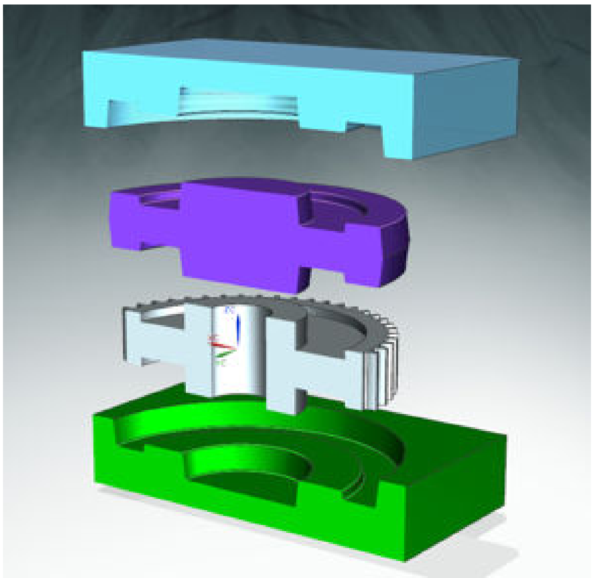

Fig.1: CAD assembly of basic components of a technological process of a production of a gear.

An example of a medium demanding project can be a complex input of the proposal and manufacturing technology of a gear. The gear wheel is machined from a pre-cast blank -

cast. It is necessary to design a tool for the production of the casting, in this case the cavity mold split parting plane. Example of a model of basic components in CAD is shown in Figure 1.

The gear wheel is proposed in a compliance with the rules of design. The model of the casting - part of the gear will be suggested according to the complexity of shapes, sizes, and the requirement of "spillover" of some structural elements. The shape and dimensions of the casting are associative with the final product. 3D data model of the casting is the initial geometry for manufacturing of mold cavity, separated in the separating plane - the lower and upper part. For example strength check of components in the assembly, casting simulation and creation of technical documentation components and forms according to the required scope of the project can still be included. Given example enables us to introduce, describe and apply the procedures included in the thematic plans of technology of related subjects taught at secondary vocational schools and colleges of engineering focus. Basic subjects and some specialized subjects such as basics of handling with CAD applications are mentioned in the list of subjects. Solutions and procedures applied by students working on a project should be based on theoretical knowledge and be in accordance with the principles of technical standardization. New, innovative solutions must be technologically justified [5]. A teacher fulfills the role of a coordinator and a consultant during the course and conducts continuous, respectively, final project evaluation.

V. Realization of projects

Entered projects should have several characteristic features that determine the target range of knowledge and skills of students, even if topic of project is chosen, by an individual or the research team itself. In case of a team work on solving of project, three-member groups were proved. An example of a done project can be a design of a detail, such as a part of a mean of transport, a sport facility, a model product, a hand tool, etc.

One of the criteria for the entering of a project is the modeling complexity of components.

It is appropriate to allow students working on a project selected according to their areas of interest, input must be corrected by the teacher to meet certain criteria.

These criteria are:

- The scope of work anticipated for the project, it depends on the allotted time, the number of team members and is designed primarily by the number of components.
- The complexity of modeled parts.
- The expected range of calculations and simulations.
- Difficulty of the proposed technology.
- Request of a complete manufacturing documentation.

The project must not be in scale and complexity too trivial. This leads to not utilization of the allocated time and reduces the overall efficiency of understanding by the applied method.

Conversely in case of an extensive project there is a risk that the project will not be completed. Failure to complete the project can be also due to an inadequate organization of activities during the project, caused by a little experience of students. The role of a tutor in the phase of the entry is the directing of imagination of a listener to realizable limits in compliance with established criteria and with respecting of the given goal. It is important to take into account the fact that for objective reasons, unfinished project can be considered as successful and can be positively evaluated.

VI. Evaluation of Work on projects

More ways usually lead to a correctly finished project. Selected modeling methods can show the level of skills and ability to work with the used CAD application and to diagnose additional skills for solving of a given engineering task and to identify the strategic thinking of students. An efficient creation of technological process of a production of a real output often depends on a chosen method of modeling. The purpose of project evaluation is not just a classification, but also feedback for students and teacher. Evaluation of projects, respectively solvers should be divided into two phases. The first phase is the continuous assessment based on the observation of pupils and checking of status of unfinished projects. Here we evaluate especially the activity and the approach of students to solving problems associated with the project. We assess the improvement in the use of CAx applications, work with information resources and compliance with the time schedule plan for the project.

The second phase is the analysis of the data of the finished project. Here we evaluate overall compliance with predetermined criteria, compliance with technical standards, general rules of design and production processes.

The elements under consideration should be discussed with the student in both phases of evaluation. A part of the evaluation is an assessment of the creativity of individual solvers of the project and specifically identifying of superior solutions.

VII. Support of Work on projects

It is appropriate, especially in the first stage of the projects, to give listeners available comprehensive teaching material based on guides, where the basic steps of work on projects, but also problematic practices in the used CAx application are briefly introduced. Based on research, focusing inter alia on pupils' attitudes to learning supported by CAx applications, a lack of learning materials for the independent work on projects can be observed. This problem also applies to the education of work with a used CAx tool [4]. A resource primarily facilitates to students start working and can usually compensate low time devoted to the subject and to coordinated activity. Despite the fact that various projects should have common specific features, the variety of entries often brings with it the possibility of non-traditional and new practices. New approaches to specific solutions can be in open study materials recorded and used in solving of subsequent projects. Manual should contain at least the following closer outlined points:

- Basic criteria of structure of the project.
- Methodology of creation of time schedule plan.
- Recommendations of distribution of activities in a team.
- Organization and security of all data and information related to the project.
- Links on available information sources.
- The procedures for setting up data files used in the used CAx application.
- Naming conventions of the CAD files of components and assemblies.
- Recommendations for setting up files with 2D drawing documentation.
- Procedures for connecting non-geometric information attributes to data models.
- Instructions for defining loads and boundary conditions for strength control of components.
- Instructions to making measurements and calculations on the geometry models.
- Procedures for creating final reports of done analyzes and simulations.
- Presentation and distribution of complete documentation of the completed project.
- The process of change management models in the design phase.

A description of the most commonly used complex functions and procedures specific to the used CAx tool should be attached in addition to the above recommendations.

VIII. Product Lifecycle Management System in the role of the LMS learning

PLM - Product Lifecycle Management is a management philosophy of a management of a life cycle of any product. The process is carried out through systems based on the capabilities of data storage, sharing, security and definition of information flows. PLM system enables the integration of a wide range of data formats, including the option of viewing them. The ability to define the processes according to specific requirement creates the potential to promote teaching, In practice, PLM tools are deployed primarily in technical fields for management of development and production data. As a graduate of a technical field will start in practice, it is very likely that its activities will be closely associated with the use of instruments featured. In the present study, the product is a virtual prototype of the pupils' project. The case study is an example of distribution of educational materials, simulations, model CA data, but also the instructions of a teacher - a project coordinator who has the opportunity to monitor all activities in near real time and respond through the system, including the diagnosis of specific outcomes and their assessment. The data sets can be archived, viewed and analyzed retrospectively. The operator PLM system through a Web interface provides the access to the application for the use of independent of a school locality or workplace.

Entering a CAx / PLM project is based on actual needs, in accordance with a thematic plan of a subject or a course. This may be a short-term project aimed at acquiring skills for implementation of a particular procedure or set of procedures related to the sub-task.

On the contrary, it may be a large project such as the nature of coursework or term paper. In all cases, the activities associated with the use of PLM in the role of the LMS are identical.

The main objective is the distribution of educational materials in the form of an electronic text and image materials, videos and sample solutions. Nonlinearity of access to individual thematic units can join the project designed with educational materials related to various problematic solution. PLM can be characterized primarily as a database system, extended by the possibility of defining the processes of information flow and communication.

The ability to define processes according to specific requirements can customize the application for control of data and management of information flows in solving of large and complex sub-tasks. For solving of problems, this characteristic is beneficial for the tutor - a project consultant, but also for the technicians - a solver of the project.

The study shows the potential to support work on technical projects, specifically of engineering field. In this area, PLM applications are mostly used and performance and environment of this area are also mostly adapted. One such example is the ability to integrate most popular formats of data files, including a CAx data and ability to link databases with the appropriate applications.

The ability to customize applications for specific PLM industry can also be used for support of education on projects such as economic or scientific disciplines. For working on engineering-oriented projects, the following features, based on experience and needs of engineering practice can be used:

- The use of a database of standard components implemented across all projects.
- The use of a database of its specific components and making them available for other projects.
- Creation of technological processes using the database processes.
- Visualization of 3D data from different systems without the necessity to own a license of a CAx tool.
- Rating of projects through tools of the approval and change management.

The use of PLM applications puts higher requirements for qualification of tutors and a system administrator. You can argue why not to use some of the known e-learning applications, or Internet or intranet sites. There are following benefits of PLM tools for students:

- Introduction to the category of tools used in practice.
- The possibility of defining of processes of a check of ongoing and finished projects.
- Obtaining patterns for naming conventions associated with the organization of project data.

The use of PLM tools brings also certain challenges that may hinder its overall deployment to support teaching. Unlike CAx tools this category of applications is not of strategic importance in the education sector for suppliers, and thus there are currently no licenses for academic purposes. On the other hand, the costs are lower than in the case of graphical systems. But there is a possibility to multiple rent the application for solving of eg. a semester or a year project. Acquisition of tools can be supported by funds from grants, or engineering companies in the region may participate in which graduates find their professional application. Other difficulty can be a qualification of teachers. Operating with this instrument is, however, significantly easier than for example working with CAD applications. Training to acquire sufficient skills to use is a matter of not more than one day for teachers and for students. PLM environment of the learning project is shown in Figure 2.

Flat_Pattern/A-Flex_Foil	_Layout Revision
ItemRevision Master	
Flat_Pattern/A	_Layout Revision Master
BOM View Revisions	
Specifications	
Flat_Pattern-CAD_model_vzor/A	UGMASTER
Flat_Pattern-tabulka_parametru/A	MSExcel
Flat_Pattern-Postup_reseni/A	PDF
Flat_Pattern-Vlastni_zaznamy/A	MSWord
Flat_Pattern_Videoprezentace/A	Zip
Flat_Pattern_Vlastni_reseni/A	UGPART

Fig.2: File of datasets specific to the learning PLM project.

Comprehensive application of the PLM philosophy for the support of study projects, which combines the full-and part-time studiyng is the subject of an investigation carried out at industrial company.

The development of knowledge and skills of students is tested on two parallel groups of students. Students in the experimental group drew up designs using CAx tools with the support of PLM applications for data management and with the possibility of obtaining relevant information for projects. Teaching materials are integrated within PLM applications and their accessibility is nonlinearly controlled by a process defined in an application in PLM. Students of the control group worked only with the use of CAx applications, without the use of PLM systems. Deployment of PLM system has a proved beneficial in three aspects, important for achieving of the objectives of studies of students and also for their applicability in practice. Experiment results show the growth of motivation of technicians for study, particularly in connection with the generally perceived lack of relevant learning materials. Controlled access to text and video materials, with the current ability to preview undertaken and completed projects of virtual prototypes showed a significant increase of knowledge of issues in engineering. This was verified by tests of knowledge. Knowledge of PLM tool also significantly affects the adaptability of graduates after their move into professional practice. Evaluation of selected results of 162 respondents is shown in Figure 3. In particular there are monitored parameters of connection of school and industrial environment.

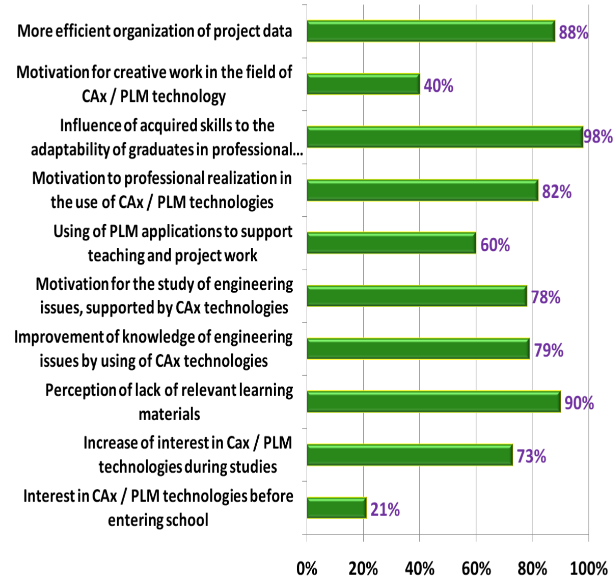

Fig.3: Selected results of positive attitudes of pupils to education, supported by the CAx / PLM technologies.

IX. Methodological Guidance for Tutors

It is very important that the teacher, who plays a particular role of a project coordinator and consultant, has besides comprehensive materials for candidates also his own materials, including recommendations and rules that should be followed during the coordination of projects. Ideally, it should be based on materials for students, expanded on the following topics:

- Procedures and criteria for determining whether the assigned project is sufficient.
- Criteria for evaluation of project objectives.
- Evaluation of the ongoing status of the project due to the assignment and the required criteria.
- Assessment of compliance with the project time schedule plan of the project.
- Evaluation of a completed project in terms of implementation of the proposal.
- Evaluation of technical candidates and students according to a comprehensive approach and activities.

Evaluation of the effectiveness of the used teaching method.

These points are above all recommendations and the role of an educator lies in the extension and the inclusion of his own methods according to the current situation in the group of students and the planned scope of the project. Development of methodical instructions is a result of the research in industrial practice. The main objective of creating of comprehensive materials for teachers is to enable the quality teaching also for teachers without permanent links with industrial practice. Due to the fact that the proposed concept is based on the requirements of industrial practice, it might be difficult to implement certain procedures across the board. Thus generated and optimized support materials for tutors can be one tool connecting theory and practice in the branch didactics of technical, especially engineering-oriented subjects. On the contrary, production of these materials makes technicians - educators, operating mainly in the practice space for reflection on the pedagogical context, issues of related didactic courses and applying the latest research findings and knowledge, carried out in connection with this issue. Optimal is the continuous cooperation of a teacher and a teacher/technician by preparation of technique texts. The structure of the text may be linear or nonlinear and can be inserted into a PLM system with the attributes listed in the previous chapter. The specific problem is a particular type of the utilized CAx applications.

Methodology of teaching and related supporting materials for teachers is designed independently of the used application. This may be used universally. The comprehensive CAx system Siemens NX and Siemens PLM Teamcenter system was used by the practical implementation of the approach. In the preparation of methodological materials, it is important to keep in addition to the technical terminology of engineering also CAD terminology. In case of known deviations from the usually named features and tools, a broader description of the procedure used and of its functions is important. Terminological clarity and accuracy is always important.

X. Research on the effectiveness of leading on project, supported by the CAx

Studying of technical, engineering-oriented problems on virtual prototyping projects, supported by the use of CAx applications leads to increased knowledge and skills of students. Acceptance or rejection of this hypothesis and optimization of the didactic system is the subject of ongoing research aimed not only to measure performance, but also their attitudes towards technology and teaching methods [6]. The process requires a comprehensive assessment of the problem in terms of technical base of schools, teacher qualifications, skills and attitudes of students to use information technologies, especially CAx applications. In implementation of the research a mixed methodology with a predominantly qualitative investigation is applied. Research is carried out during the studying of CAD courses in engineering and ICT, which are a part of the curriculum in Information Technology in mechanical engineering at a college. Qualitative research is based on the observation of procedures of individuals working on projects and analysis of results of completed projects of students. Parameters are skills and abilities of technical candidates to solve independently the role of engineering design experience. The data obtained from a sufficient number of analyzed projects can be quantified and statistically processed. Results can be presented in a graphical form and used to assess the acceptance or rejection of hypotheses. This is a typical case of mixed research, combining quantitative and qualitative methods at multiple levels. Data and conclusions complement each other and give more accurate each other. Due to the technical nature of the research questions is the approach usable and can be a source of inspiration and experience for the research and design in other technically and scientifically oriented professional didactics.

Quantitative research is based on a survey of attitudes of students of technical schools to CAx technologies and their motivation for the area of study.

The questionnaire survey is carried out through the paper and electronic questionnaires. For this purpose, the website www.kdvorak.cz was created. Through the form, located on the site, are continuously acquired data even from more distant locations. This method is preferred for the ability to easily import of data and its subsequent statistical evaluation. Results of the survey of attitudes and of motivation of students are important to optimize the learning processes. Part of the quantitative investigation is to evaluate the basic knowledge of issues of CAx applications, especially 2D and 3D CAD. In parallel with the research among the students the research data collection takes place in the industrial sphere. In particular, the fact-finding concerning the modules used CAx (CAD, CAE, CAM), a specific type and a frequency of application of CAx and a deployment of PLM tools.

Tests of general knowledge and CAx engineering are also evaluated. The test results are statistically processed and serve to clarify the findings from qualitative research phase. The first part of the research took place at the SPS on a group of fourth year students and on a group of second-year college students. Research continues on the students' projects of students of the second and of the third year of technical college in Zdar, where the teaching of CAx technologies has a long tradition, the school has a good technological base and cooperates with engineering companies in the region.

Pre-research and research phases run in a sequence, using a combination Pilot research, which has already been done, enabled insight into the problems and obtaining of baseline information to establish the basic assumptions and further specify the design of subsequent research of qualitative and quantitative approaches [7].

At this stage, investigations of methods of teaching of technical subjects, including the provision of didactic means was carried out. Simultaneously approaches to teaching of information and communication technologies and tools for design - CAD were analyzed. From these starting points a model of project-oriented education with the use of tools for design together with simulation was created. Based on these assumptions, a pre-research phase was made, consisting of several particular prepared experiments based on verifying of the contribution of design tools for use in teaching of a particular topic of a vocational subject. Verification of benefits from the use of these instruments was carried out by the technique of two parallel groups in a form of a pretest, implementation of reported teaching practices and a posttest. Results from the first two phases of the research activities can be summarized into the following points, which are the basis for planning, preparation and implementation of subsequent research [8]:

- Technicians mostly cannot adequately implement cross-curricular links and.
- Knowledge of participants of the appropriate level of study does not meet the requirements of industrial practice competencies of graduates.
- Participants with their designs cannot work in the field of constructing and technology in subsequent stages of the life cycle of a product (product - result of solving of a project).
- Participants are often not sufficiently motivated to the study of engineering issues.
- Even in the fields of engineering, participants are motivated to the intensive use of information technology.
- Participants fail to obtain and to use of available relevant information sources.

Based on the findings of pilot research and preliminary research, the research question was generated: "Will the deployment of tools for design and simulation in solving of technical problems, engineering oriented studying, to increase skills of graduates for solving tasks of industrial practice?"

This related sub-research questions:

- Will the project oriented studying based on the use of CAx applications strengthen cross-curricular links?

- Increases the work with CAx applications creativity and proactive approach of technical participants?

- Will the intensive use of CAx applications in teaching increase the motivation of technicians to study engineering issues?

The research objective is to increase professional competences of technical participants and graduates of technical schools of engineering specialization. Further to research questions research hypotheses were formulated whose validity is currently authenticated by statistical evaluation of data obtained by analyzing of students' projects and by quantification of selected parameters:

H1: *The use of CAx applications in solving of technical projects leads to increased knowledge and skills of graduates for solving of structural engineering problems*.

H2: *Studying supported by CAx applications leads to increased motivation of participants to study technical issues*.

H3: *Implementation of simulations and visualizations on 3D CAD data for virtual prototyping leads to strengthening of interdisciplinary relationships of the studied field*.

Acceptance, respectively, rejection of hypotheses based on the results of statistical processing of data is bound mainly by quantitatively oriented research. The preset mixed research design is based on quantified data from a qualitative investigation [9]. The base is sufficient data of research completed projects. The disadvantage of this research conception is the labor intense and time demand of the in-depth analysis of CAx and other data. The analysis proceeds according to the strict key. On the contrary, great advantage is the insight into the issue. Quantified are, in particular, the following parameters:

- Implementation of virtual prototype components from the point of view of a functional significance.
- Design of components and assemblies from the point of view of an available production technology. -
- Mutual relations of objects in models and assemblies from the point of view of a functional performing of changes.
- Topology of a creation of a model and an assembly. Organizing of CAx data and documentation related to the project.

XI. Conclusion

Systematic use of 3D CAx applications in the technical projects is the way how to increase the efficiency of solving technical problems. Applied approach corresponds with the trend of computer knowledge and skills of the current generation of potential engineers. Ability to be familiar with the procedures for solving of design processes, simulation and technological problems is a requirement of industrial practice. There is an opportunity for a professional growth of teachers and to the use of their own creativity in the preparation and coordination of projects [10]. CAx / PLM applications can be used in addition to engineering solutions also for jobs in construction, electrical and other related fields. A number of specialized modules extend these tools for the functionality and procedures for solving specific problems. Possibility to create own tools in the form of macros and libraries of other features requires a thorough knowledge of the system and often the programming experience, but may be a subject of further investigation and research of motivated listeners of electronically oriented disciplines. Another option is to use for support of teaching of selected topics in science, where you can apply modeling, visualization, or simulation potential of CAx applications. Typical examples are mechanics and optics in physics, analytical and constructive geometry in space, design of electronic components and logical tasks [11]. In the future these areas can be the subject of further experiments and research. Currently conducted research surveys confirm the validity of hypotheses about the development of knowledge of engineering issues and skills to work with CAx applications as a result of the staged deployment approach. At the same time there is a provable positive impact on a pupils' motivation and attitudes to the mentioned concept and work with tools for design, simulation, and data management. Binding to the industrial sector is an important factor for a successful development of engineering disciplines and technical education. This article was created under the project called Specific research done at UHK Hradec Králové No. SV 2108.

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