

# Computer modeling, simulations and design in the engineering -research of selected indicators

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**Abstract**—Spatial intelligence is the ability of manifesting good orientation in space and ease of creating visual images. Using spatial intelligence we see better pictures or movies, or movies. Individual spatial intelligence easily fitted using tables, graphs, maps, etc. Spatial intelligence was considers as one of the basic skills they need members of the technical professions. They are engineers, planners, surveyors, architects, artists, sculptors, artists. The basis of spatial intelligence is the high level of perception and attention. Essential in solving problems based on the use of spatial intelligence is also a systematic exercise (special training). We may also discuss the factors of spatial orientation and visualization again in the context of perception and attention.

**Keywords**— Computer graphics, visual spatial intelligence, spatial modeling, interactive applications

## I. INTRODUCTION

**T**HIS article is a description of spatial intelligence research. The research was realized by applying technology of computer graphics and some of the alternative methods. This paper deals with the progress and results of examining the impact of teaching spatial modeling and computer graphics applied to the development of intelligence visual spatial learners. Research provides an answer to the question whether it makes sense to explore ways in which the level of spatial intelligence can be further developed through special training.

Essential in solving problems based on the use of spatial intelligence is also a systematic exercise (special training). We may also discuss the factors of spatial orientation and visualization again in the context of perception and attention. As a rule, does not guarantee that excellent perception exceptional spatial intelligence.

The core of spatial intelligence is [2] capabilities that ensure accurate visual perception of the world, allow to transform and to modify the original perceptions. These capabilities also allow you to create your own visual experience of mental images even, when does not exist external stimuli. Spatial intelligence is to be understood as a set of loosely related skills. In this sense, provides the ability to recognize the same form. Furthermore, the ability to transform from one form into another forms, or to recognize that such a transformation has occurred. It is the ability to create mental images and then

transform these ideas [3]. Part of spatial intelligence capability is good graphical record spatial information. These abilities are as [1] used when working with any graphical representations respectively. We use two-dimensional or three-dimensional version of part of the real world, or other symbolic presentation of reality. Examples include maps, diagrams or geometric shapes. The development of spatial intelligence is by Gardner [3] for a normal person closely associated with visual perception, i.e. own observations of the world. The concept of spatial intelligence is so widespread attribute of "visual."

Here it should be noted the following three definitions according to [2]:

Spatial Intelligence manifests the ability to create and easy to understand graphs, charts, diagrams, maps, films, mobilize spatial ideas and work with them.

Visual spatial intelligence is the ability to visually spatial – visual-construction ability - the ability to perceive, understand and interpret visual and spatial information, as well as the ability to create visual representations and spatial relations during learning and problem solving.

Skill visual spatial is disposition (or assumed inclination) to correctly perceive, understand and interprets visual and spatial information.

In addition to crystalline and fluid intelligence is through factor analysis to identify the factors of spatial visualization and perceptual speed. Identified through the first sub-group intelligence tests was, according to Mackintosh [9] defined the spatial skill. Spatial skill is not to uniform, the main factor is called spatial visualization. Its importance is crucial in solving the three-dimensional mental rotation tasks, creating various puzzles or as a test of spatial relationships DAT (Differential Aptitude Test). The second factor is called spatial orientation. For him it is a typical task of visualizing a different perspective, is related to the environment and orientation maps, recognition, direction and distance. The third factor is identified by testing a simple rotation.

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## II. TOOLS FOR DESIGN AND SIMULATION

Applications of this category are commonly used in the school environment. A complete installation is very expensive, but a part of a business strategy of the majority of software vendors

in this category of software is to ensure the accessibility of its use in the education sector with regard to the material possibilities of schools. There are academic licenses, fully functional and for a symbolic price. They can be often installed on home computers of students and educators [4]. This important fact gives students space for individual development and learning outside the classroom. It allows to teachers continuous work on input, optimization and evaluation of pupils' work. Costs of academic licensing may be included in grant programs, or they may be involved in industrial enterprises for the region's schools. The financial aspect is not a barrier for the use of this category of software in teaching. CAD - Computer Aided Design are tools for computer support of creating of 3D or 2D digital models and 2D drawings. Currently, the standard is production of volumetric or surfaced 3D model by parametric methods [5]. The parametric model has dimensions and relationships between related objects determined by values of parameters that can be constant or variable and whose value is the result of a defined formula. The starting point for creating of 3D solid body are usually 2D curves, which are extruded into space in a straight line, revolved around an axis, or drawn along a guide.

In spite of the fact that the priority is the creation of a 3D volume model, we can still find examples of use of a 2D curve model. 2D curve model can be used for example to generate a NC code to control of a machine by the creation of the technology for machining of a simple body, or as a reference for the calculation and the finite element simulation. Besides creating a basis for further constructional activities based on calculations and simulations with 3D models and their set, it is used to create visualizations, the proposal in the context of the assembly and last but not least to perform basic measurements and physical analysis, directly in this module.

Knowledge and skills of work with 2D and then with 3D CAD applications are together with theoretical knowledge of basic and cross-sector engineering subjects basis for subsequent computer-aided design activities, and subsequent work on complex educational projects. Acquisition of basic skills is necessary already in the first years of the study, together with the knowledge and skills of using a computer, operating system and applications for creating text, spreadsheets and presentations [6].

Computer Aided Engineering (CAE) 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 are 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 a CAE module in teaching is possible through case studies and examples of 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 educational projects is expected. CAM - Computer Aided Manufacturing enables to create and verify machining technology for a numerically controlled machine. In addition to a tool-path that is determined by shape features of a design, the type and size of the used tool can be defined and cutting conditions can be determined. Production technology is optimized on 3D data of digital models.

### III. ENGINEERING AND PEDAGOGICAL TEACHING CONCEPT OF ENGINEERING COMPUTER-MODELING SUBJECTS

Creating and testing of new progressive ways of teaching of technical courses may be based on engineering and pedagogical approach to teaching, as detailed above all in [2]. „As engineering pedagogy are considered all activities aimed at improving of teaching of technical subjects regarding objectives, content and forms of teaching”.

Sources of engineering pedagogy and links between them are shown in Fig. 2. Objectives in this area are predominantly determined by the demands of industrial practice. Content is given by yet acquired knowledge of field and should react on the on-going development and implementation of new technologies. The development is evident also in the field of educational technology and teaching methods. Support for teaching of technical subjects through the instruments used in industrial practice and developing of new practices is an example of the close relationship of theory and practice in didactics of technical subjects. The paper presents one of methods of use of modern didactical technologies in practical teaching.

The deployment of information technologies in teaching of non-informatics subjects reflects the current trend of dispositions and interest of generation of potential engineers. This is connected with the achievement of learning objectives as listed in the taxonomy and for teaching of engineering subjects closer specified by [2] not only in the cognitive area. Natural perception of computer applications environment leads to the gradual formation of the affective area and work with objects in a 3D virtual environment also to obtaining of skills in the psychomotor area.

The structural design in a virtual environment, supported by performing simulation and design of technology solutions in the framework of educational project leads to the organization of knowledge structures and consolidation of curricular, and in some cases, interdisciplinary relations of a studied issue [3].

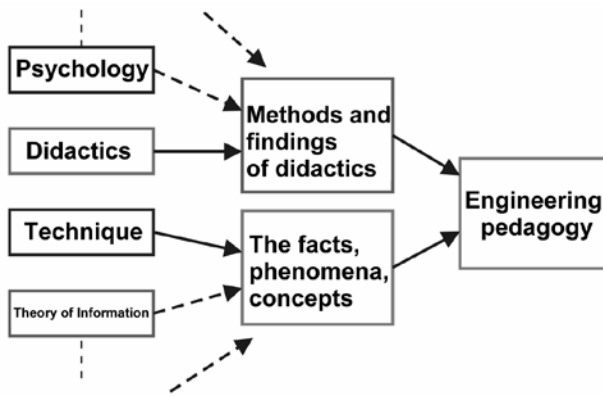


Fig. 1 Engineering pedagogy sources [2].

#### IV. THE SUBJECT OF RESEARCH ACTIVITIES

Optimization of the teaching methods is based on a research conducted at secondary schools and colleges of engineering and of information-engineering focus. In connection with the project teaching, supported by information technologies, growth of motivation of students to study engineering problems and their subsequent application in professional experience in the field of study is monitored. Experiences with computer-aided education and the possibility of advantageous use of potential of other, in engineering practice used, software tools are listed in the paper. In particular, the issues of application of tools for data management in the role of learning management system are presented, which is particularly beneficial in the final stage of preparation of technicians, where largely individual work and teamwork on complex projects of virtual prototypes is expected. The strategy of data management system enables checked work on educational projects also outside the school environment. Interim results of research are mentioned in the text with links to possible solutions and optimizing of the didactic system of teaching of engineering subjects is given [4].

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 the use 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 [2]. Verification and optimization of teaching methods takes place within the long-term research conducted in the teaching of engineering-oriented subjects at the secondary school and college. Survey is focused on the increase of

knowledge of students by teaching of basic academic subjects with the use of visualization and simulation possibilities of computer applications. Implementation of teaching 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 students' 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 student. 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. A part of a comprehensive research is based on this sector in addition to the analysis procedures carried out in sophisticated design and technological departments of industrial companies, the investigation is aimed at the adaptability of students and graduates in practice. The result of these activities should be an optimized didactic system of teaching of engineering subjects, supported by tools for design, simulation and data management [3]. Educational procedures of relevant thematic areas of other subjects taught at all levels of schools can be derived of this concept.

The influence of teaching technology 2D graphics on the process of examining spatial intelligence can't eliminate from below for the following reasons:

- At least its foundations are part of teaching Computer Science (Computer Science), currently a basic understanding of 2D graphics technologies belong to general secondary education [4].
- Spatial (especially free artistic) modeling can't be fully taught without 2D graphics techniques (e.g. the creation of textures, masks)
- Visual imagination always affects performance in tests of spatial intelligence [3].

The level of visual-spatial intelligence of respondents is dependent variable. Was assessed on the basis of on-line non-verbal test and expressed via T-variety. Independent variables are the number of completed lessons spatial modeling (i.e. time of direct exposure to teaching secondary level) and experience working through spatial modeling systems under study. The first factor represents the completion of a number of teaching units respectively four intervals. (These are based assumption of 33 weeks of instruction in one school year).

The second factor represents:

- Inexperience with work through spatial modeling systems during study,
- Experience with work through spatial modeling systems during study
- The third factor is:
- Experience with work through spatial modeling systems (during study) and conventional methods of teaching,
- Experience with work through spatial modeling systems (during study) and unconventional teaching methods.

- Experimental test group is 108 students in the educational program for the area of educational Multimedia creation: Computer Graphics. Two control groups is 216 students technical and artistic disciplines at university, who have experience in study of technology of computer graphics and solid modeling through conventional methods such experience or not at all. All three groups of respondents are numerically equally represented.

We describe in detail the experimental group which was tested. The educational plan includes a number of specialized courses that are not based solely on teaching solid modeling technology. It contains more fields: Photography, Typography, Printing Technology, Digital Video Creation and more. The course "Designing 3D models" represents creation through free and parametric solid modeling. Custom work is mainly based on operations with visual stimuli. Visual stimuli are moving object, creation of new objects or adding new components, removing existing objects or their parts or modify them, the choice of a different perspective, etc.). Other specialized courses are aimed at teaching creation through classical art techniques. In these courses taught painter, sculptor, architect, fashion designer.

In the experimental group students were applied unconventional teaching methods. We describe how to use of methods in articles [7, 8]. These methods include the application of project multimedia or software supports teaching, virtual reality technology simple and fast prototyping (rapid prototype). During the course we are trying in the experimental group suppress specific errors in the process of learning of parametric modeling.

#### V. 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 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 license, 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. The cost of academic licensing may be included in grant programs, or industrial enterprises in the region of schools can participate. Graduates and students often find professional applications in these companies. Financial aspect is not a barrier to the use of this category of software in teaching.

The aim of the project-oriented teaching, 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" teaching of individual subjects 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.
- 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.

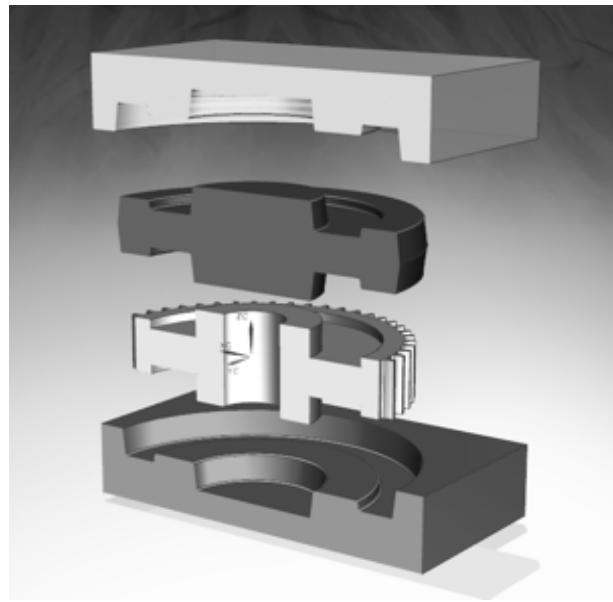


Fig. 2 CAD assembly of basic components of the technological process of production of a gear.

An example of 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 in Figure 1. The gear wheel is proposed in 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 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]. Teacher fulfills the role of a coordinator and a consultant during the course and conducts continuous, respectively, final project evaluation.

## VI. SUBSTANTIVE RESEARCH HYPOTHESES

1 Respondents in research, who have work experience through spatial modeling system, achieving higher levels of visual-spatial intelligence.

2 Application time of work through spatial modeling in the study, affects the development of the visual-spatial intelligence.

3 Learning spatial modeling supported by unconventional methods, affects the development of visual-spatial intelligence more, than learning spatial modeling through conventional methods.

File structure is an important source of information for qualitative examination of the benefits of the described concept of teaching. 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.

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. 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 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.

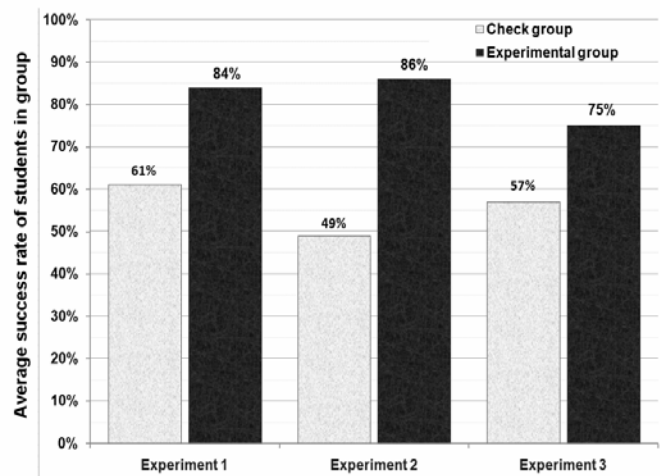


Fig. 3 Verification of deployment of a CAD tool in education - success of students in posttest

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 are here presented.

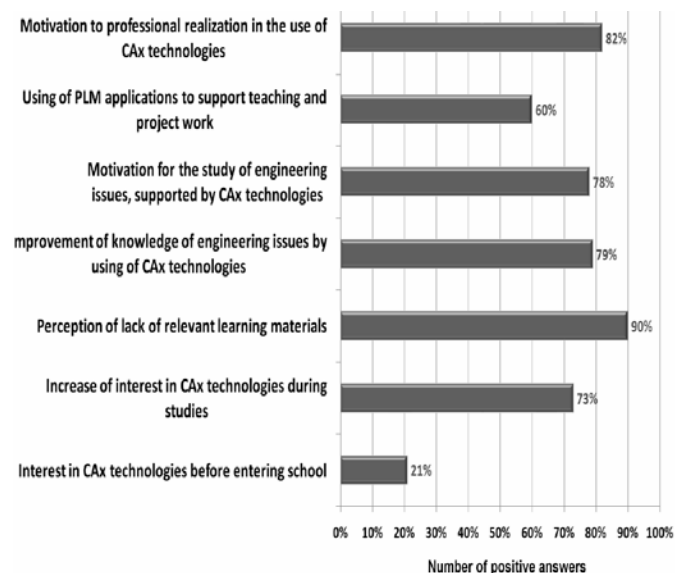


Fig. 4 Results of the survey of attitudes of students and graduates of technical schools to CAx technologies

The following example demonstrates a configuration of a PLM system to meet the educational role of the LMS. The data structure and information flows are based on the experience and research investigations in education. Use of a PLM system in comparison with known universal LMS systems brings the opportunity to familiarize with the approach applied in industrial practice.

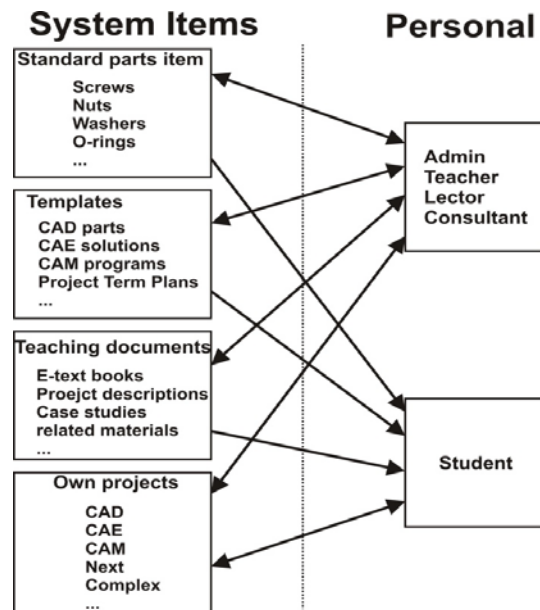


Fig. 5 Diagram of data structure of PLM system in the role of the LMS

#### V. SYSTEM FOR TESTING OF VISUAL-SPATIAL INTELLIGENCE

User interface test system must have no common or similar component systems are designed for spatial modeling. We Determine the requirement to avoid advantage (or disadvantage) of any of the groups of respondents. In this respect it should be noted that the principle of operation in the test system are selections of alternatives (virtually through images, elements button, checkbox, radio button, etc.). Modeling systems is based on three-dimensional solid models and surfaces through a much greater number of different elements, tools and techniques. Given the purpose of our study was needed to test of respondents on more (foreign) workplaces. It would be impractical to install a copy of the test system to individual local stations, so we decided to apply the technology through interactive web server system.

Operation of active elements providing interactivity to a Web application requires a constant exchange of status information between the client and the server. This significantly slows the running applications and limits its possibilities. The solution lies in the expansion of Internet browsers for interactive presentation layer. This layer provides asynchronous messages through the communication between the Web client and server. Model event driven interface eliminates the need to generate the HTML code for each response to an event. Microsoft Silverlight is one of the technologies that based on such a philosophy. Since the second version of Silverlight, is the system implemented by Microsoft. NET technology.

When we designed test applications, we proceeded mainly from the literature [1, 2, 5]. Own images works were created by Autodesk 3DS Max and Adobe Photoshop. The set of images is composed of three categories of tasks. Each group of tasks preceded three works of training, without the proper solution the user can't continue testing. The correct answer for each of the first tasks of training is given in the accompanying text. The correct answers for the following two additional

training tasks are no longer displayed, only possible choice answers incorrect.

Each of the three categories of testing tasks is time-limited, time-limited job training are not. We tried the role of these groups in ascending order according to their difficulty, but it is clear that the ideal state can't be reached. In order even and odd jobs (pair) are intentionally formed so as to be equivalent to their complexity and to determine the reliability coefficient by bisection method. Some difficult tasks had to be after the test operation of the system that initially excluded from unsatisfactory reliability coefficient. Testing tasks is a total of 76 their system is designed to test the ability of most respondents. Maximum of correct answers have no one of respondents. If the respondent does not know the correct answer to a particular task, it was possible can be omitted (to keep limited time).

When was selected such alternatives, is the respondent by the system always be aware of this fact. Among the tasks respondent can freely switch forward and backward. Selected respondent answers are immediately stored in memory when switching between tasks are already selected answers currently displayed. Between jobs when paging backwards therefore no loss already selected answers. The collected data is sent to the server side at the moment of completion of the last job or after the expiry of the time limit for response to the realization of the role of the third category. Based on the information identified by the respondent is always assigned to a given category. Selection of respondents from each category for subsequent processing of measured data is performed using the method for generating random numbers from a predetermined interval, which is available through Microsoft. NET technology.

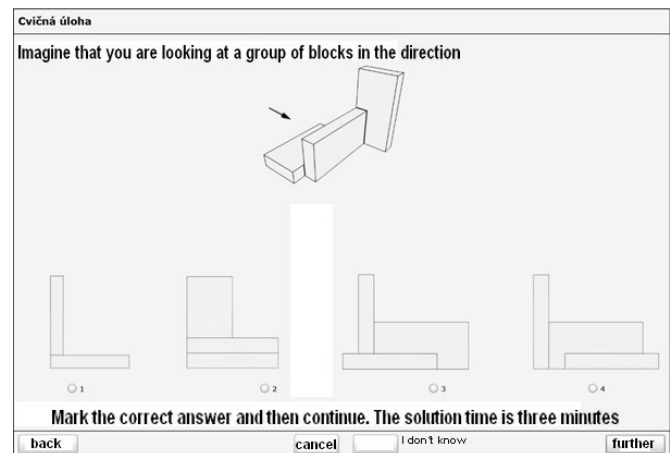


Fig. 6 Sample of work environment testing web applications (training task)

Computer monitors at some workplaces have low resolution image (or is so only set). Web browser (e.g. Internet Explorer) can be set after running the zoom level to 125%. These situations may not realized the respondent or may not be able to correct, suggests that our experience of the test system operation. The result was hiding control buttons below the bottom edge of the screen. For that reason had to be adjusted (reduced) default window size test system.



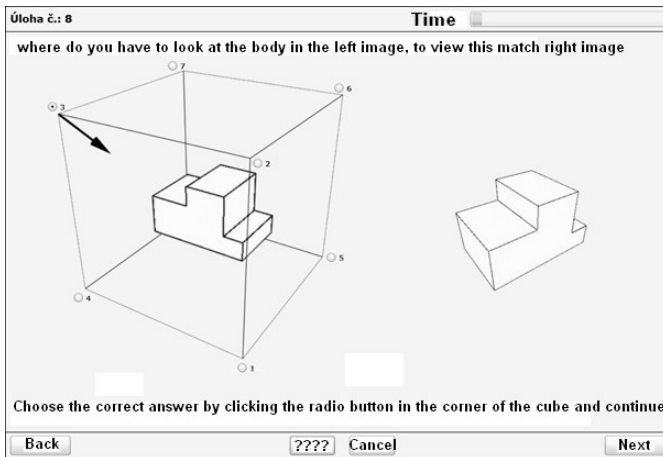


Fig. 7 Sample of work environment testing web applications (time-limited task)

Efficient teaching methods with a goal to strengthen cross-curricular relations of specialist subjects are the teaching on complex projects [6]. Knowledge of subjects such as technology of a field, engineering, engineering technology, technical mechanics, creation of technical documentation, information and communication technologies and other industry-oriented courses taught at lower secondary schools is used in the education. Transition to the teaching on project supported by CAx / PLM technologies is gradual and in the higher grades complex project work have predominantly role. In particular, teaching at college is since the beginning focused on project teaching to consolidate ties of gained knowledge and skills of the studied field [7].

The projects are solved in subjects of CAD, CAE and ICT in engineering. The number of lessons corresponds to one semester or term and the range is designed specifically for individuals or groups of two to three investigators. Some of the semester projects are developed to the level of successfully defended thesis. The recommended timetable for implementation of the educational project, indicating the most important activities.

Table I Timetable for ideal process of implementation of a pupils' project with key points

Activity / Timing	1. month	2. month	3. month	4. month	5. month	6. month
Project specifications	█					
Initial presentation		█				
Design work on the project		█	█	█	█	
Calculations, simulation, design review			█	█	█	
Creation of technical documentation				█	█	
Generation and verification of NC program					█	
Final presentation and data transfer						█
Checking the status of the project	◆	◆		◆	◆	◆

Visualization of 3D data of the completed project of a virtual prototype of bike frame 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. 8 3D virtual prototype of a mountain bike frame.

Table II Description of standardization sample (completed primary education, high school respondents - male)

age	n	$\bar{x}$	s	$\chi^2_{0,05}(7)$	$r_{sb}$	$r_p$
15 - 21	168	47,74	11,45	13,810 < 14,067	0,92	-0,85

Table III Description of standardization sample (completed primary education, high school respondents - female)

age	n	$\bar{x}$	s	$\chi^2_{0,05}(6)$	$r_{sb}$	$r_p$
15 - 21	156	46,59	11,20	6,256 < 12,592	0,93	-0,83

## VI. STANDARDIZATION OF TEST

Trial selection is a total of 324 respondents. This selection was divided into two groups with respect to the declared gender difference in the level of spatial intelligence. Through the test system has been collecting information on gender, age, his branch (or experience with spatial modeling and the different methods of teaching), the number of lessons completed in the relevant subjects (or on the basis of the classification to a class) and study results achieved. Each correct fulfilled subtask was rated one point raw score.

Raw score does not reflect the level of the respondent, but it can be assessed on the basis of a comparison with the performances of the other respondents. The purpose of standardization is to create standard dough, which allows the inclusion of each respondent's raw score according to a certain scale. Standardization methods are based on the assumption of a normal distribution of test results and are based on determining the distance of the individual results from the

arithmetic mean (by standard deviation). To express the achieved test results were used T-spectrum. Normal distribution raw scores were verified through chi-square test. (The use of any in the post above statistical methods as described in the literature [7, 8,9]).

#### VII. RELIABILITY OF TEST

The measurement is reliable if repetitions under the same conditions, relatively the same results. Accurate measurement of the minimum load errors, the errors do not acquire large values or frequency. Reliability and accuracy are common aspects of reliability measurement. Reliability is a necessary condition for validity of measurement, even though it is still not guaranteed. *rsb* reliability coefficient can take values in the interval  $<0, 1>$ , where value 1 expresses the ideal situation. A test is considered where reliability coefficient values is at least 0,8. Reliability coefficient can be determined using the methods of repeated measurements, parallel measurements, halving and others, each representing a certain problem.

The advantage of halving method is the applicability of the tests when tasks in terms of difficulty are not homogeneous. The condition of the method is sort tasks with increasing difficulty. The test consists of always immediately two consecutive equivalent jobs. The results are broken down by order of the jobs (even, odd) in the two groups. Determination of the coefficient of reliability was carried out using the method of halving, by Pearson's correlation coefficient and Spearman-Brown formula. After realizing we retest reliability of his later verified through repeated measurement methods.

#### VIII. VALIDITY OF TEST

The test is valid, when measured by what measure has a theoretical assumption. Validity of measurement can be assessed on the basis of comparison with other (external) criterion whose validity is undisputed. Validity of tests of spatial intelligence is determined e.g. by testing the ability of respondents to manipulate different "puzzles", disassemble or physical models consist of bodies. With the exception of measuring the elapsed time remains debatable issue in the accuracy of measuring the success of such manually-functional roles.

We set external criteria by declared results (the certificate) students in the curriculum focused on the application of spatial modeling. The tightness of the relationship between academic performance in the subject and test-scores was assessed by Pearson's correlation coefficient  $r_p$ , which would ideally be reached -1.

#### VII. EVALUATION OF STATISTIC HYPOTHESES

In the first step, we determine the independence test chi-square for contingency table. Frequencies of test results and the expected frequencies are divided into pivot tables by the dependent variable and independent variables. The level of visual-spatial intelligence in tables divided into three intervals by T-scale. Test criterion expresses the size of the difference between reality and pronounced null hypothesis. The critical value is set for the level of significance of 5% and a specified

number of degrees of freedom. If the criterion value of the dough is less than the critical value, the null hypothesis is not rejected and vice versa.

Selected test only provides any statistically significant relationship between a dependent variable and independent variable. Further interpreting the test and determine which field of table with proven relationship manifests, we realized through the scheme, and a signed z-score. The values of z-score calculated for each field in the table are tested for significance levels  $\alpha = 0,05$   $\alpha = 0,01$  and  $\alpha = 0,001$ . The tightness of the relationship between the dependent variable and the independent variable was also expressed by the coefficient of contingency.

#### IX. CONCLUSION

Because they have not been refuted first and second factual hypothesis is the logical conclusion of provision of teaching spatial modeling and computer graphics technology in general as an important factor of development visual-spatial intelligence with practical positive impact on the profession. The successful performance of the visual-spatial intelligence conditional. [11, 12, 13]

Since it was not rebutted by the third factual hypothesis, further application and development of unconventional teaching methods of spatial modeling and computer graphics in general has not been questioned. It must be added that the third null hypothesis is the difference between the value of dough criteria and critical value small. With the intention to further support the second factual hypothesis, we compared the success of respondents in both measurements. However, the following findings were negative. We note only that the time lag of approximately two months in this case is not sufficient to demonstrate a statistically significant difference.

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