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RESEARCH ON THE IMPACT OF COMPUTER MODELLING TO DEVELOP SPATIAL INTELLIGENCE

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***Abstract*-The subject of the article is mainly research on the influence of teaching simulation and modelling applications using computer graphics to develop and increase the capabilities of visual-spatial intelligence of university students. This article presents selected results of non-standardized testing spatial intelligence**

Keywords -; Spatial intelligence, Spatial modelling, Spatial intelligence testing,

I. INTRODUCTION

Action and the inclusion of man in contemporary society is heavily influenced by his intelligence. Intelligence has a great significance in the context of various sciences and has contributed to the level of our everyday lives. The term intelligence is associated with success and quality of life, all professions are rising demands for higher levels of education, which also depends on intelligence.

Mackintosh in 2000 published a chronological list of several definitions of intelligence work by the eminent scientists in this field. Intelligence is an example:

- summary and overall ability person to act purposefully, tothink rationally and successfully deal with their surroundings, Wechsler, 1944
- general mental performance, Burt, 1949
- natural cognitive ability, Burt, 1955
- fundamental ability that is first in the hierarchy of intellectual skills, Butcher, 1968
- Mental ability to behave appropriately in the areas of continuity of experiences that include responding to the new phenomenon, or automation of information processing as a function of meta-components, performance components, and components in acquiring knowledge, Sternberg, 1985
- General logic capability, which is useful in a variety of tasks, which include problem solving, Kline, 1991

The first attempts to make practical use of intelligence tests come from an English scientist Francis Galton. He was inspired by a cousin of Charles Darwin and his theory of evolution. Galton came from the idea that the quality of information they collect using the senses and intelligence is determined by the level of sensory and perceptual abilities that have a genetic basis.

Galton after processing tests in 1884 showed that the ability of adults, such as the level of auditory sensation of visual perception, reaction time and memory shapes, as well as physical parameters such as head size, are not correlated with intelligence. Galton was the first to systematically compiled data of a large number of people, the results statistically processed and the assumption of the normal distribution level of intelligence in the general population.

French psychologist Alfred Binet and the doctor denied the measurement of intelligence on the basis of sensory tests focused on cognition, judgment and criticism adaptation of the activities, carried out. Binet along with Simon submitted in 1905 “mental age range”. This scale measured primarily by their knowledge and skills in the practical field. They assumed that solving problems in testing should be slower individuals mentally delayed and logically faster individuals above-average intelligence. The ability to solve difficult tasks are commensurate with age, especially amongst children. This idea was directed to the choice of age as an independent criterion for assessing intelligence.

II. SYSTEM CONCEPTS

System approach understands intelligence as performance in information processing and processing processes in the context with the individual characteristics and in the context of the cultural environment. System concepts are represented by multiple intelligences theory of Howard Gardner and triarchic theories of Robert Sternberg. Gardner defined seven types of intelligence independent of one another. The level of various types is different among individuals. It is influenced by heredity and environment. Individual types of intelligence are not mutually influence one without the other is to some extent impossible, while it can be described as a semi-autonomous systems. Individual types are: linguistic intelligence, logical - mathematical, spatial, musical, bodily - physical and human resources, which rules are intrapersonal and interpersonal.Gardner's theory has had a positive response in the scientific community, but also garnered criticism. As a questionable assumption is called the independent effect of each type of intelligence, criticized the idea of locating the individual intelligence in specific areas of the brain. From the perspective of cognitive theories of

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intelligence criticisms directed against the concept of modular units of information processing[1].

III.SPATIAL INTELLIGENCE

The essence of spatial intelligence is the perception of the visual world skills that enable to modify and transform perceptions and create a visual perception of mental images, even when there are no external stimuli. Using these capabilities construct shapes and manipulate them. Spatial intelligence capabilities are not fully identical: for some people is accurate visual perception and yet he could not draw or recall imaginary world. Spatial intelligence is used in various environments. Maybe when the orientation of the building, but also in seaworthy.

Spatial intelligence and spatial abilities are used especially in activities with various graphic descriptions of the real world. Typically, these two-dimensional representation, three-dimensional, or symbolic: diagrams, maps, geometric shapes.

In the fields of art is the result based on spatial composition and balance and spatial intelligence of the author determines the effect of the work on the viewer.

A certain type of high spatial intelligence works with imaginary similarities of different forms. Some creative writers are capable of detecting metamorphic similarity of different phenomena. We can cite Darwin's vision of the "tree of life", Dalton's atomic model, a scale model of the solar system. Fred likens the unconscious to a hidden part of the iceberg under water. These visual images are often become the basis of scientific theories and make them lay clarity[2].

Research conducted in the UK has brought an interesting fact that this intelligence is largely equipped with taxi drivers. The rationale is that, thanks to the daily movement in the streets at the cabbies still developing the part of the brain that processes visual information.

The spatial and visual intelligence is generally thought to be a male trait. The men are evolutionarily employed activities, such as hunting, fighting and exploration. Women show more verbal intelligence, interior and social.

Vital importance of spatial intelligence in the natural sciences. Einstein and Russell were enthusiastic about the concept of Euclidean geometry. Einstein was interested in the relationship of surface and spatial shapes. The basis of his intuitive thinking was classical geometry. Invent experiments based primarily on the concepts in your mind. Einstein himself described his method of scientific work: "My way of thinking is not based on apparently never written or spoken language. As elements of his thinking I would call rather symbols of a more or less clear images which can be arbitrarily repeated, and combine ... “These elements include thoughts in my case into a visual and sometimes physical realm. “ McKim, 1972.

In the natural sciences and the humanities and arts disciplines can apply spatial intelligence in varying degrees. Various fields of physics and technology for spatial intelligence are more demanding than the traditional humanities. There are more applicable importance of verbal structures.

Definitions of spatial intelligence are different. Gardner and Schmidt consider it a basic ability in technical professions, but also artistic fields. Schmidt describes the factors of spatial orientation and visualization in the contexts of perception and attention. Experimentally verifies that the right does not guarantee a good perception of high spatial intelligence. One may be equipped with an excellent visual perception, but it may not be able to create an imaginary world of ideas. Gardner verify certain shortcomings in the spatial conception in humans exceptionally equipped in the areas of music and speech.

IV.MEASURE OF INTELLIGENCE, INTELLIGENCE TESTS

The biggest development of intelligence testing took place in the 20th century. They were assembled hundreds of intelligence tests. The vast majority of them are currently in use. Only a few tests that have proven historically as the best and most accurate uses contemporary psychology.

These are in particular:

- Raven's Progressive Matrices
- Wechsler intelligence tests
- Analytical intelligence test
- Test the structure of intelligence

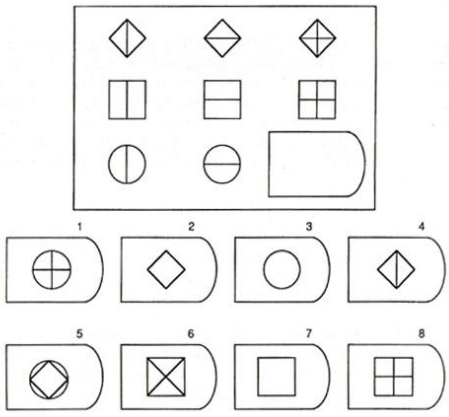

Fig. 1 Principle of Raven´s matrices (test image)

V. SPATIAL MODELING AND SPATIAL INTELLIGENCE

In computer graphics can be viewed in many ways and can be divided into different categories. These categories are related and often complement each other and penetrate. Study of computer graphics not be viewed in isolation of sub-modules (graphics vector or raster) or as teaching software tools[3].

Spatial (geometric) modelingis the process of creating and displaying three-dimensional objects using a computer. Spatial modeling system (modeler) is the name for a computer program that implements spatial models respectively, representation of spatial objects (solids and surfaces) through mathematical tools

All modeling programs are essentially based on the volume elements (geometric primitives e.g. box, sphere, cone) and set operations (union, intersection, difference). In teaching technical subjects are currently applying computer aided drafting. At the heart of each system type CAD (computer aided design) is a type of parametric modellers. The trend in the design of objects and not just technically oriented is applying parametric modelling. Parametric modeller is designed for creating volume or area objects,

there are also hybrid modeller. Parametric modeller is usually based on the representation of objects by means of NURBS (non-uniform rational B-spline[4].

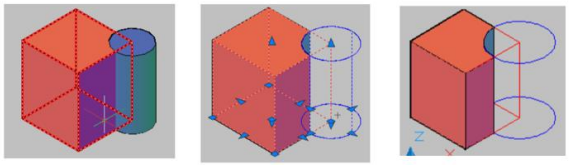

Fig. 2 Spatial modelling primitives in the program: making a difference bodies

VI. SPATIAL MODELING AND SPATIAL SKILLS

Modelling systems may vary in their work environment, user interface, general principles of spatial modelling remain similar. Relevant software application performs mainly the function of creative tools. Parametric models are formed by means of sketches, volume or area components. Their definitions must be clear with no redundant or conflicting information possible solutions there usually higher. The work environment for creating drawings can easily generate various projections previously created three-dimensional model[5]. (Modifying the drawing can possibly change the size of the model.) The more difficult the contrary, when students based on the submitted drawings form a three-dimensional model. Success in realizing such a task no doubt also depends on the level of visual spatial intelligence of each student. We further assume that both of the above workflows facilitate their development. Students are placed considerable demands in the areas of logical thinking and spatial imagination. Systems for accurate and free modelling are pretty compatible, and usually allow transmission models by dedicated data formats[6]. Systems for free creative work, given its purpose has better visualization tools, simply because it makes sense to them to transmit accurate models. Selection of suitable software tools and techniques to develop a particular model is dependent upon its end use. CAD systems are used primarily for the purpose of constructing (used mainly in industrial engineering and construction).

VII. DESIGN OF A SYSTEM FOR TESTING VISUAL-SPATIAL INTELLIGENCE

Custom images jobs are created through the Autodesk 3DS Max and Adobe Photoshop. Each group of three tasks precede the job training, without proper resolving user can´t continue testing. Each of the three categories of testing tasks is time-limited, time-limited training tasks are. We tried the role of these groups in ascending order by their difficulty, but it is clear that the ideal state can´t be reached. In order for the odd and even (pair) tasks have been deliberately formed so that its difficulty and equivalent to determining the coefficient of reliability of the system using the method of bisection. Some difficult task had to be after the test run, the system initially excluded because of unsatisfactory reliability coefficient. Test tasks are total of 60, the system is designed to test the maximum capacity to respondents.The full potential maximum correct answers did not reach any of the respondents. If the respondent does not know the answer to a particular job, it can be omitted to waste my allotted time.

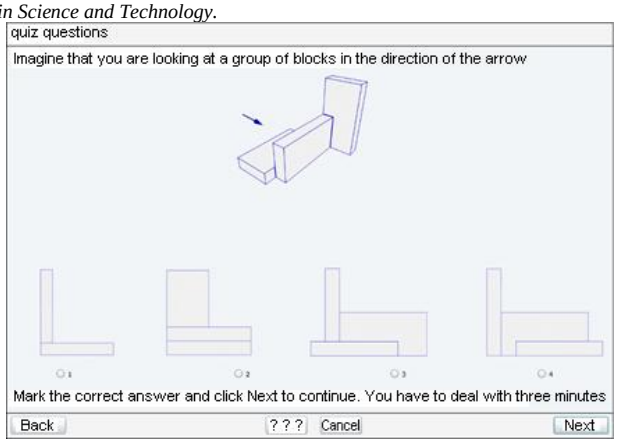

Fig. 3Sample working environment testing web applications (job training)

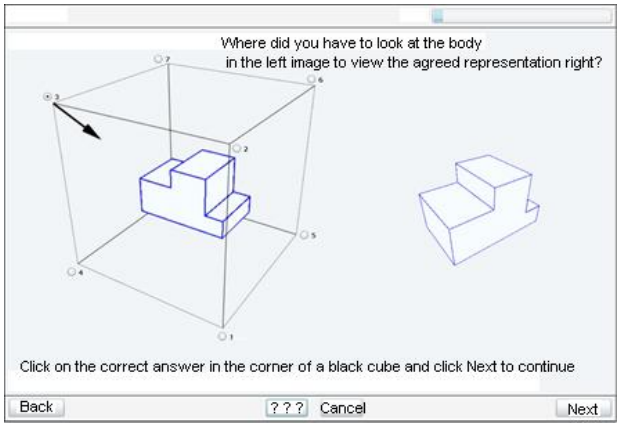

Fig. 4 Sample working environment testing web applications (job training)

When selecting such alternatives through the system of this fact always notified. Among the tasks the respondent can freely switch forward or backward. Selected respondent answers are instantly stored in the memory, when switching between tasks are no longer chosen responses currently displayed. When paging between tasks backwards thus not lost already selected answers. The collected data is sent to the server side at the moment of completion of the last job or after the time limit for implementing a response to the task in the third category. Based on the information detected by the respondent is always assigned to a given category. Selecting respondents from each category for subsequent processing of measured data is realized through a method for generating random numbers of a predetermined interval, which is available through the Microsoft .NET platform[7].

It would be impractical to install copies of the test system at each local station, so we decided to apply the technology through interactive web server system.

The level of visual-spatial intelligence of respondents is dependent of variable. It is assessed on the basis of the results online nonverbal test. Independent variables are the number of completed lessons of spatial modelling.

VIII. FORMULATION OF HYPOTHESES FOR QUANTITATIVE RESEARCH

Based on the research questions we formulate hypotheses qualitative research with a view to allow the verification of relevant research and statistical methods.

H_1: Entry level of visual intelligence is among different groups of students the same.

H_2: Students who have extended their studies with work experience through spatial modelling system, reaching the same level of visual-spatial intelligence as students without experience

How to formulate hypotheses determines the method of treatment, respectively a way to prove or disprove the hypothesis. Hypothesis H_1 and H_2 formulates differences, therefore we use statistical methods to detect the significance of differences.

In terms of evaluation using statistical software should be formulated so null hypothesis. The content of the null hypothesis may be also claim that between two or more characteristics of the population there is no relationship (i.e. the relationship is zero). Mostly null hypothesis expresses the opposite view, but we want to prove

H_{01}The input level of visual intelligence is monitored by different groups of students varies.

H_{02}Students who have extended their studies with work experience through spatial modelling system, achieve the same close, the level of visual-spatial intelligence as a student with no experience.

Individual hypotheses can be divided into sub-sub-hypothesis tested by groups, sub-hypothesis are gradually formulated e.g.: input level of visual intelligence of students in teaching in 2012 is different than students in 2013 and so on.

Research subjects are current students of higher technical studies and science teaching and non-teaching Faculty of Educationand the Faculty of Science, University of Hradec Kralovein Czech Republic.

IX. EVALUATION OF RESEARCH

In the first part of the research is to compare groups of respondents who begin teaching at each grade level. The following text is given a brief abstract (report) statistical evaluation. Gradually we test the null hypothesis. The test is always presented at the beginning of study, observe the input level of spatial intelligence before beginning training. Application software is NCSS 10. For the evaluation of hypotheses is used t-test. Principle t-test assumes a normal distribution, which in turn will check for each pair of groups:

Example: Analysis of results 2012 -2013:

Verification of normality: the two files (the results of the initial test 2012, 2013) have a normal distribution:

Tests of Assumptions

Assumption	Value	Prob Lev.	Decision (α = 0,050)
Skewness Normality (start_2012)	0,5513	0,581435	Cannot reject normality)
Kurtosis Normality (start_2-012)	0,5563	0,578033	Cannot reject normality
Omnibus Normality (start_2012)	0,6133	0,735892	Cannot reject normality
Skewness Normality (start_2013)	0,4053	0,685255	Cannot reject normality
Kurtosis Normality (start_2013)	0,2366	0,812972	Cannot reject normality
Omnibus Normality (start_2013)	0,2202	0,895724	Cannot reject normality

Reject the null hypothesis, the results of initial tests of 2012 – 2013 (start files) is not statistically significant.

Eqdal.Variance T-Test
μ1 - μ2 (start_2012) - (start_2013)

Alternatíve Hypothesís	Mean Difference	Standard Error of Difference
μ1 - μ2 ≠ 0	-0.1904762	1,931779

T-Statistic ´-0,0986
Prob Level: 0,00001Reject H_O at α = 0,050: Yes

Aspin-Welch Uriequal-Variance T-Test
μ1 - μ2 (úvod_2012) - (úvod_2013)

Alternatíve Hypothesis	Mean Difference	Standard Error of Difference
μ1 - μ2 ≠ 0	-0,1904762	1,933013

T-Statistic = 0,0983
Prob Level: 0,00001Reject H_O at α = 0,050: Yes

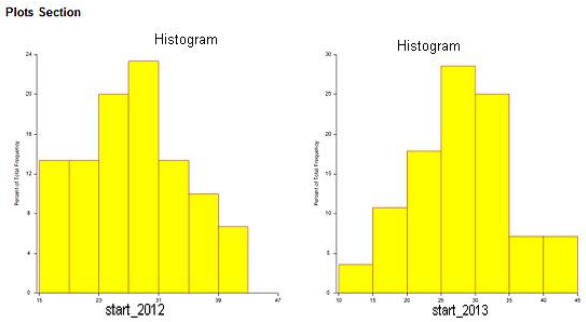

Fig. 5Histograms groups at the beginning of the study (comparison 2012-2013)

Identical results were obtained for the other groups. The results of entrance tests of spatial intelligence in 2012, 2013 and 2014 wereanalyzed as identical. A complete list of the analysis is too large and there is a not fully listed.

Another part of the research is to compare the results of the groups at the beginning and end of the study (after 1st semester):

Equal-Variance T-Test μ1 - μ2:
(start_2012) - (semester_1_2012)

Alternative Hypothesis	Mean Difference	Standard Error of Difference
μ1 - μ2 ≠ 0	-9.666667	2,02806

T-Statistic = -4,7665d.f. = 58
Prob Level: 0,00001 Reject H_O at α = 0,050: Yes

Aspin-Welch Unequal-Variance T-Test μ1 - μ2:
(start_2012) - (semestr_1_2012)

Alternative Hypothesis	Mean Difference	Standard Error of Difference
μ1 - μ2 ≠ 0	-9,666667	2,02806

T-Statistic = -4,7665d.f. = 55.73
Prob. Level = 0,00001Reject H_O at α = 0,050: Yes

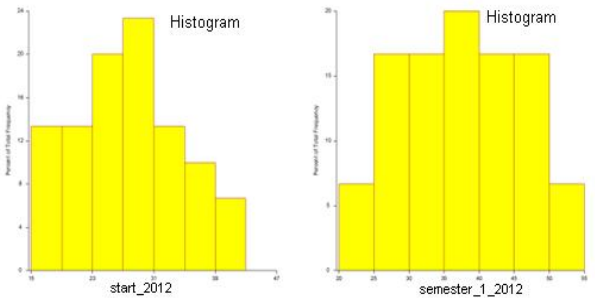

Fig. 6Histograms of files of results 2012 (before training and after training)

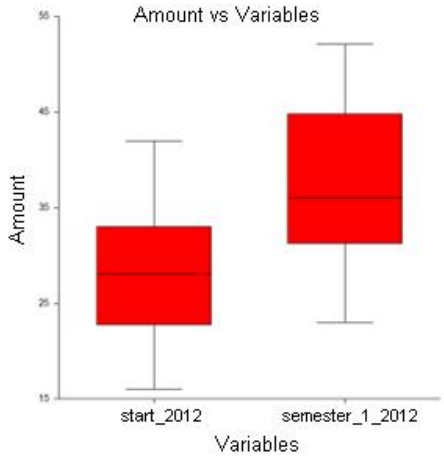

Fig. 7Histograms of files of results 2012 (before training and after training)

Analysis brings reject the null hypothesis - level results after one semester is not the same as at the beginning of instruction.

X. CONCLUSIONS

Development of views on human intelligence is also developing methods for its measurement. Original objective methods of measuring intelligence were, among other things differentiation in teaching school children. Part of the school population with poorer test is theoretically possible to allocate to specific groups, or they can work using different methodologies. On the other hand, methods and pace of learning can be tailored to individuals with above-average intelligence and thus enable them to develop targeted.

Certain classification of the population according to intelligence tests also raises controversial opinions, e.g. a negative impact on motivation and self-esteem thus defined by students and pupils.

Spatial intelligence is the basis for visual perception, which allows to transform and modify the visual perceptions to create a visual experience and ideas, even though it does not cause any external stimuli. Spatial intelligence is therefore to be understood as a set of loosely related skills. Spatial intelligence, as well as the ability to identify similar or identical shapes transform the various forms and recognize that some sort of transformation occurred.

Based on the evaluation of the research work we can clearly say that the teaching of parametric modelling applied in computer graphics leads not only to knowledge of skills specific to this specialized field, but a demonstrable and measurable improvements in students' abilities in spatial intelligence.

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