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CONTENT

RADIOCARBON VARIATIONS IN THE BIOSPHERE AND CLIMATE CHANGE
P. P. Povinec 1
CALCIUM CHANNELS IN HEALTH AND DISEASE
Ľ. Lacinova 7
DATA ANALYSIS IN HIGH ENERGY PHYSICS
M. Vala 13
TIME TRAVELLING AND PARALLEL UNIVERSES
R. Pinčák 19
SCALING BEHAVIOR IN NON-EQUILIBRIUM PHYSICAL SYSTEMS
L. Ts. Adzhemyan, M. Hnatič, J. Honkonen, E. V. Ivanova, M. V. Kompaniets, T. Lučivjanský, L. Mižišin 27
ELECTRON CAPTURE - WAY TO STRUCTURE OF TRANSFERMIUM ISOTOPES
A. Broniš 33
THE RELATIVISTIC MEAN-FIELD MODEL AND NEUTRON DRIP LINE
J. Leja, Š. Gmuca 35
$La_{0.80}Ag_{0.15}MnO_3$ MAGNETIC NANOPARTICLES FOR SELF-CONTROLLED MAGNETIC FLUID HYPERTHERMIA
M. Kovalik, Mar. Mihalik, M. Zentková, Mat. Mihalik, M. Kubovčíková, Z. L. Bujňáková, J. Briančin, M. Vavra, V. Girman, M. Lisnichuk, M. Perovic, M. Boškovic, M. Fitta, R. Pelka 37
DETERMINATION OF THE BANDGAP DEFECT STATES NATURE IN PHOTOVOLTAICS MATERIALS FROM THE COMPONENTS OF THE COMPLEX IMPEDANCE
K. Gmucová, V. Nádaždy, K. Végsö 39
FAST DATA COLLECTION USING MICROCONTROLLERS
S. Iľkovič 41
NEW RARE EARTH FREE PERMANENT MAGNETS IN CoFeTa SYSTEM
S. Arapan, P. Nieves Cordones, J. Šebesta, A. Džubinská, M. Reiffers, M. Fabián, D. Legut, K. Arun 43
DIELECTRIC AND THERMAL PROPERTIES OF NANOFLUIDS WITH FULLERENE AND MAGNETIC NANOPARTICLES
M. Rajňák, K. Paulovičová, M. Timko, P. Kopčanský, J. Kurimský, B. Dolník, R. Cimbala, M. Franko 45
PHYSICAL PARAMETERS OF THE KELVIN MODEL AND TWO-MASS-SPRINGDAMPER MODEL
J. Kmec 47
HYDROGEN GAS SENSOR WITH CAPACITATOR-LIKE ARRANGEMENT AND NANOPOROUS TOP ELECTRODE
M. Patrnčiak, T. Plecenik, B. Grančič, P. Ďurina, T. Roch, L. Satrapinskyy 49
EVALUATION AND SCORING OF PROBLEM SOLUTIONS IN THE INTERNATIONAL YOUNG PHYSICISTS' TOURNAMENT
M. Kireš, K. Revická 51
STUDENTS´ RESULTS IN THE CRITICAL THINKING TEST AFTER DISTANCE EDUCATION
A. Kľučarová, V. Šebeň 53
APPLICATION OF OPEN SAGEMATH SOFTWARE IN PHYSICS EDUCATION AND RESEARCH
D. Borovsky, J. Hanc 55
ASTRONOMY AT THE CHILDREN'S UNIVERSITY

M. Csatáryová 57
INFLUENCE OF LONG-RANGE SPREADING ON SPECIFIC REACTION-DIFFUSION SYSTEMS
M. Hnatič, M. Kecer, T. Lučivjanský 59
EFFECT OF OXYGEN CONTENT ON PROPERTIES OF $La_{1-x}Ag_xMnO_3$
Mar. Mihalik, K. Csach, M. Kovalik, Mat. Mihalik, M. Zentková, M. Fitta 61
STUDY OF MAGNETIC NANOPARTICLES $CoFe_2O_4$ AS HEAT SOURCES IN MAGNETIC PARTICLE HYPERTHERMIA
Ľ. Nagy, A. Zeleňáková, P. Hrubovčák, N. Mielnik, J. Szucsová 63
INTERACTIVE METHODS IN TEACHING UNIVERSITY GENERAL PHYSICS COURSE
Z. Ješková, J. Hanč, D. Borovský 65
HOW WILL PHYSICS AT TECHNICAL UNIVERSITIES LOOK LIKE IN 2032?
P. Bokes, M. Vančo 67
PHYSICS EDUCATION AT THE FACULTY OF ELECTRICAL ENGINEERING AND INFORMATICS OF TECHNICAL UNIVERSITY OF KOŠICE OVER TWO DECADES
N. Šmídová, M. Kovaľaková 69
THE USE OF PHYSICS EXPERIMENT VIDEOS IN ONLINE LABORATORY PRACTICALS
Z. Gibová, J. Kecer, P. Duranka, M. Kovaľaková 71
LABORATORY MEASUREMENTS FOR BASIC PHYSICS COURSE
M. Janek 73
THERMOELECTRIC EFFECT USING A BLENDED LEARNING METHOD IN THE FUTURE CLASSROOM LAB
A. Juhásová, M. Kireš 75
EXPLORATION OF NUCLEAR EXCITED STATES BY SKYRME QRPA METHOD
A. Repko, V.O. Nesterenko, J. Kvasil 77
ANALYTICITY OF EM FFs WITH HADRON EM CURRENT TRANSFORMATIONS IN ISOSPIN SPACE REVEALED UNEXPECTED PREDICTIONS IN PARTICLE PHYSICS
A. Z. Dubničková, S. Dubnička 81
ALTERNATIVE EVALUATION OF THE CONTRIBUTION OF THE PROCESS $e^+e^- \rightarrow K^0K^{-0}$ TO THE MAGNETIC ANOMALY OF THE MUON
S. Dubnička, A. Z. Dubničková, L. Holka, A. Liptaj 83
CONFINED COVARIANT QUARK MODEL
S. Dubnička, A. Z. Dubničková, M.A. Ivanov, A. Liptaj 85
SEARCH FOR OSCILLATING STRUCTURE FOR CHARGED PION ELECTRO-MAGNETIC FORM FACTOR
E. Bartoš, S. Dubnička, A. Z. Dubničková 87
FINAL ELUCIDATION OF DAMPED OSCILLATING STRUCTURES IN EFFECTIVE NUCLEON EM FORM FACTORS
E. Bartoš, S. Dubnička, A. Z. Dubničková, L. Holka, A.Liptaj 89
ORIGIN OF EXTREME TWO-DIMENSIONALITY OBSERVED IN THE QUANTUM MAGNET $Cu(tn)Cl_2$
O. Vinnik, R. Tarasenko, E. Čižmar, L. Kotvytska, M. Orendač, A. Orendačova 91
INFLUENCE OF LARGE NANOCLUSTERS (~ 1 NM) ON LOW-TEMPERATURE THERMODYNAMICAL PROPERTIES OF As_XS_{100-X} GLASSY SYSTEM
P. Baloh, V. Tkáč, M. Orendáč, A. Feher, R. Holomb, V. Mitsa 93
THERMAL ENTANGLEMENT OF A GEOMETRICALLY FRUSTRATED SPIN-1 HEISENBERG DIAMOND CLUSTER
A. Ghannadan, K. Karl'ová, J. Strečka 95
FINDING SUITABLE MAGNETIC PROPERTIES OF MAGNETIC BEADS FOR MAGNETIC SEPARATION

M. Barutiak, A. Zeleňáková, P. Hrubovčák, Ľ. Nagy, J. Szucsová, E. Beňová, V. Zeleňák 97

MAGNETIC PROPERTIES OF IRON BASED COMPOSITE MATERIALS WITH MAGNETICALLY ACTIVE INSULATION OF PARTICLES
Z. Birčáková, P. Kollár, J. Füzér, M. Fáberová, R. Bureš, M. Strečková, J. Szabó 99

EXPERIMENTAL STUDY OF MAGNETIC PROPERTIES OF $S = ½$ TWODIMENSIONAL QUANTUM ANTIFERROMAGNET $Cu(en)(H_2O)_2SO_4$ ENCAPSULATED INSIDE SBA-15 MESOPOROUS SILICA MATRIX
P. Danylchenko, R. Tarasenko, E. Čižmár, V. Tkáč, V. Zeleňák, A. Orendáčová, M. Orendáč 101

ANALYSIS OF THE PROPERTIES OF THE COPPER-SUBSTITUTED ZEOLITIC IMIDAZOLATE FRAMEWORKS AND COMPARISON WITH THE DIAMAGNETIC STRUCTURE
L. Kotvytska, R. Tarasenko, R. Feyerherm, S. Gabáni, O. Lyutakov, O. Vinnik, M. Orendáč, A. Orendáčová 103

SELF-ORGANIZED STRUCTURES AND NANOSIZED LEVELS OF THEIR FORMATION IN THE NON-CRYSTALLINE MATERIALS As(Ge)-S(Se) SYSTEM INDUCED BY WHITE NOISE
M. Mar'yan, N. Yurkovych, V. Šeben 105

INFLUENCE OF NEW METHODE OF SURFACE TREATMENT OF FEROMAGNETIC POWDER ON THE COERCIVITY OF SOFT MAGNETIC COMPOSITE
T. Rudeichuk, R. Maciaszek, D. Olekšáková, P. Kollár 107

THE EFFECT OF EXTERNAL ELECTRIC FIELD ON THE QUANTUM AND THERMAL ENTANGLEMENT IN THE MIXED SPIN-(1/2,S) HEISENBERG DIMER
H. Vargová, J. Strečka, N. Tomašovičová 109

INVESTIGATION OF THE LATTICE HEAT CAPACITY OF METAL-ORGANIC POLYMERS WITH ETHYLENEDIAMINE
O. Vinnik, R. Tarasenko, L. Kotvytska, I. Potočňák, K. Zakuťanská, N. Tomašovičová, M. Orendáč, A. Orendáčová 111

HARMONICALLY TRAPPED BROWNIAN PARTICLES IN UNDERDAMPED AND OVERDAMPED REGIMES
V. Lisý, J. Tóthová 113

ENTANGLEMENT IN THE MIXED SPIN-(1/2,S) HEISENBERG DIMER
H. Vargová, J. Strečka 115

RELAXATION PROCESSES IN POLYMERS
J. Kudelčik 117

NONLINEAR RESPONSE OF PLANAR KINETIC RESONATOR COUPLED TO TRANSMISSION LINE RESONATOR
M. Baránek, P. Neilinger, D. Manca, M. Grajcar 119

INFLUENCE OF STORAGE ON THE STRUCTURE AND MOLECULAR MOBILITY IN THE THERMOPLASTIC STARCH-BASED NANOCOMPOSITES
L. Ondriš, M. Kovaľaková, I. Chodák, O. Fričová 121

RHEOLOGICAL EVALUATION OF THERMOSENSITIVE HYDROGELS AS IN SITU FORMING GELS FOR OROMUCOSAL USE
K. Paulovičová, J. Tóthová, S. Rohaľová, J. Gajdziok 123

CHANGES IN STRUCTURE AND MOLECULAR MOBILITY IN THERMOPLASTIC STARCH-BASED NANOCOMPOSITES CAUSED BY LONG TERM STORAGE
S. Saparová, O. Fričová, H. Peideyesh, M. Kovaľaková 125

RHEOLOGICAL STUDY OF THE POSSIBILITY TO LOWER THE VISCOSITY OF COMPLEX FLUIDS WITH DILUTED NANOPARTICLES

J. Tóthová, K. Paulovičová, V. Lisý 127
MEASUREMENT OF STRANGENESS IN THE ALICE EXPERIMENT AT LHC
K. Tropp, M. Bombara 129
MULTIPLICITY DISTRIBUTIONS OF RELATIVISTIC PARTICLES IN NUCLEAR COLLISIONS
V. Gomulcová, J. Vrláková, M. Vaľa, A.Kravčáková 131
DIFFUSION COEFFICIENT FOR COSMIC RAY MODULATION MODELS
V. Mykhailenko, P. Bobík 133
SIMULATION OF COSMIC RAYS INTERACTION WITH SIMPLE HUMAN EYE MODEL IN GEANT 4 PACKAGE
D. Švecová, P. Bobík, B. Pastirčák 135
DETERMINATION OF COLLISION PARAMETERS IN EMULSION DETECTOR
A. Kravčáková, J. Vrláková, M. Vaľa 137
EDUCATIONAL USE OF Jmol VISUALIZATION SOFTWARE IN BIOPHYSICS
S. Kotorová, J. Chlpík, J. Cirák 139
OPEN LABORATORY OF NUCLEAR PHYSICS
J. Vrláková, A. Kravčáková, V. Gomulcová, I. Štefančínová 141
INTRODUCING THE COURSE "PHYSICAL BASICS OF COMPUTER GAMES"
M. Konôpka, M. Zemanová Diešková, K. Sedlačková, P. Bokes 143
INTERACTION OF OSELTAMIVIR WITH LIPID BILAYER
A. Búcsi, A. Čelková, J. C. Martínez, D. Uhríková 145
EFFECT OF IONIC STRENGTH AND SURFACE CHARGE DENSITY ON THE DNA CONDENSATION
M. Chovancová, L. Hubčík, K. Babošová, D. Uhriková 147
NEW EARTHQUAKE CATALOGUE FOR THE TERRITORY OF SLOVAKIA
R. Kysel, M. Šugár, K. Csicsay, L. Fojtíková, A. Cipciar 149
THE SEISMIC HAZARD MAP FOR THE TERRITORY OF SLOVAKIA IN TERMS OF MACROSEISMIC INTENSITY
M. Šugár, R. Kysel, J. Kristek 151
CONVERGENT PERTURBATION THEORY FOR INVESTIGATION OF THE HIGH-TEMPERATURE SUPERCONDUCTING PHASE TRANSITIONS
M. Hnatič, M. Nalimov, A. Ovsiannikov 153

INTERACTIVE METHODS IN TEACHING UNIVERSITY GENERAL PHYSICS COURSE

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INTRODUCTION

Researches in the field of higher education show that traditional way of instruction based on lecture and problem-solving methods impart little conceptual understanding of physics concepts. A large body of studies has been conducted over more than 20 years showing that the implementation of interactive methods in university courses is more effective compared to the courses based on traditional lecture-based methods.

Interactive or interactive engagement methods (IE methods), see Hake [1], are those designed at least in part to promote conceptual understanding through interactive engagement of students in heads-on (always) and hands-on (usually) activities which yield immediate feedback through discussion with peers and/or instructors.

Examples of interactive methods successfully used at the university level include Peer Instruction [2], lectures with interactive demonstrations [3], Just-in-time learning [4], interactive engagement models, simulations and animations [5], flipped-learning methods [6] and many others. One of the first extensive research in this field was conducted by Hake [1] on a sample of 6500 students at universities, colleges, and high schools showed that the use of interactive engagement methods can increase mechanics-course effectiveness well beyond that obtained with traditional methods. Similar results were also confirmed later by other researchers all over the world [7 - 13].

In Slovakia, the traditional methods dominate at the university level. Based on positive research results we have adopted and implemented selected interactive methods into the first introductory physics course that students - future physicists and physics teachers enroll in after entering university. Research on evaluating the impact on students' conceptual understanding was conducted in order to show the effectiveness of the developed model of teaching and learning.

INTERACTIVE METHODS IN THE INTRODUCTORY PHYSICS COURSE

The first introductory physics course for future physicists and physics teachers at the Faculty of Science, Pavol Jozef Safarik University (UPJŠ) is designed in a structure of 4-hour lecture and 2-hour problem-solving classes per week [14]. In addition to these compulsory lessons students can select an optional extra 2-hour class. The course content includes Mechanics as the main part and also basics of molecular physics and thermodynamics. Keeping the original course structure, we selected and adapted suitable interactive methods.

Within a lecture, interactive lecture demonstrations (ILD) are regularly conducted. Demonstrations follow a procedure designed by Thornton and Sokoloff [3]. They involve simple conceptual experiments in which students are asked for predictions while engaged in group discussion and their predictions are followed by a real demonstration to compare with their prior knowledge.

During the lecture, the teacher engages students by posing prepared conceptual questions, usually in the form of multiple-choice questions. In this case, the procedure of the Peer instruction method is followed [2] when students are expected first to answer individually, then they discuss the problem with their peers and select the answer using the online voting tool. This way teacher and also students get immediate feedback about their level of understanding. In case of a low gained score teacher can immediately return back to the identified misconception and discuss the concept again.

The original structure of problem-solving classes is enhanced by implementing more interactive student-centred activities. Students solve more realistic problems by applying the physical principles that they have learned. When solving problems, they use computer-based tools for data collection, mathematical modelling, data analysis, and interpretation.

Above this, students in groups work on a long-term project. The project assignment is formulated by the teacher and it is more complex compared to the activities that students conduct in regular classes. At the end students present and comment on the results in front of the class. The whole introductory physics course has online support of an LMS Moodle e-learning platform.

RESEARCH ON THE INSTRUCTION EFFECTIVENESS

We have been implemented the designed model of teaching and learning [14] for more than 10 years (2012-2022). In this research we are looking for an answer to the research question: *Is the introductory physics course effective with regard to conceptual understanding of mechanics*? In order to answer this question and evaluate the level of conceptual understanding, Force concept inventory (FCI) test was used as the primary research instrument [1]. Its Slovak version was regularly administrated before and after the course.

FCI is the well-known standardized test of students' conceptual understanding of basic concepts of Newtonian mechanics and one of the most reliable and useful physics tests available for introductory physics teachers. The instruction quality and effectiveness of the teaching method for the whole course in a given academic year can be described very well by a statistical quantity called average normalized gain $\langle g \rangle$. The quantity $\langle g \rangle$, see the definition in [1], can have values from -1 to 1. The higher positive (negative) $\langle g \rangle$ is achieved in FCI, the higher increase (decrease) in conceptual understanding is gained by students.

The research sample described in Tab. 1. involves 1st year students – future physicists and physics teachers

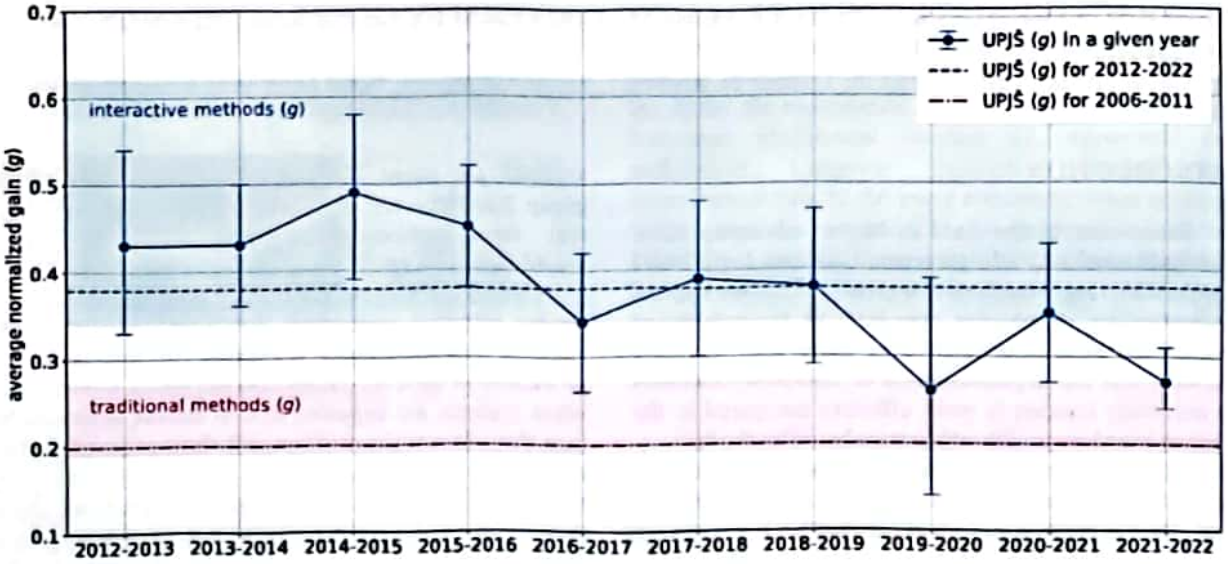

Fig. 1. Graphical summary of average normalized gain $\langle g \rangle$ during academic years at UPJŠ

($N = 231$) who have been tested regularly at UPJŠ since 2006 before and after completing the course. Our main research results can be visualized graphically in Fig.1.

TAB. 1. Research sample

Methods	study program	N
traditional (2006-2011)	physics	45
	physics teacher	53
interactive (2012-2022)	physics	77
	physics teacher	56
All students		**231**

CONCLUSIONS

The results demonstrate that our interactive instruction is nearly twice as effective as previous traditional instruction. At the same time, our results are consistent with generally accepted expected values in applying teaching methods [1] - the blue band for interactive and the red for traditional ones. However, the decreasing trend during the last 5 years requires special attention, which we explain during our oral presentation.

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