



P. J. ŠAFÁRIK UNIVERSITY
FACULTY OF SCIENCE
INSTITUTE OF PHYSICS
Park Angelinum 9, 040 01 Košice, Slovakia
www.science.upjs.sk



Jozef Hanč

***Application of the Flipped Classroom Model in
science and Math Education in Slovakia***

Paper

Proceedings of the 10th International Conference on Hands-on Science,
HSCI2013
(1st – 5th July 2013, Košice, Slovakia)

<https://upjs.academia.edu/JozefHanc>
jozef.hanc@upjs.sk

How to cite:

Hanč, J. (2013). *Application of the flipped classroom model in science and math education in Slovakia*. In HSCI 2013: Proceedings of the 10th International conference on Hands-on Science (1st-5th July 2013, Košice), pp. 229–234. Košice, Slovakia: P.J. Šafárik University.

HSCI2013

Proceedings of the
10th International Conference on

Hands-on Science

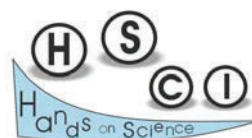
Educating for Science and through Science

1st-5th July 2013

Pavol Jozef Šafárik University
Košice, Slovakia



The Hands-on Science Network



HSCI2013
Proceedings of the
10th International Conference on Hands-on Science
Educating for Science and through Science
1st-5th July 2013
Pavol Jozef Šafárik University, Košice, Slovakia
ISBN 978-989-98032-2-0
Online available on <http://www.hsci.info>

Chair:

Manuel Filipe Pereira da Cunha Martins Costa (Portugal)

Chair of Local Organizing Committee:

Marián Kireš (Slovakia)

International Advisory Committee:

Abhay Kothari (India)	Maria Inês Nogueira (Brazil)
Amit Garg (India)	Maria Odete Valente (Portugal)
Ann Torsted (Danmark)	Marian Kires (Slovakia)
António Carlos Pavão (Brazil)	Marisa Michelini (Italy)
Armando Dias Tavares Jr. (Brazil)	Maria Teresa Malheiro (Portugal)
Clementina Timus (Romania)	Mario Belloni, (USA)
Daniel Gil Pérez (Spain)	Maxim Tomilin (Russia)
George Kalkanis (Greece)	Mehmet Erdogan (Turkey)
Erik Johansson (Sweden)	Mikiya Muramatsu, (Brasil)
Eva Trnova (Czech Republic)	Mourad Zghal (Tunisia)
Fernando Ribeiro (Portugal)	Mustafa Erol (Turkey)
Francisco Sousa (Portugal)	Nilgün Erentay (Turkey)
Francisco Esquembre (Spain)	Panagiotis Michaelides (Greece)
Hai-Ning Cui (China)	Paulo Idalino Balça Varela (Portugal)
Horst Bannwarth (Germany)	Pedro Membiela Iglesias (Spain)
Iryna Berezovska, (Ukraine)	Radu Chisleag (Romania)
Jesus Blanco (Spain)	Roger Ferlet (France)
Joaquim Carneiro (Portugal)	Sasa Divjak (Slovenia)
Jose Benito Vazquez-Dorrio (Spain)	Sonia Seixas (Portugal)
Joseph Trna (Czech Republic)	Suzanne Gatt (Malta)
Maria de Jesus Gomes (Portugal)	Walburga Bannwarth-Pabst (Germany)

Local Organizing Committee:

Dušan Šveda	L'udmila Onderová
Zuzana Ješková	Ján Guniš
Katarína Kimáková	Slávka Blichová
Mária Ganajová	Radoslav Kalakay
Stanislav Lukáč	Rastislav Adámek
Lubomír Šnajder	Stela Csachová
Jozef Hanč	Josef Dobos

HSCI2013
Proceedings of the
10th International Conference on Hands-on Science
Educating for Science and through Science
1st-5th July 2013
Pavol Jozef Šafárik University, Košice, Slovakia
ISBN 978-989-98032-2-0
Online available on <http://www.hsci.info>

Edited by

Manuel Filipe Pereira da Cunha Martins Costa, University of Minho, Portugal

José Benito Vázquez Dorrío, University of Vigo, Spain

Marián Kireš, Pavol Jozef Šafárik University, Košice, Slovakia



Universidade do Minho
Escola de Ciências

Universidade de Vigo

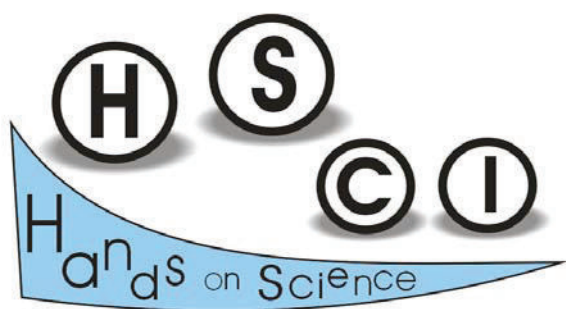


Pavol Jozef Šafárik University in Košice
Faculty of Science



The Hands-on Science Network





Copyright © 2013 H-Sci

ISBN 978-989-98032-2-0

Printed by: Equilibria, s.r.o., Košice, Slovakia

Number of copies: 180

First printing: July 2013

Distributed worldwide by *The Hands-on Science Network* - contact@hsci.info

Full text available online at <http://www.hsci.info>

The papers published in this book compose the Proceedings of the 10th International Conference on Hands-on Science. Papers were selected by the Conference Committees to be presented in oral or poster format, and were subject to review by the editors and program committee. They are exclusive responsibility of the authors and are published herein as submitted, in interest of timely dissemination.

Please use the following format to cite material from this book:

Author(s). Title of Paper. Proceedings of the 10th International Conference on Hands-on Science. Costa MF, Dorrio BV, Kireš M (Eds.); 2013, 1-5 July; Pavol Jozef Šafárik University, Košice, Slovakia. 2013. Page numbers.

The authors of this book, the Hands-on Science Network, the organizers and the sponsors of the HSCI2013 Conference, none of them, accept any responsibility for any use of the information contained in this book.

All rights reserved.

Permission to use is granted if appropriate reference to this source is made, the use is for educational purposes and no fees or other income is charged.

FOREWORD

INQUIRY BASED SCIENCE EDUCATION	1
THE USE OF ICT IN THE FRAMEWORK OF INQUIRY BASED SCIENCE EDUCATION (IBSE)	
Ton Ellermeijer	3
THE PHYSICS OF THE DRIVEN SPINNING TOP	
Ioan Grosu	7
GAMES, GAMES AND GAMES	
Asli Tasci, Ebru Aghasi	9
IPPOG - BRINGING PARTICLE PHYSICS INTO CLASSROOMS	
Ivan Melo	10
CONNECTING CLASSROOMS TO THE MILKY WAY	
Roger Ferler	15
THE CITY BRIDGES PROJECT: CONNECTING PEOPLE, MERGING SCIENCES	
Alexander Kazachkov, Marián Kireš, Abraham Salinas Castellanos	17
TEACHING RENEWABLE ENERGY SOURCES BY INQUIRED BASED METHODS	
Elena Vladescu	20
TEACHING MATHEMATICS THROUGH IBSE METHODS	
Lucian Constantin Vladescu	24
INQUIRY BASED SCIENCE EDUCATION – APPLICATION IN CHEMISTRY	
Hana Čtrnáctová, Monika Petriláková, Veronika Zámečnicková	27
HANDS-ON SCIENCE COURSE FOR UPPER PRIMARY AND LOWER SECONDARY SCHOOLS IN POLAND – A CHALLENGE FOR USING IBSE METHODOLOGY IN DEVELOPING PRACTICAL AND EXPLORING SKILLS	
Bożena Karawajczyk, Marek Kwiatkowski	32
BELIEFS OF TEACHERS OF MATHEMATICS ABOUT TEACHING IN A CONSTRUCTIVIST WAY	
Veronika Hubeňáková, Dušan Šveda	36
CYBERNETICS FROM THE POINT OF VIEW OF THE HANDS-ON PRINCIPLE	
Max Igor Bazovsky	41
SUMMER CAMPS SCHOLA LUDUS: EXPERIMENTÁREŇ	
Viera Haverlíková	46
KNOWLEDGE THROUGH SCIENCE AND ART	
Stefureac Crina	49
A STUDY OF ELEMENTARY STUDENTS' MODELING ABILITY AND LEARNING TRANSFER	
Jen-Chin Lin, Chien-Liang Lin, Fu Yi Shieh	62
EXPERIENCE WITH THE IMPLEMENTATION OF INQUIRY-BASED ACTIVITIES ENHANCED BY DIGITAL TECHNOLOGIES AT ONE OF THE SLOVAK GRAMMAR SCHOOLS	
Veronika Timková, Zuzana Ješková, Mária Horváthová	67
STUDYING SCIENCE WITH MILK CANDY MAKING	
William Stebníki Tabora	73
HOW ATMOSPHERIC PRESSURE CAN LIFT AN ADULT- HANDS-ON EXPERIMENTS BY USING SYRINGE-SYSTEM	
C. H. Chou, M. S. Yang	79
INVESTIGATING PROPERTIES OF LIGHT IN THE FRAME OF LOWER AND UPPER SECONDARY EDUCATION	
Martin Hruška, Stanislav Holec, Jana Raganová	83
SCHOOL PHYSICS EXPERIMENTS FROM THE FIELD OF NUCLEAR PHYSICS	
Peter Zilavy	87
CREATIVITY AND MOTIVATION IN PHYSICS EDUCATION	
Marcela Chovancová	92
HOME EXPERIMENTS OF PUPILS AND STUDENTS - A WAY TO INCREASE THE INTEREST OF YOUNG PEOPLE IN PHYSICS, ENGINEERING AND SCIENCE	
I. Baník, M. Chovancová, G. Pavlendová	96
IMPLICATIONS FOR INSTRUCTION IN INCLINED PLANE HANDS-ON EXPERIMENT	
Yun-Ju Chiu, Feng-Yi Chen	102

CLASSIFICATION AND MEASUREMENT AS A TOOL FOR INQUIRY-BASED APPROACH IN SCIENCE EDUCATION	
Mária Orolínová	106
LEARNING MATERIALS SCIENCE AND TECHNOLOGY FROM HANDS-ON ACTIVITIES	
Carmen. Pérez, Antonio Collazo, Benito.V. Dorrió	110
INVESTIGATE THE SHADOWS OF OBJECTS: A PEDAGOGICAL INTERVENTION PROJECT WITH PRIMARY SCHOOL CHILDREN	
Silvana Novera, Cátia Abreu, Paulo Varela, Manuel Filipe Costa	115
ANALYSIS OF THE PROCESS OF EXPLORING A PHYSICS ACTIVITY WITH PRE-SCHOOL CHILDREN: THE BALLOON ROCKET	
Paulo Varela Rita Pereira, Cristina Silva, Marta Fernandes, Manuel Filipe Costa	121
REGULATION OF GENE EXPRESSION – USING GENE REPORTERS LACZ AND MCHERRY TO ASSESS THE RESPONSE OF THE LACTOSE OPERON PROMOTER TO CATABOLITE REPRESSION AND POSITIVE INDUCTION	
Catia Soares, Sofia Camarinha, Susana Pereira	126
EXPERIENCE IN USING INQUIRY-BASED METHOD IN CHEMISTRY TEACHING	
Mária Ganajová, Milena Kristofová	131
PROJECT ESTABLISH - CHEMISTRY AND BIOLOGY	
Věra Čížková, Hana Čtrnáctová, Mária Ganajová, Katarína Kimáková, Petr Šmejkal	135
PHENOMENOLOGY IN SCIENCE EDUCATION	
F. Caglin Akillioglu	141
A VIEW OF PROBLEMATIC OF FISHERIES AND AQUACULTURE IN EUROPE	
Sonia Borges Seixas	142
OVERVIEW OF THE IMPACT OF IBSE TRAINING COURSES ON LEARNING STEM IN PRIMARY AND SECONDARY SCHOOLS	
Luminita Florentina Chicinas, Nicolae Micescu	142
SCIENCE ON STAGE EUROPE	
David Featonby	143
SCIENCE WITH SENSORS IN PRIMARY SCHOOLS	
Ewa Kedzierska, Ton Ellermeijer	143
EXPLORING MARINE ECOSYSTEMS WITH ELEMENTARY STUDENTS: A SUCCESSFUL JOURNEY	
Cláudia Faria, Raquel Gaspar, Cátia Santos	143
INQUIRY-BASED LEARNING FOCUSED ON WATER FREEZING	
Marek Balážovič, Boris Tomášik	144
ALTERNATIVE PUPIL'S CONCEPTIONS ABOUT PHOTOSYNTHESIS AND PLANT RESPIRATION BY PUPILS OF 6TH GRADE OF LOWER SECONDARY SCHOOL	
Katerina Svandova	144
SCIENTIFIC RESEARCH PROJECTS IN VOCATIONAL TRAINING SCHOOLS	
Zita Esteves, Manuel F. M. Costa	145
POPULARIZATION OF SCIENCE IN SOCIETY	147
A SCIENCE ACTIVITY GUIDED BY CHILDREN AT PRE-SCHOOL LEVEL: FROM A STRING TO A PENDULUM	
Maria de Fátima Sá Machado, Marta Marques, Paulo Machado, Manuel F. M. Costa, Mário Almeida	149
PHYSICS OUTREACH AT THE UNIVERSITY OF RZESZOW	
Malgorzata Pociask-Bialy, Iryna Berezovska, Krzysztof Golec-Biernat	154
CORRESPONDENCE MATHEMATICAL SEMINARS AS A FORM OF INCREASING OF KNOWLEDGE POTENTIAL	
Róbert Hajduk	158
ONE EXAMPLE ON COMBINATORICS	
František Mošna	162
INITIATING THE SCIENTIFIC METHOD, INITIATING YOUNG RESEARCHERS	
Josep M. Fernández-Novell, Carme Zaragoza Domènech	164
PRACTICAL ACTIVITIES ON CHEMISTRY FOR YOUNG STUDENTS	
Josep M. Fernández-Novell, Carme Zaragoza Domènech	169

MASTERCLASSES AND INFORMAL EDUCATION IN SLOVAKIA Júlia Hlaváčová, Marek Bombara, Alexander Dirner, Mikuláš Gintner, Ivan Melo, Boris Tomášik, Pavol Bartoš, František Franko	175
10 TH INTERNATIONAL CONFERENCE ON HANDS-ON SCIENCE 1 - 5 JULY 2013 KOŠICE, SLOVAKIA SPIE Scholarship; benefits and responsibility Clementina Timus	181
THE ROLE OF INQUIRY SCIENCE LAB WITHIN SCIENCE CENTRE Marián Kireš, Mária Nováková	185
NABOJ - INTERNATIONAL MATHEMATICAL COMPETITION FOR HIGH SCHOOL STUDENTS Róbert Hajduk	188
AN ANNUAL HANDS-ON SCIENCE COMPETITION Salvador Rodríguez, Raquel Vergara, Benito V. Dorrio	190
DEVELOPMENT OF POSITIVE ATTITUDES TOWARDS SCIENCE AT THE CHILDREN SUMMER CAMP Jana Raganová, Martin Hruška, Mária Beniačíková, Katarína Krišková	193
POPULARISATION OF CHEMISTRY AMONG THE INHABITANTS OF GDAŃSK REGION Malgorzata Czaja, Bożena Karawajczyk, Marek Kwiatkowski	198
STATISTICAL ANALYSIS ON THREE HANDS-ON SCIENCE NATIONAL SCIENCE FAIRS IN PORTUGAL Zita Esteves, Manuel F. M. Costa	200
A COUPLE OF PHYSICS TEACHING IDEAS Ludmila Onderová, Jozef Ondera	205
“KATTAN SCIENCE SNACKS”: SMALL EDUCATIONAL SCIENCE EXPERIMENTS TO POPULARIZE SCIENCE AMONG THE PALESTINIAN SOCIETY Bisan KM Battrawi	210
BRINGING BACK OLD PHYSICS & CHEMISTRY INSTRUMENTS TO LIFE: FROM SECONDARY SCHOOLS TO THE GENERAL PUBLIC João Oliveira, Isabel Malaquias	211
FIGHTING SCIENTIFIC ILLITERACY IN PORTUGAL FROM MID XVIII CENTURY TO MID XX CENTURY: A FEW MEANINGFUL ATTEMPTS TO SPREAD SCIENTIFIC KNOWLEDGE OUTSIDE THE PUBLIC SCHOOL Maria Teresa S.R. Gomes, João A.B.P. Oliveira	212
THE PUBLIC COMMUNICATION OF SCIENCE IN GRADUATE PROGRAMS IN PUBLIC HEALTH IN BRAZIL: A PERSPECTIVE OF COORDINATORS Carlos Antonio Teixeira, Paulo Rogério Gallo	212
INQUIRY ACTIVITIES IN STEEL PARK Mária Nováková, Marián Kireš	213
ENGAGING PARENTS INVOLVED IN THEIR CHILDREN'S LEARNING THROUGH HANDS-ON SCIENCE ACTIVITIES Yi-Ting Cheng, Huey-Por Chang, Wen-Yu Chang	213
BIOCIENTISTAS DE PALMO E MEIO - HANDS-ON SCIENCE FOR PRE-SCHOOLERS AT THE DEPARTMENT OF BIOLOGY OF UNIVERSITY OF MINHO Cristina Almeida Aguiar, Maria Judite Almeida, Maria Teresa Almeida, Andreia Gomes, Sandra Paiva	214
PRE-SERVICE AND IN-SERVICE SCIENCE TEACHER TRAINING	215
SCIENCE TEACHER TRAINING AT THE DEPARTMENT OF PHYSICS EDUCATION, MFF UK IN PRAGUE Dana Mandíková, Jitka Houfková, Zdeněk Drozd	217
DRAMA-MANTLE OF THE EXPERT : CREATING CONTEXTS FOR TEACHING INTEGRATIVE INQUIRY BASED ELEMENTARY SCIENCE Samar Darwish Kirresh	221
APPLICATION OF THE FLIPPED CLASSROOM MODEL IN SCIENCE AND MATH EDUCATION IN SLOVAKIA Jozef Hanč	229
MOLECULAR BIOLOGY AND GENETICS - ONE OF THE OVERLOOKED THEMES IN HIGH SCHOOL PRACTICAL BIOLOGY COURSES IN CZECH REPUBLIC Vanda Janštová, Lukáš Falteisek	235

THE ROLES OF CARTOONS AND COMICS IN SCIENCE EDUCATION Eva Trnova, Josef Trna, Vaclav Vacek	240
THE ROLES OF DEMONSTRATION EXPERIMENTS IN SCIENCE EDUCATION Eva Trnova, Josef Trna, Petr Novak	244
SCIENCE TOYS AND INTERACTIVE EXHIBITS IN CHEMISTRY TEACHERS' EDUCATION Ján Reguli	250
TEACHER PREPARATION FOR INQUIRY BASED BIOLOGY EDUCATION AT P. J. ŠAFÁRIK UNIVERSITY Katarína Kimáková, Andrea Lešková	254
A BIOINORGANIC/COORDINATION CHEMISTRY INTEGRATIVE EXPERIMENTAL APPROACH: REVERSIBILITY OF THE ACID HYDROLYSIS OF A CR-S BOND Teresa M. Santos, Júlio Pedrosa de Jesus	258
BIOCHAR HANDS-ON EDUCATION Tomáš Milér, Jan Hollan, Jindřiška Svobodová	263
FACTORS INFLUENCING ATTITUDE TOWARDS DISSECTIONS IN SCHOOLS Jana Fančovičová, Andrea Lešková	267
IN-SERVICE TEACHER TRAINING IN IBSE IN SLOVAKIA AND ITS IMPACT ON TEACHERS AND STUDENTS IN THE FRAMEWORK OF THE ESTABLISH PROJECT Zuzana Ješková, Katarína Kimáková, Mária Ganajová, Marián Kireš	272
A STUDY OF THE INFLUENCE OF SCIENCE MAGIC INSTRUCTIONS ON PRE-SERVICE SCIENCE TEACHERS' SCIENTIFIC LEARNING MOTIVATION AND CONCEPT APPLICATION Fu-Yi Shieh, Jen-Chin Lin	276
CREATIVE HANDS-ON ACTIVITIES WITH WATER, PAPER AND WIRE Alexander Kazachkov	281
FORENSIC – BIOLOGY WORKSHOP Tomáš Pinkr, Vanda Janštová, Jan Černý	284
PREPARING TEACHERS FOR THE USE OF ICT IN THE FRAMEWORK OF INQUIRY BASED SCIENCE EDUCATION (IBSE) – THE ESTABLISH APPROACH Ewa Kedzierska, Zuzana Ješková, Trinh Ba Tran, Ton Ellermeyer, Marián Kireš	290
LEARNING SCIENCE PROCESS SKILLS VIA CPD DESIGN MODULE Katarina Kotulakova	298
INTEREST IN THE SCIENCE – THE BREAKPOINT Juraj Slabeycius, Peter Hanisko, Daniel Polčín	303
THE TEACHER OF CHEMISTRY AND THE CREATION OF TEST ITEMS Tereza Kudrnová, Renata Šulcová	307
INNOVATION IN STATE CURRICULUM AND TEACHING NATURAL SCIENCES IN LOWER SECONDARY EDUCATION IN SLOVAKIA Mária Siváková, Peter Kelecsényi, Mariana Páleníková	312
BLENDED LEARNING FOR SCIENTIFIC INQUIRY: RESEARCH EVIDENCE FROM A US CLASSROOM Eva Erdosne Toth	318
PRESERVICE SCIENCE TEACHERS PERCEPTIONS ABOUT USING SCIENCE NOTEBOOKS: A COMPARATIVE INVESTIGATION OF UNITED STATES AND TURKEY SAMPLE İlke Çalıřkan	319
PRESERVICE SCIENCE TEACHERS EXPERIENCES WITH THE IMPLEMENTATION OF PROJECT BASED LEARNING Dogan Dogan, Eylem Eroglu Dogan	320
IMPROVING THE SCIENTIFIC PROCESS SKILLS OF ELEMANTARY PROSPECTIVE TEACHERS THROUGH HANDS ON SCIENCE PRACTICE: AN ACTION RESEARCH STUDY Necati Hirça, Mücahit Köse, Muhammet Usak	320
AN EXAMPLE OF INTERDISCIPLINARITY: PHYSICS, CHEMISTRY AND MATHEMATICS MERGE WITH BIOLOGY AND GEOLOGY IN AN URBAN FIELD TRIP Lídia Guimarães, A. Mário Almeida, Ricardo Rodrigues dos Santos, Manuel F. Costa	321

IS IT NECESSARY A FORCE FOR AN OBJECT TO MOVE?	322
Alcina Rito, Rui Vila-Chã, A. Mário Almeida, Manuel F. Costa	
EXPERIMENTS IN SCIENCE AT PRIMARY SCHOOL	322
Jitka Houfková, Dana Mandíková, Zdeněk Drozd	
WHAT HAPPENS NEXT?	323
David Featonby	
SECRET LIFE IN AN AQUARIUM FILTER	323
Jan Mourek, Barbora Talavášková	
DIGITAL TECHNOLOGIES IN EDUCATION	325
THE CARTOON GUIDE TO RELATIVITY	327
Jan Novotný, Jindřiška Svobodová	
ASSESSING THE ROLE OF SOCIAL NETWORKS IN INCREASING INTEREST IN SCIENCE AND SCIENCE LITERACY AMONG A SAMPLE OF FACEBOOK USERS	330
Bisan Battrawi, Rami Muhtaseb	
INVESTIGATION OF SEQUENCES USING DIGITAL COGNITIVE TECHNOLOGIES	338
Stanislav Lukáč, Jozef Sekerák	
VIDEO RECORDINGS OF SCHOOL PHYSICAL EXPERIMENT	343
František Látal, Zdeněk Pucholt	
AFFORDABLE TECHNOLOGY FOR EDUCATION IN PALESTINE	347
Hamzeh S. Kirresh	
HANDS-ON EXPERIMENTS AND ELEMENTS OF MODERN SCIENCE IN COURSE OF SCHOOL PHYSICS	351
Denis Artemenkov, Victoria Belaga, Ivan Lomachenkov, Yury Panebrattsev, Natalia Vorontsova, Vladislav Zhumaev	
WEB-DEVELOPER S TOOLKIT: TEACHING WEB-DEVELOPMENT AT TERNOPIL NATIONAL TECHNICAL UNIVERSITY	352
Iryna Berezovska, Anatoly Solovyov, Oleksandr Matsyuk	
ONLINE SCIENCE CLASSROOM	353
Sergey Balalykin, Victoria Belaga, Alexandr Dirner, Evgenia Golubeva, Ksenia Klygina, Anna Komarova, Yury Panebrattsev, Alisa Potapova, Elena Potrebenikova, Pavel Semchukov, Alexandr Shoshin, Nikita Sidorov, Oleg Smirnov, Yulia Stepanova, Michail Stetsenko, Stanislav Vokal, Natalia Vorontsova	
HOW VIDEOS CAN BE USED IN E-LEARNING – A CASE STUDY	353
Sónia Seixas	
AUTHOR INDEX	355

APPLICATION OF THE FLIPPED CLASSROOM MODEL IN SCIENCE AND MATH EDUCATION IN SLOVAKIA

Jozef Hanč

Department of Physics Education Research,
Institute of Physics,
P.J. Šafárik University in Košice,
jozef.hanc@upjs.sk

Abstract. *At the present the flipped classroom model of teaching and learning became one of mainstreams in science and math education research.*

In essence, “flipping the classroom” means that typical activities used to occur in class (like lecturing, explaining, simple demonstrations) is exposed and accessed outside and in advance of class (e.g. at home). The class becomes the place for interactive learning including authentic hands-on activities (inquiry based lab work, interactive demonstrations) and minds-on activities (inquiry based problem-solving, peer and class discussion, or debates).

In our contribution we explain pedagogical and practical details (tenets, benefits, pitfalls) of the flipped classroom based on our three years long direct experience from science and math education in Slovakia at secondary and higher education and training pre-service and in-service teachers. At the same time we explain our view of the technology and teaching methods in the flipped classroom.

Keywords. Science and math education, blended learning, flipped classroom, question driven instruction, digital technology

1. Introduction

Information revolution and digital technology dramatically transforms our society, ways how we work, how we communicate or how we spend our leisure time. These days digital technology is practically everywhere, touches our everyday lives. At the same time it changes demands for skills dealing with active successful life, so the presence of technology in education is inevitable (e.g. [1]).

In connection with using technology in education our department became an integral part of several significant educational projects for

training in-service teachers which are just finished or still currently running:

- *the European 7FP project „Establish” [2,3], where the main objective is dissemination and use of the inquiry-based teaching method for science (enhanced by ICT) with second level students (age 12-18 years) on a large scale in Europe by creating authentic learning environments, involving all stakeholders;*
<http://www.establish-fp7.eu/>
- *the national projects „Modernization of the education at primary and secondary schools” [4], with the primary goal to raise awareness and capability of more than 6800 in-service Slovak teachers in ways how digital technologies can change classrooms into modern student-oriented environments for training, developing and enhancing required student’s skills;*
<http://www.modernizaciavzdelavania.sk/>
- *the science popularization project „Sciencenet” [5] that has formed the long-term strategic partnership with high schools called Sciencenet and whose one of main objective was to provide novel education and popularization means (esp. new digital technologies) for high school partners and to train their teachers in using them.*
<http://www.sciencenet.upjs.sk>

However it is important to realize that the extensive educational research has shown in many cases [1,6–11] that the effectiveness of digital technologies depends strongly on the pedagogical ways in which teachers use them.

Many well-established and sound pedagogical approaches can be successfully employed in the so-called blended learning [10], where from the viewpoint of technology the key role is played by Web technology. This pedagogical strategy is nothing else as an effective and powerful fusion of face-to-face classroom learning and out-of-class online learning.

Among the most widely used approaches in science and math blended learning belong *Just-in-Time Teaching* [8], *Small group learning* [12], *Question driven instruction* [7] or *Flipped classroom* [13].

Slovak teachers (especially in physics) have been introduced with teaching materials dealing with blending learning in the form of Just-In-Time Teaching and Question driven instruction in mentioned national projects „Modernization of

the education at primary and secondary schools” [14] and “Sciencenet” [5]. During running these projects some pedagogical problems have occurred, so we have also started to train some groups of teachers in the blended learning based on the flipped classroom model.

In this article we explain some pedagogical and practical details of the flipped classroom model of teaching and learning which comes from our three years long direct experience from science and math education in Slovakia at secondary and higher education.

2. Theoretical framework, teaching methods and technology

2.1 Concept of the flipped classroom

According to Bergman and Sams [13], two American teachers of chemistry, who coined the term *flipped classroom*, the flipped classroom model of teaching and learning (briefly also the flipped learning) means, that which is traditionally done in class (like exposition of new content, lecturing, listening, making notes, comprehension, simple demonstrations or teacher’s experiments) is now done at home, and that which is traditionally done as homework (like solving problems, doing projects, creative writing) is now completed in class.

From the theoretical viewpoint the basic idea of the flipped classroom model consists in the well-known revised Bloom taxonomy [15], which classifies cognitive work in two dimensions – abstractness of knowledge and difficulty (level) of thinking skills.

During the flipped learning, in accordance with this taxonomy, students are doing simpler (lower) thinking activities (gaining knowledge and understanding) and acquiring more concrete knowledge (like factual) mainly outside of class, and practicing the more difficult (higher) activities (applying, analyzing, evaluating, creating) and constructing more abstract conceptual or metacognitive in the class, where they have the support of their peers and instructor.

As a strong benefit the flipped learning has the effect of creating extra time, which in class allows instructors moderating discussions and debates about more difficult topics, identifying and resolving students’ misconceptions, doing more complex hands-on activities or training key skills. In other words the flipped learning maximizes the value of face-to-face time – the

scarcest learning resource from viewpoint of interactivity. A summary of typical activities during the flipped learning is presented in Table 1.

Time	Activities
prior to class	Reading blog, magazine, book, textbook; Writing notes in Cornell style Watching video-lectures, TV news, movie scenes, video manuals or tutorials; Doing simple experiments, simulations or remote experiments, field trips; Playing games; Visiting museum, exhibits, Finding out information, Doing research, Communicating via interview, sms, videoconference, social network;
during class	Interactive demonstrations Inquiry based activities and lab works, Workshop experimental activities, Inquiry based problem-solving, question driven (peer instruction) activities, peer and class discussions or debates, Project based activities, Cooperative group problem solving Creative writing, Critical thinking training

Table 1. Activities in the flipped classroom

The flipped classroom model has also several disadvantages, but there are also techniques how to eliminate them to a negligible level [16].

2.2 Question driven instruction and the learning cycle approach

Question-driven instruction and its activities belong to very appropriate in-class activities of the flipped learning. This interactive teaching method using classroom response systems (e-voting) was created by the physics education research group of University of Amherst (Beatty, Gerace, Leonard, & Dufresne) [7,9]. The typical class session in such case is structured around three or four question cycles per 45-min long time slot. Each question cycle includes the following steps:

1. Posing a question (problem) by the instructor
2. Small-Group work, discussion on the problem

3. Collecting answers of students by e-voting
4. Displaying the histogram of answers without revealing the correct answer
5. Opening up and moderating a class-wide discussion
6. Closure activities (typically reposing the same question or sending a related question; summarizing the key points or giving a micro-lecture)

From the viewpoint of the well-known constructivist ideas of J. Piaget [6,17,18] we have decided to adjust our flipped learning to a very successful teaching design representing a form of inquiry-based teaching, *the Learning Cycle approach* [18,19]. This approach, developed by Robert Karplus and its team, divides the activities of instruction into three phases (Fig. 1).

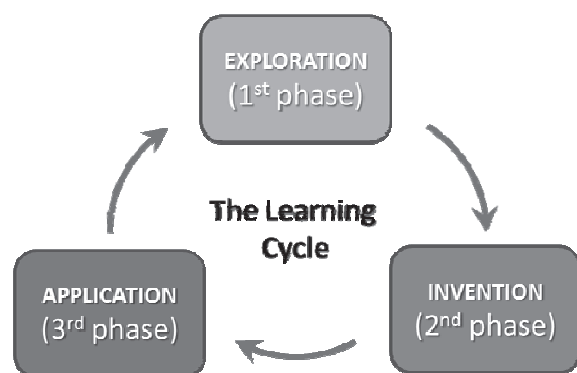


Figure 1. A teaching strategy called the learning cycle proposed by Karplus and his team

In the first *exploration* phase (usually through hands-on activities) students alone or in small groups are first given experience with a concept to be developed. This experience is getting without any special instructions, guidance or instructor's intervention.

After that the *conceptual invention* phase follows where students with/without teacher's guidance derive the concept from the previous experience. This phase usually brings students together (to class) with the instructor playing a moderator role.

The final phase, the *application* phase, gives the student the opportunity to explore the usefulness and application of the concept in other circumstances and conditions.

The learning cycle approach is successfully applied in great variety of educational settings, from science subjects (math, physics, chemistry, biology) to humanities, at all levels of education

and in groups ranging from 5 to 150 students.

2.3 Technology in the flipped classroom

Implementation of the flipped learning in practice means creating conditions for completing various activities. As you will see in particular examples mentioned in next section 3 (or in [13]) the flipped classroom depends heavily on technology, especially Web 2.0. For managing education it is appropriate to use an LMS like Moodle or based on [20] we are trying to use the social network Google+ and blog (Blogger).

In case of not using LMS any communication and discussions can be provided by social network Google+. Students are doing experiments via computer interactive simulations (Geogebra, Phet, Google maps), digital probes and special software. Special software is also used in case of recording videos via screencasting (Camtasia, Jing, OneNote). Storing, hosting, e-voting is easily performed by free cloud services (Youtube, Google disk, Polleverywhere).

3. Two flipped-learning examples

3.1. Calculus in higher education

Usually the higher mathematics as the calculus of single variable is taught at universities by deductive scheme: definition of a concept, theorem (property of the concept), proof (rigorous logical argument), and example (concept illustration). This method invented by ancient Greeks has great importance to mathematics itself, to its theoretical foundations. However, if we look at the deductive learning in light of the constructivism and the learning cycle, such approach cannot principally work for majority of students. For example in traditional deductive introduction to the key calculus concept derivative, students should be familiar with the theory of limits based on the delta-epsilon technique. And as a result many science students (especially those who are not majors in math) if they are able to find derivatives, consider the concept mysterious, do calculations only mechanically and fail to solve practical science problems because they have often little idea what derivatives mean.

Students do not understand calculus not only conceptually, but have also problems with their own metacognition about learning science and

math. In other words students have wrong ideas about answers to questions like what does it mean to understand math and physics? Is physics or math about memorizing and applying rules and equations or about reasoning and making sense of the physical world? Do I understand what does it mean if I am doing science and how scientific method work?, etc.

The second important problem of our instruction is a sample of students who came to study science at our University. According to our test of mathematical literacy from high school (administrated every year before the course) average quality of students continuously drops and gap between what students need to know and they know extends. Moreover our calculus classes are more and more heterogeneous in skills and performance. Many of our students start to struggle with course content after a few lessons.

If we tried to adjust our instruction to average students, we run immediately into problems with time and it was practically impossible to follow our syllabus. Time becomes immediately the scarcest learning resource.

Another frequent and not minor problem in university courses deals with absentness of a teacher, students or mere instruction (lectures, recitations) due to holidays, illness, school or scientific events.

We have tried to solve these pedagogical problems in our course Fundamentals of math for physicists using the flipped learning applying ideas of the calculus reform [21] which took place in US during the 80's and 90's of the twentieth century and completely re-thought the calculus curriculum for non-majors in math.

Most important for us were two central ideas of this reform which are fully consistent with the-learning-cycle strategy: (1) calculus: a pump, not a filter (less details in logical rigor, but clear and transparent in presenting key ideas; substantially more real applications), (2) using technology, inductive learning method and "Rule of Four" for presenting ideas at the same time graphically, numerically, symbolically and verbally [21,22].

To get better idea we present an example of the flipped calculus class connected with our introduction to the concept of derivative.

In the first exploration phase, prior to class, students start with motivational reading, Conquer the third pole, from the science popular magazine Geo about the first successful attempt to climb the highest mountain in the world. They are also said that this activity is important in getting good

intuition and idea about derivative.

To get own first experience student also follow Hillary's and Norgay's expedition to Mount Everest virtually in a simple interactive hands-on activity – doing 3D simulation of the climb complemented by watching real Youtube videos and photos offered by Google maps (Fig.2). Exploring on own students submit their answers to a simple task: Try to draw a profile of Mount Everest during Hillary's and Norgay's climb of Mt. Everest and mark the most difficult point of this climb. Give reasons for your choice.

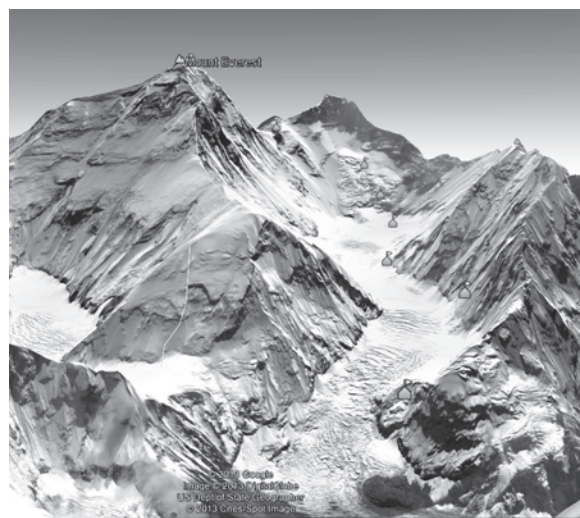


Figure 2. A simple interactive exploration activity using 3D Google maps

The exploration phase continues with watching our mini YouTube video-lecture (10 minutes) about "steepest location" of Mount Everest's profile. Students prepare and submit own notes by using Cornell note-taking method [13] together with completing a simple assessment rubrics containing their reactions. The result of the phase is student's clear and intuitive idea that the derivative of a function at a point means geometrically a synonym for the slope (steepness) of the profile (curve or graph) or physically an instantaneous rate of change of considered quantity in time (or instantaneous growth).

In the second invention phase, in class, thanks to in-class minds-on and hands-on activities (Geogebra simulations) students in question driven instruction are trying to answer a series of questions using an e-voting response system based on their mobiles and web service <http://www.polleverywhere.com>

This phase leads students in formulating the exact calculus definition of the slope of linear

function and also a geometrical definition of slope of nonlinear function as the slope of the line tangent to the curve representing the graph of the function.

The invention phase is finished again out of class where students watch our Youtube collection of four recapitulating videos and submit own Cornell notes summarizing their learning.

In final application phase (again in the form of question driven instruction) students extend the range of applicability of the concept and finish with the limit definition of the derivative. The limit concept is discussed only intuitively as expressing the slope of the line between two infinitesimally close points on the graph of the function.

3.2 Popularization of science at secondary schools

One of the objectives of the partnership Sciencenet (the project mentioned above) is to realize regular popular scientific activities like lectures, workshops, and public science days for students and their parents, which have a strong potential to show the fascinating world of physics and science. As a successful example of such activities becomes an interactive popularization lesson. Could Spider-Man really stop a subway train?, which can be also treated as the form of flipped classroom based on the learning cycle mentioned above. The main objective of the lesson is to show the power of applying scientific models to real situations. In this case students will invent and apply a simple kinematical model of the situation – constant deceleration model.

At least one day before the popularization action and out of class students are encouraged to create informal groups and asked to complete the first exploration phase of the learning cycle. Without any special instructions or guidance or intervention they are getting own experience by watching one of Spider-Man movie scenes (5 minutes long), when Spider-Man stops a New York City subway train. Investigating the video students submit their answers to this simple task: Try to find in the video as much scientific information as possible.

The beginning of the face-to-face interactive lesson represents start of the second invention phase of the learning cycle. Using question-driven instruction students try to make sense of the data collected during the exploration phase and connect to the key question: Could Spider-Man really stop a subway train?

Using e-voting for answering multi-choice questions together with peer and class-wide instruction and applying the Ockham razor (metaphorically illustrated by a joke about a spherical cow) they develop and invent a simple kinematical model of the situation (“constant deceleration model”). With teacher guidance they find that the power of the superhero is not exaggerated at all and it is comparable to strength of a very mighty gorilla.

Later students deploy the model in a real life situation (airbag in car) which represents the third last application phase of the learning cycle. As homework in a simple lab activity (video-analysis of a crash test according to video manual) students complete the application phase by checking in the developed model.

4. Conclusions

At the present the flipped classroom model of teaching and learning becomes one of the mainstreams in science and math education research. This approach allows instructor to create and maximize the use of the scarcest learning resource from viewpoint of interactivity – classroom time. It means more student-student and student-instructor interactions, students learning at own pace, addressing absenteeism and helping struggling students.

Our first results support the conclusion that the flipped learning can result in greater achievement in math and science, better understanding and retention of concepts, improved attitudes toward science and science learning, better reasoning ability, and superior process skills than would be the case with traditional instructional approaches.

5. Acknowledgements

I would like to thank especially to my colleague, collaborator and friend Slavo Tuleja from Grammar school in Humenné, for continuous sharing and exchanging knowledge, inspiring ideas and experience dealing with the flipped learning at all levels of education.

The presented results are based on our work in several projects: (1) the international 7FP project ESTABLISH (European Union's Seventh Framework Programme FP7/2007-2013 under grant agreement n° 244749), (2) Modernization of the education at primary and secondary schools (ITMS project codes: 26110130083, 26140130013, 26110130084, 26140130014) supported by the European Social Fund, (3) and finally project SCIENCENET, financially

covered by the grant LPP-0134-09 of Slovak research and development agency (APVV) in the program for Human Potential Support in R&D and Science Popularization.

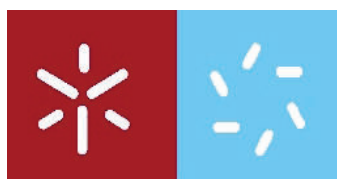
6. References

- [1] Bell RL. Technology In The Secondary Science Classroom. National Science Teachers Association; 2007.
- [2] Ješková Z, Kireš M, Ganajová M, Kimáková K. Inquiry-based learning in science enhanced by digital technologies. Proc. Iceta 2011, Stará Lesná, The High Tatras, Slovakia: 2011, p. 115–8.
- [3] Kireš M, Šveda D. Scientific Literacy for the Information Society. Proc. Iceta 2012, Stará Lesná, The High Tatras, Slovakia: 2012, p. 193–6.
- [4] Hanč J, Kireš M, Šveda D. The digital literacy and key competencies as the cornerstones of primary and secondary education modernization. Proc. Iceta 2011, Stará Lesná, The High Tatras, Slovakia: 2010, p. 411–6.
- [5] Hanč J. Interactive science popularization lectures using modern technology in the partnership Sciencenet (in Slovak). Proc. Quo Vadis Educ. Sci. Technol. Second. Sch. 2010, Bratislava: 2010, p. 82–8.
- [6] Donovan MS, Brandsford JD, editors. How Students Learn: Mathematics in the Classroom. Washington, D.C.: The National Academies Press; 2005.
- [7] Beatty ID, Gerace WJ, Leonard WJ, Dufresne RJ. Designing effective questions for classroom response system teaching. Am J Phys 2006;74:31–9.
- [8] Simkins S, Maier M, editors. Just in Time Teaching: Across the Disciplines, and Across the Academy. Stylus Publishing; 2009.
- [9] Bruff D. Teaching with Classroom Response Systems: Creating Active Learning Environments. John Wiley & Sons; 2009.
- [10] Glazer FS, editor. Blended Learning: Across the Disciplines, Across the Academy. Stylus Publishing; 2011.
- [11] Seel NM, editor. Encyclopedia of the Sciences of Learning. Springer Science; 2012.
- [12] Cooper JL, Robinson P, editors. Small Group Learning in Higher Education: Research and Practice. New Forums Press; 2011.
- [13] Bergmann J, Sams A. Flip Your Classroom: Reach Every Student in Every Class Every Day. International Society for Technology in Education; 2012.
- [14] Ješková Z. Using ICT in physics instruction at secondary schools (in Slovak). Košice: Elfa; 2010.
- [15] Anderson LW, Krathwohl DR, Bloom BS. A taxonomy for learning, teaching, and assessing: a revision of Bloom's taxonomy of educational objectives. Longman; 2001.
- [16] November A, Mull B. Flipped learning: A response to five common criticisms. Eschool News 2012;15:62–8.
- [17] Redish EF. Teaching Physics with the Physics Suite CD. Wiley; 2003.
- [18] Fuller RG, Campbell TC, Dykstra, Jr. DI, Stevens SM. College Teaching and the Development of Reasoning. Charlotte: Information Age Publishing; 2009.
- [19] Marek EA. Why the learning cycle? J Elem Sci Educ 2008;20:63–9.
- [20] Erkollar A, Oberer B. Trends in Social Media Application: The Potential of Google+ for Education Shown in the Example of a Bachelor's Degree Course on Marketing. In: Kim T, Adeli H, Kim H, Kang H, Kim K, Kiumi A, et al., editors. Softw. Eng. Bus. Contin. Educ., vol. 257, Springer Berlin Heidelberg; 2011, p. 569–78.
- [21] Haver WE, editor. Calculus: Catalyzing a National Community for Reform: Awards 1987-1995. The Mathematical Association of America; 1999.
- [22] Hughes-Hallett D, Gleason AM, Lock PF, Flath DE, Gordon SP, Lomen DO, et al. Applied Calculus. John Wiley & Sons; 2009.



- Muhtaseb, R. 330
Novak, P. 244
Nováková, M. 213
Noversa, S. 115
Novotný, J. 327
Oliveira, J. 211, 212
Ondera, J. 205
Onderová, L. 205
Orolínová, M. 106
Paiva, S. 214
Páleníková, M. 312
Panebrattsev, Y. 351, 353
Pavlendová, G. 96
Pedrosa de Jesus, J. 258
Pereira, R. 121
Pereira, S. 126
Pérez, C. 110
Petriláková, M. 27
Pinkr, T. 284
Pociask-Bialy, M. 154
Polčin, D. 303
Potapova, A. 353
Potrebenikova, E. 353
Pucholt, Z. 343
Raganová, J. 83, 193
Reguli, J. 250
Rito, A. 322
Rodrigues dos Santos, R. 321
Rodríguez, S. 190
Rogério Gallo, P. 212
Sá Machado, MF. 149
Salinas Castellanos, A. 17
Santos, C. 143
Santos, TM. 258
Seixas, S. 353
Sekerák, J. 338
Semchukov, P. 353
Shoshin, A. 353
Sidorov, N. 353
Silva, C. 121
Siváková, M. 312
Slabeycius, J. 303
Šmejkal, P. 136
Smirnov, O. 353
Soares, C. 126
Solovyov, A. 352
Stebniki Tabora, W. 73
Stepanova, Y. 353
Stetsenko, M. 353
Šulcová, R. 307
Svandova, K. 144
Šveda, D. 36
Svobodová, J. 263, 327
Talavášková, B. 323
Taşcı, A. 9
Teixeira, CA. 212
Timková, V. 67
Tomášik, B. 144, 181, 175
Trna, J. 240, 244
Trnova, E. 240, 244
Uşak, M. 320
Vacek, V. 240
Varela, P. 115, 121
Vergara, R. 190
Vila-Chã, R. 322
Vladescu, E. 20
Vladescu, LC. 24
Vokal, S. 353
Vorontsova, N. 351, 353
Yang, MS. 79
Zámečnicková, V. 27
Zaragoza Domènech, C. 164
Zhumaev, V. 351
Zilavy, P. 87

The Organizers of the 10th International Conference on Hands-on Science acknowledge the sponsorship cooperation and support of these sponsorships and collaborations:

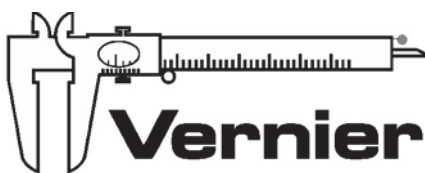


Universidade do Minho
Escola de Ciências

Universidade de Vigo



Pavol Jozef Šafárik University in Košice
Faculty of Science



SLOVAK RESEARCH
AND DEVELOPMENT
AGENCY

LPP-0223-09 Science on Stage Slovakia

SLOVENSKÁ
SPORITEĽŇA



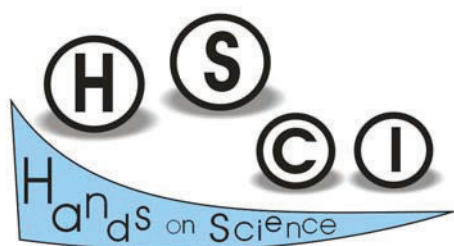
Občianske združenie
PRÍRODOVEDEC



KOŠICE2013
EUROPEAN CAPITAL OF CULTURE



SCIENCE in SCHOOL



Education and Culture
Lifelong learning programme
COMENIUS