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15TH INTERNATIONAL CONFERENCE OF EDUCATION, RESEARCH AND INNOVATION

CONFERENCE PROCEEDINGS

7-9 NOVEMBER 2022
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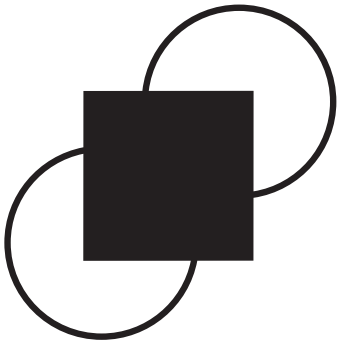

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Luis Gómez Chova, *University of Valencia, Spain*
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Preface

The ICERI2022 Conference Proceedings contain selected and revised papers from the 15th International Conference of Education, Research and Innovation.

ICERI2022 was held in Seville, Spain, from the 7th to the 9th of November 2022. ICERI is an annual event in which lecturers and researchers from 79 different countries gather to share valuable research and information about education, pedagogical technologies, and educational innovations.

Keynote speeches, networking activities, plenary sessions, parallel thematic sessions and workshops were, among some of the events on offer, delivered by world-leading educational experts at the conference, which provided participants the opportunity of global networking. The keynote speeches are available at IATED Talks (iated.org/talks/).

The scope of ICERI covered the following topics: Digital & Distance Learning, Digital Transformation of Education, Innovative Educational Technologies, Active and Student-Centered Learning, Assessment, Mentoring & Student Support, Educational Stages and Life-Long Learning, Quality & Impact of Education, Teacher Training and Educational. Management, STEM Education, Discipline-Oriented Sessions, Language Learning and Teaching, Inclusion and Multiculturality.

The ICERI2022 Proceedings include the accepted contributions presented at the ICERI2022 Conference. The ICERI2022 International Program Committee is composed of lecturers and researchers from all around the globe. A blind peer review process was followed in order to guarantee the quality of the final publication and during this process, the following points were evaluated: information content, relevance to the educational field, general structure, clarity of contents, originality, and relation to the conference topics and disciplines. The publication is solely in English.

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Finally, we wish to extend our most sincere thanks to all members and delegates who have contributed to these ICERI2022 Proceedings. We also wish to express our gratitude to all participants and attendees for their engagement, dedication and passion for education.

Luis Gómez Chova
Agustín López Martínez
Joanna Lees

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ICERI2022 Keynote Speakers

Keynote Speakers

Tracey Tokuhama-Espinosa – *Harvard University Extension School, United States*
Manu Kapur – *ETH Zurich, Switzerland*

Tracey Tokuhama-Espinosa – Harvard University Extension School (United States)

Keynote speech: What Every University Professor Should Know About Meaning Making

Over the years we have heard a lot about the important role of social-emotional learning within school settings. We have also learned something about how the brain learns in regular classrooms. What is less explored is how people make meaning out of their worlds by combining knowledge of how others feel and knowledge of how others think to construct reality. New neuroimaging technology now gives us a glimpse as to how people influence each other's learning through a dynamic exchange of cognition and emotion. Meaning Making is a term used to describe how humans give context to their learning. In this keynote we will explain how humans learn from this perspective, and why and how higher education must shift to remain relevant in modern times.

Biography:

Tracey Tokuhama-Espinosa, Ph.D. is from Berkeley, California, is an alumna of the Harvard Graduate School of Education, and currently teaches a course at the Harvard University Extension School entitled The Neuroscience of Learning: An Introduction to Mind, Brain, Health, and Education Science. She is currently an educational researcher and serves as an Associate Editor of Nature Partner Journal Science of Learning and co-founder of Connections: The Learning Sciences Platform.

Tracey researches indicators to measure educational quality; learning in the digital age; transdisciplinary thinking; bilingualism and multilingualism; and the general improvement of teacher practices. Her most recent books are the Bringing the Neuroscience of Learning to Online Teaching: An Educator's Handbook (2021); Neuromyths: Debunking False Ideas About the Brain (2019); and The Five Pillars of the Mind: Redesigning Education to Fit the Brain (2019). She has authored articles for UNESCO and was a member of the Organisation for Economic Co-Operation and Development (OECD) expert panel to redefine teachers' new pedagogical knowledge in modern times.

Tracey's current focus is on understanding What Kids Want to Know About Their Own Brains, a book coming out with Columbia University's Teachers College Press next year. She is also writing a book called ThinkWrite: The Neuroscience of Writing, which explains why writing is the highest form of thinking. Finally, she is co-editing a new Handbook on Brain, Neuroscience and Education, which is a collection of work looking at the future of educational practice.
Tracey has lived and worked professionally in Tokyo, Geneva, Lima, and Boston, and is currently in New York and works with teachers, schools, governments, and NGOs in 40 different countries.

Manu Kapur – ETH Zurich (Switzerland)

Keynote speech: Productive Failure

If learning from failure is intuitively compelling, how can we intentionally design for it, and bootstrap it for deep learning? In my talk, I will describe my research on Productive Failure, and its implications for how we design powerful learning environments, innovation and creativity.

Biography:
Manu holds the Professorship for Learning Sciences and Higher Education at ETH Zurich, Switzerland, and directs The Future Learning Initiative (FLI) at ETH Zurich. An ETH+ funded initiative, the FLI brings together more than 20 professors from 10 departments at ETH to advance research on the science of teaching and learning in higher education contexts, and translate it into the practice of teaching and learning at ETH Zurich.
Prior to this, Manu was a Professor of Psychological Studies at the Education University of Hong Kong. Manu also worked at the National Institute of Education (NIE/NTU) of Singapore as the Head of the Curriculum, Teaching and Learning Department, as well as the Head of the Learning Sciences Lab (LSL).

A mechanical engineer by bachelors training, Manu has always been passionate about mathematics. He taught college mathematics for four years, during which he was also the deputy leader for Singapore's team to the 43rd International Mathematical Olympiad in Glasgow. It was then that his intrigue for mathematical cognition took root, which led him to pursue a doctoral degree in the science of learning (specialization in instructional technology) at Columbia University in New York. Manu holds a double Masters: a Master of Science in Applied Statistics from Columbia University in New York, and a Master of Education from the NIE, Singapore.

As a learning scientist, Manu makes a commitment not only to advancing understanding of human learning, but doing so in ways that make an impact in the actual ecologies of learning. Drawing on his engineering mindset for design, Manu conceptualized and developed the theory of Productive Failure to design for and bootstrap failure for learning mathematics better. He has done extensive work in real-field ecologies of STEM classrooms to transform teaching and learning using his theory of productive failure across a range of schools and universities in around the world.

His research on Productive Failure has been taken up by the Singapore's Ministry of Education for wide-scale re-design and implementation of its pre-university mathematics (statistics) curriculum and pedagogy.

Conference Tracks & Sessions

The ICERI2022 conference program is available online at https://iated.org/iceri2022

ORAL SESSIONS MONDAY

Virtual & Augmented Reality
Tutoring & Coaching
Entrepreneurship Education (1)
Robotics in Education
Flipped Learning
Best Practices in Maths Education
Students and Teachers Wellbeing
Exchange & Mobility Programmes
Technology Enhanced Learning
Rethinking Assessment in COVID-19 Times
University-Industry Collaboration (1)
Responsible Research and Innovation in STEM
Gender Issues in Education
Trends in Maths Education
Special Education (1)
New Technologies in Language Learning
Design Thinking
e-Assessment
Employability Trends and Challenges
Architecture Education Experiences
Pedagogical Innovations
Computer Science and Programing in Higher Education
Inclusion of Learners with Special Educational Needs
Teaching and Learning Foreign Languages
21st Century skills
Assessment & Feedback
Entrepreneurship Education (2)
Engineering Education
Project and Problem Based Learning
Coding at Schools
Special Education (2)
Second Language Learning & Bilingual Education

POSTER SESSIONS MONDAY

Pedagogical Experiences in Teaching and Learning
Emerging Technologies and Distance Learning

ORAL SESSIONS TUESDAY

Digital Transformation of Education
From Face-to-Face to Remote Learning
Universal Design for Learning & Learning Space Design
Media & Information Literacy
Blended and Hybrid/Hyflex Education
Professional Development of STEM Teachers
Educational Leadership and Management
Students Wellbeing during and after COVID-19
Online Teaching and Learning
Lessons learned from the COVID-19 pandemic

Student Support
Diversity Issues & Inclusive Education
Active & Experiential Learning
Professional Development of Teachers (1)
International Experiences
Remote and Virtual Laboratories
e-Learning
Quality Assurance & Learning Analytics
Inclusion & Multiculturality
Student Engagement and Motivation
Service Learning & Community Engagement
ICT Skills among Teachers
How to better match the language proficiency needs? The Kielibuusti project
Cooperative & Problem Based Learning in Computer Science
Research on Educational Technologies
University-Industry Collaboration (2)
Educational Software
Digital Literacy
Gamification & Game-based Learning
Pre-Service Teacher Education
How to Build an Entrepreneurship Education System across Educational Levels?
STEM Experiences
Social Media in Education
Workplace & Vocational Training
Curriculum Design Experiences
Engagement and Motivation during COVID-19 Pandemic
Sustainable Development Goals in Education
Professional Development of Teachers (2)
Educational Management
Health Sciences Education

POSTER SESSIONS TUESDAY

Innovations and Quality in Education
New Trends in Education and Research

VIRTUAL SESSIONS

DIGITAL TRANSFORMATION OF EDUCATION
Data Science & AI in Education
Learning Analytics & Educational Data Mining
Digital Technologies and Resources for Learning under Lockdown
Digital Transformation
21st Century Skills
Educational Programming & Robotics

DIGITAL & DISTANCE LEARNING
Distance Education in COVID-19 Times
MOOCs & Open Educational Resources
Blended & Mobile Learning
e-Learning Experiences
Learning Management Systems & Virtual Learning Environments
Post-Pandemic Scenarios in Education

INNOVATIVE EDUCATIONAL TECHNOLOGIES
AI, Chatbots & Robots
Virtual & Augmented Reality
Social Media in Education
Technology Enhanced Learning

TEACHER TRAINING & ED. MANAGEMENT
ICT & Digital Skills
Professional Development of Teachers
Educational Management

ACTIVE & STUDENT-CENTERED LEARNING
Gamification & Game-based Learning
Active & Experiential Learning
Problem & Project-Based Learning
Developing Soft and Transversal Skills
Pedagogical Innovations

ASSESSMENT, MENTORING & STUDENT SUPPORT
Assessment & Evaluation
Rethinking Assessment in COVID-19 Times
Mentoring & Tutoring
Student Support & Motivation
Student Engagement & Wellbeing in COVID-19 Times

EDUCATIONAL STAGES & LIFE-LONG LEARNING
From Pre-school to Secondary Education
Vocational Training
Transition to the Job Market
Developing Entrepreneurship in Education
Life-Long & Workplace Learning
Libraries and Museums as Learning Spaces

QUALITY & IMPACT OF EDUCATION
Quality in Education
Experiences and Challenges in Curriculum Design
Sustainability & Environmental Awareness
Social Impact of Education
University-Industry Collaboration
Education and Research

MULTICULTURALITY & INCLUSION
Multicultural Education
Diversity Issues
Special Educational Needs
Inclusive Education

STEM EDUCATION
Mathematics & Statistics
Engineering Education
STEM Experiences
Computer Science Education

LANGUAGE LEARNING AND TEACHING
Foreign Languages
New Technologies in Language Learning
Language Learning & Translation Studies

DISCIPLINE-ORIENTED SESSIONS
Architecture & Interior Design
Health Sciences Education
Business and Marketing Education
Military Education

Table of Contents

A MIXED METHODS STUDY OF LEARNING CHALLENGES: PERCEPTIONS OF FOUNDATION STUDENTS AT AN INTERNATIONAL BRANCH CAMPUS IN QATAR 1
R. Bendriss

ATTITUDES OF SOCIAL MEDIA USERS TOWARDS ONLINE PRIVACY IN TIMES OF A PANDEMIC: PRIVACY CONFIGURATION AND PROFILE DISCLOSURE ON FACEBOOK 11
L. Andrade, L. Faria, M. Andersen

SOCIAL MEDIA PRESENCE IN EMPLOYER BRANDING: CONSIDERATIONS FOR HIGHER EDUCATION INSTITUTIONS 21
L. Andrade, J. Pimenta, L. Faria

MIGRATION AND PERCEPTION OF RELIGIOUS PLURALISM: A CASE OF TURKISH COMMUNITY IN AMERICA 31
B. Gürer

UNIVERSITY STUDENTS' MOBILITY AND ITS ASPECTS 38
E. Nacházelová

THE IMPACT OF THE MIND, EMOTIONAL, AND SPIRITUAL (MES) PROGRAM ON QUALITY OF LIFE AMONG NATIONAL HIGH-SCHOOL TEACHERS IN EASTERN THAILAND 45
T. Julvanichpong, K. Piboon, T. Yingratanasuk, W. Julvanichpong, C. Singhnoy, P. Inchai

SUCCESSFUL TEACHER PREPARATION PROGRAM CHARACTERISTICS 50
R. Spangler

PLAYING CATCH UP: ALIGNING CREDIT RECOGNITION AND TRANSFER WITH MICRO-CREDENTIALS 51
R. McGreal, K. Perris

DIGITAL TRANSFORMATION IN LANGUAGE EDUCATION DURING THE COVID-19 52
H. Obari, S. Lambacher, H. Kikuchi, H. Kojima

PRE-SERVICE MATH & SCIENCE TEACHERS' VIEWS ON UTILIZING MOBILE TECHNOLOGY IN EARTH SCIENCE COURSE: A PHENOMENOGRAPHIC STUDY 53
F. Ornek

JOURNEY THROUGH LIMINALITY: FROM TEACHER, TO STUDENT, TO TEACHER 54
I. Ntonia, M. Pazio

SIX SIGMA RE-CERTIFICATION 55
D. Gonzalez

'HOW SHOULD SOCIAL WORK EDUCATION IN ENGLAND RESPOND TO THE 2020 BLACK LIVES MATTER CAMPAIGNS?' KEY THEMES FROM THE LITERATURE 56
A. Higgs

IMPROVING ONLINE LANGUAGE LEARNING INTERACTIVITY WITH MULTIUSER VIRTUAL REALITY ENVIRONMENTS: PREPARING FOR THE METAVERSE 57
P. Mourtzis, S. Mystakidis

TECHNOLOGY AND THE INSTRUCTOR: WHERE TO NOW? 66
L. Whisenant

INFORMATION SECURITY AND DIGITAL RIGHTS MANAGEMENT: A BRIEF LITERATURE REVIEW 76
L. Whisenant

TELECENTRES AS PROMOTERS OF DIGITAL CITIZENSHIP AMONGST POOR POPULATIONS IN BELO HORIZONTE, BRAZIL 81
S. Rodrigues Haddad, A. Oliveira, A.F. Beaufils

PREPARING TEACHERS TO SUPPORT EMERGENT BILINGUALS IN THE US & GLOBALLY: AN INSTITUTIONAL OVERVIEW 91
D. Romero, M. Milian

TRANSITIONING EARLY FIELD EXPERIENCES FOR PRESERVICE TEACHERS INTO ONLINE OPPORTUNITIES IN TIMES OF CRISIS 92
D. Romero, A. Romero de la Torre

CONCERNS OF PRE-ADOLESCENT CHILDREN IN PRIMARY SCHOOLS IN CHINA: FOCUSING ON CONSULTING PARTNERS AND FACTORS INHIBITING CONSULTATION 98
M. He, F. Inuzuka, I. Chung

ENCOURAGING COURSE DESIGNER ENGAGEMENT WITH DATA ANALYSIS METHODS IN VIRTUAL LEARNING ENVIRONMENTS 110
S. Smith, D. Cobham, K. Jacques

COMPLEMENTARITY BETWEEN MANAGERS' VOCATIONAL TRAINING, MANAGEMENT CONSULTING AND COMPANY'S INNOVATION ACTIVITY 118
M. Baltov, E. Nikolova, M. Neycheva

MENTORING PROGRAM FOR THE INTEGRATION OF INTERNATIONAL STUDENTS INTO HIGHER EDUCATION 127
P. Alves, C. Morais, L. Miranda

GREEN TRANSITION – CHANGING THINKING PATTERNS AND ACTIONS IN PRACTICE 137
M. Ekström, K. Hytönen

INTERNATIONALIZED ENGLISH MEDIUM INSTRUCTION PROGRAMMES IN HIGHER EDUCATION INSTITUTES 143
N. Wang

BUILDING STUDENT-CENTERED SOFTWARE BY ACTUALLY TALKING TO STUDENTS 155
C. McFadden

RESULTS OF THE INCORPORATION OF THE STRUCTURAL CODE IN THE TEACHING OF STRUCTURAL SUBJECTS FOR THE DEGREES IN MECHANICAL ENGINEERING, AGRICULTURAL ENGINEERING AND MASTER'S DEGREE IN INDUSTRIAL ENGINEERING 161
J. Ferreiro-Cabello, E. Fraile-Garcia, J. Los-Santos Ortega, C. Gonzalez-Gonzalez

DIGITAL RESOURCES TO ENHANCE EMPLOYABILITY FOR STUDENTS OF INDUSTRIAL CONSTRUCTION IN THE INDUSTRIAL ENGINEERING MASTER'S DEGREE 166
J. Ferreiro-Cabello, E. Fraile-Garcia, J. Los-Santos Ortega, C. Gonzalez-Gonzalez

DEVELOPING PROFESSIONAL IDENTITY IN FIRST YEAR OF UNIVERSITY 171
S. Dempsey

PERFORMANCE MEASUREMENT SYSTEM DECOUPLING 172
R. Vancelee, R. Kelly

TUTORSHIPS TO PROMOTE UNIVERSITY EDUCATIONAL INCLUSION 173
B.A. Naranjo Sánchez, F. Potes Duque

THE DEVELOPMENT-FORMATIVE FUNCTION OF EDUCATIONAL EVALUATION 183
I. Szőköl, O. Kováč

INTERIOR DESIGN EDUCATION IN SEARCH OF MEANING 189
D. Hasirci

A BILINGUAL PROGRAM AT PRE-UNIVERSITY LEVEL (17-19 YEAR OLD): THE CASE OF COLLEGIAL INTERNATIONAL SAINTE-ANNE 194
H. Rompre

DESIGNING FOR CREATIVE RESEARCH IN GRADUATE EDUCATION 195
T. Hurwich, D. Nicholas, F. Fleming, P. Gondek, J. Katz-Buonincontro, D. King, E. Perignat

ETHICS IN EDUCATION AND THE USE OF TECHNOLOGY 202
M. Ben-Jacob, A. Glazerman, D. Wang

THE PROFESSIONAL LEARNING COMMUNITIES IMPERATIVE: HOW SCHOOLS NAVIGATE THE DYNAMICS OF SYSTEMIC AND SCHOOL-BASED DEMANDS IN PLC IMPLEMENTATION 203
S. Rule, T. Wang

CELL BIOLOGY EDUCATION WITH ADVANCED 3D TECHNOLOGIES FOR K-12 STUDENTS 204
S. Tanabashi

THE EVOLUTION OF HIGHER EDUCATION - INSTITUTION-TO-INSTITUTION MUTUAL-EXCHANGE 208
E. Arnold

A SUDDEN SHIFT FROM FACE-TO-FACE TO DIGITAL: WHAT CHALLENGES DID TUTORS FACE WHILE TUTORING DURING COVID-19? 209
L.M. Langesee, L. Franke, J. Heller

REMOTE TEACHING IN THE EARLY YEARS: AN ETHNOGRAPHIC STUDY OF TEACHERS OF PRESCHOOL CHILDREN DURING THE PANDEMIC 217
E. Tolentino

IMPACT OF THE COVID-19 CRISIS ON EDUCATION IN NIGERIA: LESSONS LEARNED 222
L. Audu, A. Lawani

COMPLETION RATE IN INFORMATICS STUDIES – CZECH REPUBLIC EXPERIENCE 228
L. Nedomova, P. Doucek, M. Maryska

GENDER ASPECT IN INFORMATICS STUDIES 233
L. Nedomova, P. Doucek, M. Maryska

GUIDELINES FOR TEACHING FOR INFORMATICS TEACHER NOVICES 239
M. Mladenović, M. Ozretić

A MULTIMODAL TWIST: USING WEBSITES AND VIDEO IN A UNIVERSITY ACADEMIC WRITING COURSE 248
M. Andrew

IF YOU SHRINK IT, WILL THEY STILL SUCCEED? COMPARING THE EFFECTIVENESS OF PEDAGOGICAL MODELS FOR ACCELERATED LEARNING IN AN ONLINE MASTER'S DEGREE PROGRAM 249
L. Mandel

INTEREST IN CYBERSECURITY EDUCATION AMONG APPLIED SCIENCES STUDENT POPULATION 258
N. Kasunic, S. Bracun

NATURE-BASED LEARNING: DESIGNING OUTDOOR PLAY ENVIRONMENTS 266
B. Isci, D. Hasirci

IS COMPANY'S COMMITMENT TO LEARNING A FACTOR FOR MARKETING INNOVATIONS? 274
E. Nikolova, M. Neycheva, V. Ruseva

UPSKILLING THE COMPETENCEIES OF TEACHERS IN THE PRIVATE SECTOR THROUGH STEAM AND DDMT MODEL 282
K F T. Lam, T.H. Wang, N. Ku, J H. Chen

EXPLORING THE EMOTIONAL RESPONSES INDUCED BY A REAL PERSON CHAT AND AN AI CHATBOT ASSISTANT 288
G. Qu, H. Zhou, M. Wang, B. Yang, T. Goh

GAMIFICATION IN PRIMARY ENGLISH TEACHING AS A SPRINGBOARD TO CONTROL PUPILS' BEHAVIOR AND MOTIVATION 294
P. Tereso, M. Cruz

LEARNING ABOUT MANAGEMENT FROM PRACTITIONERS - DISCOURSES, DILEMMAS AND CONTRADICTIONS STEMMING FROM ANALYSIS OF SEMI-STRUCTURED INTERVIEWS CONDUCTED BY STUDENTS 305
K. Pavlica, I. Matoušková

THE DESIGN AND DEVELOPMENT OF AN INSTITUTIONAL DIGITAL TOOLKIT TO ENHANCE RESEARCH TEACHING INTEGRATION 311
S. Floyd, R. Bond, I. McChesney, M. Ballentine

TRANSITION FROM FACE-TO-FACE TO HYBRID HACKATHONS DURING COVID-19 PANDEMIC 321
R. Khan, N. Sethi

THE INCLUSION OF ELF TRANSCULTURAL COMMUNICATION AND COMMUNICATION STRATEGIES IN ENGLISH LANGUAGE TEACHER EDUCATION 328
M. Antonello

PROBLEM-BASED TEACHING APPLIED TO PRACTICAL LABORATORY CLASSES: INFLUENCE OF THE STUDENT'S ACADEMIC PROFILE 333
O. Díaz, E. Segredo-Morales, E. González

TEACHING EXPERIENCE IMPLEMENTING PRACTICAL CASES ON WATER TREATMENT IN UNIVERSITY COURSES 339
O. Díaz, E. Segredo-Morales, E. González

CENTRALLY MANAGED VIRTUAL SYSTEM FOR SECURITY EDUCATION 343
M. Gazdík, P. Kaňuch, P. Helebrandt

EXPLORING THE USE OF A CHATBOT TO MEASURE THE EMOTIONAL INTELLIGENCE OF TEACHERS AND STUDENTS IN HIGHER EDUCATION 348
L. Zheng, Y. Ding, T. Goh, C. Zheng, D. Xiao

COMMUNICATION IN ENGLISH AS A LINGUA FRANCA: CHALLENGES FOR TEACHING ENGLISH AS A FOREIGN LANGUAGE 353
P. Vettorel, M. Antonello

COVID-19 CHALLENGES ON STUDENTS' ONLINE LEARNING: SOUTH AFRICAN HIGHER EDUCATIONAL INSTITUTIONS PERSPECTIVES 361
R. Minty, R. Brink, A. Alao

FEEDBACK PRACTICES: HOW CAN COACHING ADDRESS THE NEED FOR DEEP COMMUNICATION TO SUPPORT STUDENT LEARNING AND WELL-BEING? 371
I. Langseth

PHENOMENA TRIGGERING HEURISTIC STRATEGIES IN SOLVING ATYPICAL WORD PROBLEMS 380
K. Mottlová, J. Slezáková

PERSONAL, PROFESSIONAL, AND COMMUNITY TRANSFORMATIONS TROUGH INTERNATIONAL TEACHER EXCHANGE PROGRAMS 386
M. Milian

OPEN EDUCATIONAL RESOURCES AND PRACTICES PROMOTING COLLABORATIVE CONSTRUCTION AND SHARING OF KNOWLEDGE AT LAUREA UNIVERSITY OF APPLIED SCIENCES 387
A. Helariutta, M. Fred

OUROUTE: CREATING A NEW GENERATION OF CULTURAL AMBASSADORS THROUGH EDUCATION AND TRAINING 388
C. Castro Dias, D. Pina, P. Costa

SCHOOL AND SOCIAL INCLUSION OF GIPSY ETHNIC YOUTH: THE INTERVENTION OF SPECIALIZED TECHNICIANS IN THE INTEGRATED PROGRAM OF EDUCATION AND TRAINING 397
S. Almeida

DIGITAL PEDAGOGIES IN TEACHER EDUCATION POST COVID-19 408
Y. Weinberger, M. Shonfeld

FINANCIAL LITERACY IN INVESTING: INTERACTIVE METHODS FOR BACHELOR'S PROGRAMS 415
S. Bekareva, A. Getmanova, A. Ivanova

INVESTIGATING THE RELATIONSHIP BETWEEN SPATIAL SKILLS AND ENGINEERING DESIGN 421
G. Raju, S. Sorby, C. Reid

BARRIERS TO THE UTILIZATION OF EDUCATIONAL SOFTWARE 427
R. Garrote Jurado, T. Pettersson, M. Zwierewicz

POST-PANDEMIC ARCHITECTURAL DESIGN PEDAGOGY 434
J. Kroft, L. De Bartolo, S. Agma, A. Weiss, V. Hui, L.D. Diaz

INVESTIGATING THE BENEFITS OF TRANSITIONING FROM FIXED-POINT TO NAVIGABLE VR 440
L. De Bartolo, A. Weiss, A. Huang, V. Hui

PLANNING AND TEACHING DEMO LESSONS TO DEVELOP ONE OF THE COMPETENCIES OF THE EXIT PROFILE IN THE ENGLISH LANGUAGE TEACHING (ELT) TRAINING PROGRAM AT UNAE, ECUADOR 450
U. Recino, D. Villagomez, J.G. Fajardo

WHAT IS BEHIND ARCHITECTURAL EDUCATION? SOFT SKILLS COMPETENCES IN 6 EUROPEAN SCHOOLS OF ARCHITECTURE 459
C. Sentieri Omarrementería

USING UNIVERSAL DESIGN GAME AS AN EDUCATIONAL TOOL – CASE RUFFPROTO 468
J. Lahti

PROBLEMS BASED LEARNING TO ESTIMATE FUTURE WATER AVAILABILITY DUE TO CLIMATE CHANGE 476
G. Ibarra-Berastegi

FAREWELL TO THE PANDEMIC AND FACING THE WAR: CONTEMPORARY CHALLENGES FOR HIGHER EDUCATION IN ROMANIA 477
G.A. Necula

EDUCATION AS A GREEN SOLUTION FOR REDUCING THE ECOLOGICAL FOOTPRINT 478
H. Friman, I. Banner, Y. Sitbon, Y. Einav, N. Shaked

GAMIFICATION AND CONTINUOUS LEARNING – ON A QUEST FOR MORE ENGAGING EDUCATION 484
P. Tapala

MOTIVATION STRATEGIES TO KEEP TRAINEES ENGAGED 491
E. Ciani, A. Laus

THE E-CLASSROOM EXPERIENCE OF INTERDISCIPLINARY CONTENT: SPANISH LANGUAGE SUPPORT 500
M.C. Santana-Rogers

IN-SERVICE EDUCATION OF TEACHING ASSISTANTS FOR PUPILS WITH INTELLECTUAL DISABILITIES SUPPORTED BY AUTO-ETHNOGRAPHIC RESEARCH 505
K. Becirovic, Z. Bagaric, D. Cerepinko

DIGITAL EDUCATIONAL CONTENT: INCLUSIVE PEDAGOGY AS A PUBLIC INNOVATION SCHEME TO STRENGTHEN CITIZEN LEARNING PROCESSES 512
J. Garcia, L. Pacheco, L. Alarcón, N. Parra, M. Silva, J. Bula

THE IMPACT OF FAMU SMART ACADEMIES 21ST CENTURY COMMUNITY LEARNING CENTER ON STUDENT PERFORMANCE: AN INNOVATIVE EDUCATION MODEL FOR ADDRESSING ACADEMIC DISPARITY 520
R. Ellis, Jr., T. McGriff, V. Wilson

THE INCLUSIVE CURRICULUM WORKGROUP: AFFIRMING ANTI-RACISM AND DIVERSITY IN THE WRITING PROGRAM 521
C. Wastal

IMPLEMENTATION OF INNOVATIVE METHODS IN THE TEACHING OF LITERARY EDUCATION FROM THE PERSPECTIVE OF TEACHERS AND UNIVERSITY STUDENTS 522
M. Mašát, K. Šmakalová, A. Štěpánková, L. Nosková, E. Marková, J. Hřivnová, J. Sladová

DESIGN THINKING SPRINTS IN HIGHER EDUCATION - THREE CASES AND APPROACHES 527
L. Wallenius

DO WE STILL NEED FULLY EQUIPPED LAB COMPUTERS AFTER THE PANDEMIC? 537
C. Pang, C. Anton

WOMEN AND STEM CAREERS: A CURRENT DIAGNOSIS OF THE SITUATION IN ECUADOR BASED ON LABOR MARKET INDICATORS 547
A. Guerrero, M.A. Ruano, C. Avilés, J. Mazzini

ONLINE MUSEUMS: A PEDAGOGIC TOOL TO FACILITATE OBJECT-ANALYSIS AND AN ENRICHED DECOLONISED LEARNING EXPERIENCE FOR FASHION DESIGN STUDENTS IN HIGHER EDUCATION DURING THE COVID-19 PANDEMIC 553
C. O'Shea

THE CHANGING CONDITIONS OF THE UNIVERSITIES—FROM THE FACE-TO-FACE EDUCATIONAL EXPERIENCE TO VIRTUAL LEARNING ECOSYSTEMS—HOW THIS AFFECTS THE DEVELOPMENT OF DEEP LEARNING AND CRITICAL REFLEXIVE THINKING 561
G. Sart

THE ADOLESCENT FOREIGN LANGUAGE CLASSROOM ANXIETY SCALE (AFLCAS) – PRELIMINARY RESULTS OF ITS APPLICATION AMONGST FRENCH-SPEAKING STUDENTS OF EFL IN SWISS SECONDARY SCHOOLS AND IMPLICATIONS FOR PRE-SERVICE TEACHER TRAINING 562
D. Bosmans, E. Jenny

HOW TO IMPROVE IT-BASED ENTREPRENEURSHIP EDUCATION COURSES AT THE UNIVERSITIES AND PREPARE THE STUDENTS FOR THE COMING ECONOMIC CRISES? 571
G. Sart

AN APPROACH TO FORMATION OF COMPETENCIES OF TEACHERS IN COMPUTER SCIENCE AND PHYSICS FOR IMPLEMENTATION OF ONLINE TRAINING 572
E. Goranova

HIGHER EDUCATION TEACHING TRANSFORMATION WITH EDUCATIONAL NEUROSCIENCE PRACTICES 579
M. Fragkaki, S. Mystakidis, K. Dimitropoulos

EXPERIENCES IN CREATING ONLINE LANGUAGE OFFERINGS IN INTERNATIONAL COOPERATION 585
M. Ohinen-Salvén, T. Hämäläinen

CHANGING THE CURRICULUM TO ENHANCE STUDENT LEARNING 590
J. Greeff, E. Taylor

LEADING A DEPARTMENT AT A HIGHER EDUCATION INSTITUTION DURING COVID: THE IMPORTANCE OF GROUP REFLECTION 601
E. Taylor, J. Greeff

TOWARDS A GENUINE STUDENT CENTERED APPROACH TO LEARNING 602
R. Andersen, C. Simonsen

NETWORK TESTING ENVIRONMENT BASED ON VIRTUALIZATION TECHNOLOGY - LAB SOLUTION 610
V. Šac, L. Havaš, D. Srpak, D. Godec

HERE WE GO AGAIN: DIDACTIC SUITABILITY ANALYSIS OF A STATISTICAL-GRAPHS TASK 619
H. Bogas, E. Morais, M.M. Nascimento

ALTERNATIVE ASSESSMENT IN THE EYES OF UNIVERSITY TEACHERS: EXPLORING THE RELATIONSHIPS BETWEEN TEACHERS' ATTITUDES, TEACHING ENVIRONMENT AND BEHAVIOUR 628
S.C. Kong, C.N. Yuen

RESEARCH AND ANALYSIS OF WORKING INDICATORS OF ONLINE LEARNING AS A DIFFERENT EDUCATIONAL ENVIRONMENT 636
V. Doneva, S. Tsankov

VIRTUALIZATION AS A TOOL TO ENCOURAGE ACTIVE LEARNING IN PRACTICAL LABORATORY CLASSES 644
G. Turnes, M. Bauzà, N. Crespí, C. Palomino

WHAT IS THE PURPOSE OF HIGHER EDUCATION IN ELECTRICAL ENGINEERING? HARD SKILLS OR SOFT SKILLS? 649
H. Friman, H. Ragones, M. Balberg

EXPLORING THE PEDAGOGIC PRACTICES OF TEACHING STAFF IN THE IRISH TECHNOLOGICAL HIGHER EDUCATION SECTOR USING TEACHING AND LEARNING REGIME THEORY 653
N. Harding

LANGUAGE, CULTURE AND FEEDBACK – AN EXPLORATION OF EUROPEAN STUDENTS' EXPERIENCES AND UNDERSTANDING OF FEEDBACK 665
M. Pazio

NOVICE TEACHERS – RETROSPECTIVE REFLECTIONS AT FIRST YEARS OF TEACHING 666
A. Moshe, P. Shavit

A MULTIDIMENSIONAL ASSESSMENT OF SELF-DETERMINATION IN STUDENTS WITH INTELLECTUAL DISABILITIES 667
P. Shavit

CREATION OF LEARNING SCENARIOS IN IMMERSIVE WORLDS WITH MINECRAFT EDUCATION EDITION 668
S.A. Casanova Valencia, M.A. Valenzo-Jiménez

MULTIDISCIPLINARY COLLABORATIVE APPROACH TO SYSTEMS CHANGE FOR SCHOOL MENTAL HEALTH 673
J. Freeny, A. Fulgiam Thurston, S. Haddad

DEVELOPMENT OF EMPLOYABILITY IN HIGHER EDUCATION: ADAPTATION THE EAS METHOD AND ITS IMPLEMENTATION 674
P. González-Navarro, L.I. Llinares-Insa, A.I. Córdoba-Iñesta, N. García-Serra, R. Zurriaga-Llorens, A.M. Casino-García

SOCIAL AND LABOUR INCLUSION. THE INSERTION ENTERPRISE AS DRIVERS OF DEVELOPMENT OF EMPLOYABILITY 680
L.I. Llinares-Insa, P. González-Navarro, S. Colomer-Cornejo

TRANSFORM-EDU: INCREASING GRADUATE EMPLOYABILITY THROUGH EMOTIONAL AND SOCIAL SKILLS DEVELOPMENT 685
A. Carthy, M. O'Regan, W. Chalmers, O. Philip

EDUCRO SUMMER CAMP FOR CULTURE AND TOURISM STUDENTS: BEST PRACTICES AND LESSONS LEARNT 686
O. Bogdanova

A PROPOSAL FOR EVALUATING EMERGENCY REMOTE EDUCATION BY CREATING A DIGITAL PORTFOLIO 691
N. Assuncao Minuzi, A. Helena Sonego, A. Goulart Rodrigues, A. Wisnieski de Oliveira, P. Behar, L. Rocha Machado

CROSS-LINGUISTIC INTERFERENCE IN MULTILINGUAL ACQUISITION: CHALLENGES, EXPERIENCE AND STRATEGIES FOR LEARNERS 698
O. Maximova, T. Soloveva

GROUP INFOGRAPHICS, PREPARATION, PRESENTATION AND DEBATE. COLLABORATIVE WORK IN THE UNIVERSITY CLASSROOM 707
M.A. Carabal-Montagud, M.B. De Miguel-Molina, M. De Miguel-Molina, D. Catalá-Pérez

FOCUS GROUP AS A QUALITATIVE EVALUATION TOOL OF A UNIVERSITY TEACHING PROJECT BASED ON INFOGRAPHICS, IN THE HERITAGE CONSERVATION AND RESTORATION AREA 715
M.A. Carabal-Montagud, M. De Miguel-Molina, V. Santamarina-Campos, M.B. De Miguel-Molina

NEW CHALLENGES FOR HIGHER EDUCATION: THE CASE OF DATING VIOLENCE 723
P. Nelas, C. Chaves, M. Ferreira, E. Coutinho, S. Campos

ENTREPRENEURIAL SELF-LEADERSHIP AND MINDFULNESS: CURRICULA OUTLINE AND EDUCATOR GUIDELINES 728
O. Bogdanova

EXAMINING THE AFFORDANCES OF VIDEO ANNOTATION SOFTWARE (VAS) TO ENHANCE ASSESSMENT PROCESSES 734
D. Shore, A. Ahmad, D. Amry, B. Cleaver, G. Bailey, N. Hu

PLAYING AT LEARNING DESIGN 742
K. Maridatter, J. Weines

INVOLVING THE LEARNERS IN HYBRID UNIVERSITIES: USE OF STUDENT´S GENERATED VIDEOS 747
A. Mendieta-Aragón, J. Navio-Marco

APPLICATION OF DIGITAL BOARDS AS AN INNOVATION FOR TEACHING IN BIOCHEMISTRY AND MOLECULAR BIOLOGY 748
M.J. Álvarez, M. Cuadros, C. Torres, V. Sánchez, L.J. Martínez, M.I. Rodríguez, V. Arenas-Rodríguez, S. Cuenca-López, P. Porras-Quesada, P. Sánchez

INVESTIGATION OF TEACHERS' ATTITUDES TOWARDS THE USE OF SPECIAL PROGRAMS, METHODS AND FORMS OF WORK WITH GIFTED STUDENTS IN THE REPUBLIC OF CROATIA 753
P. Nikolaus, M. Dželalija, N. Marangunić

EDUCATION OF SECURITY MANAGERS OF MEDICAL FACILITIES IN THE SLOVAK REPUBLIC 762
T. Loveček, L. Hadáček

USE OF VIRTUAL TOOLS IN THE DISSEMINATION OF DNA AND ITS APPLICATIONS 770
M.J. Álvarez, L.J. Martínez, M. Cuadros, C. Torres, V. Sánchez, M.I. Rodríguez, V. Arenas-Rodríguez, S. Cuenca-López, P. Porras-Quesada, P. Sánchez

PODCAST PRODUCTION AS A STUDENT-ACTIVE LEARNING ACTIVITY IN TEACHER EDUCATION 775
O. Hembre, S. Soensthagen

AN INTRODUCTION TO THE TOPIC OF NON-FUNGIBLE TOKENS FOR THE EDUCATIONAL SECTOR 776
A. Pfeiffer, S. Bezzina, N. Denk, V. Vella, A. Dingli

RETHINKING VISUAL ARTS EDUCATION WITH NEW TECHNOLOGIES AND RESOURCES DURING THE COVID PANDEMIC 782
L. Stefan, M. Motaianu, C. Motaianu

DELIVERING THE COMPUTING CURRICULUM ONLINE: CHALLENGES AND OPPORTUNITIES 792
O. Pishchukhina

GENDER DIFFERENCES IN SPATIAL THINKING ONLINE TRAINING 802
N. Segura Caballero, G. Maresch

FLIPPED-ICT METHODOLOGICAL EXPERIENCE FOR THEORETICAL AND PRACTICAL SUBJECTS OF DIFFERENT ENGINEERING DEGREES 809
S. Mateo Quero, M. Cuevas Aranda, S. Peinado Serrano, H. Silva de Araujo, A.J. Moya López

TEACHING PHRASAL VERBS: A PROJECT IMPLEMENTING H5P 819
L. Prades-Yerves

LEARNING TO PLAY AND PLAYING TO LEARN: AN ACCOUNT OF INTERCOMPREHENSIVE GAME-BASED LEARNING WITH MULTILINGUAL STUDENTS 826
K. Steil

INNOVATIVE ASSESSMENT AND FEEDBACK STRATEGIES IMPACTING KEY STAKEHOLDERS IN RELATION TO THE INDUSTRY PLACEMENT MODULE IN THE SCHOOL OF BUSINESS UNDERGRADUATE PROGRAMMES 835
C. Murphy, D. McSweeeney, M. Collins, E. O'Brien

HOW DO LEARNERS PERCEIVE TEAM TEACHING? DEVELOPMENT AND VALIDATION OF THE LEARNERS' TEAM TEACHING PERCEPTIONS QUESTIONNAIRE (LTTPQ) 843
M. Simons, D. De Weerdt

MOBILE SENIOR: A NEW SENIOR PROFILE FOR MOBILE DEVICE USE 852
L. Rocha Machado, A. Helena Sonego, J. Mendes, A. Goulart Rodrigues, P. Behar

FORMATION OF CONVERSATION SKILLS AMONG SECONDARY SCHOOL STUDENTS IN FOREIGN LANGUAGE CLASSES 861
E. Nazmieva, G. Chumarina, N. Pershina

THE ROLE OF USER-GENERATED CONTENT IN BRAND COMMUNICATION AND THE TACTICS TO ENCOURAGE IT 865
T. Limba, A. Šidlauskas, E. Juozėnaitė

EXPERIENTIAL LEARNING WHEN TEACHING THE TOPIC "IMPLEMENTATION OF HAMMING ENCODERS AND DECODERS USING COMPUTER-BASED TRAINING TOOLS" 872
A. Borodzhieva, I. Tsvetkova

IMPROVING THE RISK CULTURE BY EDUCATING MANAGERS IN THE ENTERPRISE 882
M. Hudáková, K. Kardoš

PROJECT-BASED LEARNING APPROACH USED FOR TEACHING AND LEARNING THE TOPIC "DESIGN OF INFINITE IMPULSE RESPONSE FILTERS IN MATLAB" IN THE COURSE "DIGITAL SIGNAL PROCESSING" DURING COVID-19 PANDEMIC 892
A. Borodzhieva, I. Tsvetkova

INNOVATION OF THE SECURITY MANAGEMENT PROGRAM OF THE FACULTY OF SECURITY ENGINEERING 901
K. Kampová

THE STUDY ON THE PROCESS OF INDIGENOUS KNOWLEDGE BASED TEACHING MATERIAL DEVELOPMENT IN TAIWAN 905
J.Y. Yang

INTEGRATING RESEARCH INTO STEM EDUCATION: APPLICATION TO WIND ENGINEERING 910
J. Estephan, A. Gan Chowdhury, E. Salna, J. Erwin, H. Landorf, R. Dou

ESCAPE PASSIVE LECTURES: AN INTERACTIVE, MULTI-THEMED DIGITAL ESCAPE ROOM ON MEDICINAL CHEMISTRY TOPICS 915
A.S. Abdul Rahim, K.M. Chuah

SPECIAL EXPONENTIAL DIOPHANTINE EQUATIONS 920
T. Riemel

BUILDING A SENSE OF LEARNING COMMUNITY DURING THE ENGLISH CLASSES AT THE "NICOLAE BALCESCU" LAND FORCES ACADEMY OF SIBIU 926
G. Mihaila Lica

TECHNICAL TRANSLATION IN TRANSLATOR TRAINING 930
G. Kovács

STUDYING BRITISH CULTURE – VISIT TO A LIBRARY 938
G. Kovács, I. Gönczi

CAN THE TRANSTHEORETICAL MODEL OF CHANGE BE USED TO MODIFY ORGAN DONATION BEHAVIOR IN NURSING STUDENTS? 946
S. Coronil-Espinosa, P. Bas-Sarmiento, M. Fernandez-Gutierrez, M. Poza-Méndez

THE IMPERATIVE OF STUDENTS AND TEACHERS' WELL-BEING IN FINNISH UNIVERSITY: A BIBLIOMETRIC APPROACH 953
S. Olaleye, E. Olaleye

AUTOMATED GENERATION OF MANDARIN EDUCATIONAL MULTIMEDIA CONTENT FROM EXISTING ENGLISH CONTENT 963
M.J. Israel, A. Qin, Y. Zhang, J. Xin, N. Shaghaghi

DISTANCE EDUCATION METHODS IN A PANDEMIC SITUATION FOR STUDYING THE TOPIC "INVESTIGATING COVERAGE AND INTERFERENCE IN MOBILE CELLULAR NETWORKS" 973
I. Tsvetkova, A. Borodzhieva

INTERACTIVE METHODS DURING ONLINE LEARNING WHEN TEACHING THE TOPIC "SPECTRAL ANALYSIS OF SIGNAL HARMONICS" 983
I. Tsvetkova, A. Borodzhieva

DEVELOPMENT OF RISKY BEHAVIOR OF PUPILS AND ITS PREVENTION AT CZECH PRIMARY SCHOOLS DURING THE COVID-19 PANDEMIC AND DISTANCE LEARNING 991
M. Krajňáková, T. Čech

TAPPING INTO POWER OF VISUALS TO ENHANCE EFL STUDENTS' COMMUNICATIVE SKILLS 996
R. Yakhina, D. Dudkova

TEACHING OF PERIODIC NON-SINUSOIDAL MODES OF ELECTRICAL CIRCUITS VIA SOFTWARE ENVIRONMENTS 1001
V. Raydovska

IMPLEMENTING A FLIPPED CLASSROOM IN THE REMOTE ONLINE LEARNING ENVIRONMENT 1010
K. Adzima

THE FORMATION OF PROFESSIONAL COMMUNICATION COMPETENCE IN RUSSIAN OF FOREIGN POSTGRADUATES NON-PHILOLOGISTS 1011
L. Iarkina, V. Abyshkina, Y. Merkulova, D. Maryanovich

THE TEACHING OF ARCHITECTURE IN TIMES OF PANDEMIC: NEW TECHNOLOGIES IN COLLABORATION IN THE INTERACTION BETWEEN STUDENTS AND TEACHERS 1016
N. Soares de Araujo, A. Piffer

A BIBLIOMETRIC APPROACH TO GLOBAL TEACHER'S TRAINING AND SUPPORT 1024
S. Olaleye

AN APPROACH TO TEACHING PROJECTILE VELOCITY MEASUREMENT IN BALLISTICS 1032
J. Skala, M. Macko, I. Pemcak, K. Abraham, Z. Krist, M. Cervenka

BURNOUT SYNDROME AND STRESS MANAGEMENT OF TEACHERS 1041
I. Plevová, L. Váchová, M. Pugnerová, V. Kavková, S. Dobešová Cakirpaloglu, J. Kvintová, B. Kvapilová

THE EXPERIENCE OF MOBBING AND THE NEGATIVE IMPACT ON THE PERCEIVED PERSONAL DISCOMFORT IN PRIMARY SCHOOL TEACHERS 1049
M. Pugnerová, I. Plevová, L. Váchová, S. Dobešová Cakirpaloglu, J. Kvintová, J. Dočkalová

WORKING TOWARDS EQUITY OF ACCESS AND SUCCESS IN STEM AT STELLENBOSCH UNIVERSITY IN SOUTH AFRICA 1059
M. Mouton

TOOLS TO IMPROVE EFFICIENCY AND CONSISTENCY IN ASSESSMENT PRACTICES WHILST DELIVERING MEANINGFUL FEEDBACK 1069
N. Palmer

A FRAMEWORK FOR CENTERING INTRODUCTORY STATISTICS AROUND THE LOGIC OF INFERENCE 1079
R. Pierce, M. Brenneman, A. Dehili

FRACTURES AT L1 AND T12 VERTEBRAE: A FOLLOW-UP COMPUTED TOMOGRAPHY SCAN AFTER TWO YEARS SHOWING BONE SPURS 1089
D. Moeller, K. Budisalich, C. Gunter, M. Myler, T. Kelsey, G. Maddux, B. Schroer

TRAINING OF A DIVERSE SCIENCE WORKFORCE IN A UNIVERSITY-INDUSTRY-GOVERNMENT RESEARCH PARTNERSHIP: CENTER FOR CELLULAR CONSTRUCTION 1099
F. Bayliss, Z. Gartner, W. Marshall, K. Rath, A. Peterfreund

TECHNOLOGIES IN LITERARY EDUCATION 1110
J. Hrinak

OBSERVATION IN ENGLISH LANGUAGE PEDAGOGY RESEARCH 1115
J. Hrinak

DEVELOPING AND EMPOWERING AUTONOMOUS LEARNERS DURING AND POST-PANDEMIC 1122
P. Koayess, J. Althawahrih, M. Massara

THE NATIONAL DIGITAL ACCESS IMPERATIVE FOR 4IR: ASSESSING DIGITAL SKILLS COMPETENCE IN RURAL SOUTH AFRICA 1123
B. Ngoqo

MANIFESTATIONS OF SOCIAL EXCLUSION OF STUDENTS: SCIENTIFIC AND PRACTICAL ASPECTS AND EVALUATION OF THE EFFECTIVENESS OF THE TEACHING STAFF 1132
N. Havrylova, L. Platash, O. Havrylov, O. Konstantyniv

WHERE DO WE GO FROM HERE? DIDACTIC AND ORGANIZATIONAL QUESTIONS AFTER THE PANDEMIC 1144
S. Willermark, M. Abrahamsson, L. Adolfsson, M. Frykman, M. Gellerstedt, P. Nilsson, L. Svensson

ONLINE EVENTS AS A TOOL TO DEVELOP STUDENTS' PROJECT MANAGEMENT SKILLS 1152
L. Bellotti, A. Kimberley

OUTREACH ACTIVITIES ON INSTAGRAM IMPROVE EDUCATIONAL AND PHYSIOLOGY COMPETENCIES: RELATIONSHIP WITH THE COURSE OF THE ENROLLED DEGREE 1153
A. Santana-Garrido, S. Arguelles, M.L. Carrascal-Moreno, M.D. Vázquez-Carretero, P. García-Miranda, F. Nogales, C.M. Vázquez, P.A. Nuñez-Abades, M.L. Calonge, M.J. Peral, M.M. Cano, A. Mate, O. Carreras, M.L. Ojeda

DESIGNING TEACHING MATERIAL FOR WORKPLACE PEDAGOGY IN SCHOOL 1154
S. Carlsson, S. Willermark

USING INSTAGRAM TO INCREASE UNIVERSITY EDUCATIONAL SKILLS. THE PROFESSORS' POINT OF VIEW 1160
M.L. Ojeda, S. Arguelles, A. Mate, M.L. Carrascal-Moreno, M.D. Vázquez-Carretero, P. García-Miranda, F. Nogales, C.M. Vázquez, P.A. Nuñez-Abades, M.L. Calonge, M.J. Peral, M.M. Cano, O. Carreras, A. Santana-Garrido

A REFLECTIVE PRACTICE PERSPECTIVE ON DEVELOPING PROFESSIONAL DIGITAL COMPETENCE AMONG TEACHERS 1168
H. Haugsbakken, S. Brynildsen

SAGE SOFTWARE FOR MOODLE VIA SAGE CELL: HOW TO ENHANCE THE LEARNING ENVIRONMENT WITH MATHEMATICAL SOFTWARE 1177
J. Jánský, J. Jekl, V. Růžička

RESEARCHING PSYCHOLOGICAL SAFETY AMONG WELFARE AND INNOVATION STUDENTS 1186
G. Andersson, B.B. Sæthern, A.M. Gløммen, T.Å. Langvik, P.A. Sandhaug, O. Hallgren, K.K. Westbye

ROLE-PLAY GAME APPLIED TO MATHS TEACHING: REPRESENTATIONS OF PUPILS ABOUT A DIGITAL ROLE-PLAY GAMING PLATFORM 1194
M. Cruz, P. Medeiros, E. Nunes

RELATIONSHIP OF DIFFERENT ASSESSMENT TYPES IN AN ONLINE INTERDISCIPLINARY COURSE 1203
A. Millet, E. Dinc, H. Mccune Bruhn, M. Feineman

ENTREPRENEURSHIP AND INNOVATION IN EDUCATION: LEADING CHANGE 1209
S. Davis, P. Holanchock

SUPPORT MEASURES AGAINST COVID-19 FOR SCHOOL INSTITUTIONS: A LINED PROPOSAL WITH TECHNOLOGIES BASED ON ARTIFICIAL INTELLIGENCE 1214
R. Coutinho, P. Notargiacomo

ASSESSMENTS IN E-LEARNING ENVIRONMENTS 1215
O. García, F. Leon, M. Pineda, A. Aguilar

FORMATION OF SOFT SKILLS AMONG MANAGEMENT STUDENTS DURING COVID-19 1221
S. Shchelokova, I. Suslova

APPLICATION OF REVERSE ENGINEERING TECHNIQUES FOR LEARNING MANUFACTURING PROCESSES 1226
E. García-Martínez, V. Miguel, A. Molina-Yagüe, A. Martínez-Martínez

ONOMASTICS KNOWLEDGE OF HUNGARIAN MINORITY SECONDARY GRAMMAR AND TRADE SCHOOL STUDENTS OF SLOVAKIA 1235
L. Angyal

THE POSSIBILITIES OF HUNGARIAN TOPONYMIC RESEARCH IN EDUCATION IN SLOVAKIA 1244
L. Angyal

A SOCIOMATERIAL CONNECTIVIST PERSPECTIVE: A NEED FOR DEVELOPING ALGORITHMIC COMPETENCE 1252
H. Haugsbakken

MEDICAL ENGLISH FOR ACADEMIC PURPOSES: THE IMPACT OF A NEW GUIDE FOR POSTGRADUATES ON DEVELOPING SPECIFIC COMMUNICATION SKILLS 1262
A. Barnau, N. Ferková

THE MOST COMMON MISTAKES IN TRANSLATION FROM LATIN AND GREEK INTO MEDICAL ENGLISH: THE ANALYSIS OF WRITTEN TESTS AT JESSENIUS FACULTY OF MEDICINE IN SLOVAKIA 1268
A. Barnau, M. Čovan

INTRODUCING AN ACCESSIBLE TASK-BASED LEARNING (ATBL) APPROACH TO INCLUSIVE ENGLISH LANGUAGE TEACHING (IELT) AT THE UNIVERSITY OF VERONA 1273
S. Hartle, E. Tenca

VIRTUAL SERVICE-LEARNING: A TOOL TO IMPROVE STUDENTS' SKILLS TRAINING AND EMPLOYABILITY 1274
M.C. González Rabanal, A.J. Acevedo Blanco

ENGLISH LEARNING INFANTS: EXPERIENCES OF FAMILIES 1280
A. Güven, C. Demirci

PRE-SERVICE TEACHERS' VIEWS OF DIFFERENT ANIMAL WELFARE ISSUES: IMPLICATIONS FOR TEACHER TRAINING COURSES 1281
A. Almeida

THE DEVELOPMENT OF CRITICAL THINKING IN SCIENCE: A CASE STUDY WITH STUDENTS OF THE 5TH YEAR OF SCHOOLING 1290
J. Lino, A. Almeida

DIGITAL TECHNOLOGIES RESPONSIVENESS AND IMPACT TO THE DISRUPTED TEACHING AND LEARNING DURING LOCKDOWN IN HIGHER EDUCATION 1296
P. Molomo

BUILDING A COLLEGIAL APPROACH TO STUDENT ENGAGEMENT AND TECHNOLOGY-ENHANCED LEARNING INITIATIVES 1303
K. Green, K. Newell, S. Downie, P. Stapley, J. Steele, T. Mitchell, J. Sampson, P. Else, H. Groeller, B. Meyer, M. Brown, D. McGhee, X.F. Huang

INDIGENOUS LITERATURE IN THE TEACHING OF PORTUGUESE AS A FOREIGN LANGUAGE IN HIGHER EDUCATION 1304
M. Silva

A STUDY ON THE EFFECTIVENESS OF REMEDIAL LESSONS IN MATHEMATICS AND PHYSICS FOR POLYTECHNIC FOUNDATION PROGRAMME STUDENTS 1310
A. Dewanto, M. Lim, P. Phang

INTEGRATION OF EDUCATIONAL ADMINISTRATION ECOSYSTEM MODEL COMPONENTS FOR SUSTAINABLE DEVELOPMENT 1316
K. Niedre-Lathere, A. Samuseviča

APPLICATION OF DESIGN THINKING IN THE UNIVERSITY OF DEFENCE STUDENT'S LEARNING PROCESS 1324
L. Rak, Ľ. Hradský

DESIGN AND VALIDATION OF A GUIDELINE TO SUPPORT THE IMPLEMENTATION OF SYSTEMIC RESILIENCE PRACTICES WITHIN ENTERPRISES 1329
B. Arenas, A. Solomon, A. Morgado, I. Rafail, R. Comas Forgas

COVID-19 AND LEARNING: PERCEPTIONS OF 4TH GRADE STUDENTS 1331
C. Ferreira, A. Bastos

ENHANCING THE EMPLOYABILITY OF HIGHLY EDUCATED IMMIGRANTS IN COLLABORATION WITH A HIGHER EDUCATION INSTITUTION AND LOCAL EMPLOYMENT SERVICES 1336
A. Karjalainen

CHALLENGES AND BENEFITS TO SOFTWARE ENGINEERING GROUP PROJECT CONTEXTS 1342
E.M. Watson

EXPLORING THE EFFICACY OF A RANGE OF CRITICAL THINKING AND PROBLEM SOLVING TECHNIQUES IN DEVELOPING AN INSTRUCTOR GUIDE 1349
D. Gordon, P. Doyle, A. Becevel, T. Baloh

THE LINK BETWEEN EMOTIONAL INTELLIGENCE AND PERSONALITY 1357
S. Lemrová, S. Dobesova Cakirpaloglu, B. Kvapilová, I. Balaban Cakirpaloglu

E-PORTFOLIO AND REFLECTION: POWERFUL PEDAGOGICAL TOOL FOR LEARNING 1364
Y. Amadu, Y. Oheneba-Sakyi

INSTAGRAF 2.0 A LEARNING TOOL. NEW CHALLENGES AND OPPORTUNITIES TO IMPROVE UNIVERSITY LEARNING 1368
B. López-Plaza, M.C. Lozano-Estevan, A. Aparicio, L.G. González-Rodríguez, L.M. Bermejo, V. Loria-Kohen, A. Peral-Suárez, M.D. Salas-González, A.M. Lorenzo Mora, J.F. Duran Guio, M.M. Larrosa Pérez, R.M. Ortega Anta, A.M. López-Sobaler

LAB MATH: A CREATIVE LABORATORY FOR RENEWED MATHEMATICAL LEARNING 1377
Y. Cerezo López, M.C. Valbuena Martínez

RUBRICS FOR THE SELF-ASSESSMENT OF SCALE MODELS AND DRAWINGS IN INDUSTRIAL DESIGN: THE IMPORTANCE OF USING DETAILED PERFORMANCE-LEVEL DESCRIPTIONS 1384
F. Felip

INDIAN SCIENCE TEACHERS RELUCTANCE TO ENGAGE IN INQUIRY METHODOLOGY 1393
D. Cline

PROBLEM SOLVING SKILLS: ANALYSIS OF THE RELATIONSHIPS BETWEEN COMPUTATIONAL THINKING AND READING COMPREHENSION 1394
A. Kakucs, K. Harangus

DOCTORAL STUDENTS' SELF-ASSESSED KNOWLEDGE AND ABILITY IN TERMS OF RESEARCH METHODS 1402
W.M. Phyo, M. Nikolov, A. Hodi

REFLECTIVE TEACHING AND LEARNING IN TEACHER EDUCATION: CHALLENGES AND POSSIBILITIES 1412
R. Bubnys

ACADEMIC DISHONESTY AMONGST POSTGRADUATE STUDENTS: THE EVOLUTION OF MISCONDUCT BASED ON EXPERTS' KNOWLEDGE 1413
R. Comas Forgas, A. Cerdà-Navarro, L. Moreno-Herrera, J. Sureda-Negre

DESIGNING EXHIBITION SPACE TO SUPPORT EARLY CHILDHOOD EDUCATION IN SCIENCE MUSEUMS: THE COMPASS OF THE NATIONAL MUSEUM OF NATURE AND SCIENCE IN JAPAN 1414
A. Takahashi, E. Yamaguchi, S. Inagaki

VALIDATING A CROSS-CULTURAL MEASURE OF EPISTEMIC COGNITION IN SCIENCE–AN EFA APPROACH 1418
D. Cairns

A COMPLEX INTERVENTION FOR INCLUSIVE KINDERGARTENS – ANALYSIS OF A SOZIALMARIE PRIZE WINNER INNOVATION IN BUDAPEST 1419
I.J. Kovács, É. Deák, G. Erőss

CAN WE INVESTIGATE SOMETHING WE CANNOT SEE? STIMULATING CRITICAL THINKING ABOUT KNOWLEDGE IN THE HISTORY AND SCIENCE CLASS 1424
L. Van Den Broeck, B. Delanote, L. Vervacke, V. Verschoren, J. De Schrijver

UNPACKING SOCIAL MEDIA CONVERSATIONS TO FIND PRODUCTIVE DIALOGUE 1432
K. Ekman

TEACHER NETWORK ADDING VALUE FOR STUDENTS 1441
T.C. Votkin, H. Laurikainen

IS THE EARTH WITHOUT PEOPLE A BETTER WORLD? STIMULATING REFLECTION ABOUT SUSTAINABILITY IN STEM COURSES 1442
V. Verschoren, L. Van Den Broeck, E. Cornelissen, S. Raeman, F. Mennes, J. De Schrijver

VIRTUAL TEAMS AS AN ARENA FOR LEARNING IN ONLINE EDUCATION - PERSPECTIVES FROM STUDENTS 1449
P.A. Godejord

GREEN GROWTH: TOWARDS THE DECARBONISATION OF THE CONSTRUCTION SECTOR THROUGH VOCATIONAL EDUCATION AND TRAINING 1455
C. García, F. Bertelmann-Angenendt, C. Bricteux, N. Chpiliotoff, C. Frey, V. Kuzma, V. Laroche, J. Longmuss, A. Palatinus, L. Pavan, B. Remacle

URSTEAM: A NEW ACADEMIC PROPOSAL OF THE UNIVERSIDAD DEL ROSARIO IN RESPONSE TO NEW DYNAMICS OF SOCIETY 1463
R. Méndez-Romero, G. Castelblanco-Arias, S. Pulgarín-Molina, C. Mancera

SWEDISH IN FINLAND - A MOOC PROMOTING INTEGRATION 1468
S. Sevón, T.C. Votkin

ACTIVITIES, ACHIEVEMENTS AND ABILITIES: A MODEL FOR EMBEDDING MENTAL WELLBEING IN TECHNOLOGY-ENHANCED LEARNING 1469
K. Lister

CORRELATION OF TRADITIONAL AND DIGITAL CONTROL FORMS IN THE PROCESS OF TEACHING FOREIGN LANGUAGES 1480
L. Moskovkin, E. Selezneva, E. Chernovets, E. Chirkova

ONLINE AND FACE-TO-FACE TEACHING PHYSICS USING AN INTERACTIVE METHOD - VIDEO ANALYSIS 1485
P. Hockicko, G. Tarjányiová, J. Kúdelčík

THE STRATEGY FOR EDUCATION AND IMPLEMENTATION OF PHOTOGRAMMETRIC 3D DIGITIZATION IN CULTURAL HERITAGE INSTITUTIONS 1495
V. Stojaković, R. Obradović, I. Đurić, I. Vasiljević, M. Obradović, J. Kićanović

3D DIGITIZATION AND VIRTUAL APPLICATION AS TOOLS FOR EDUCATION ABOUT CULTURAL HERITAGE 1496
I. Đurić, I. Vasiljević, M. Obradović, J. Kićanović, V. Stojaković, R. Obradović

RESEARCH ADVANCEMENT ACTIVITIES AS A VECTOR FOR EXECUTIVE EDUCATIONAL LEADERSHIP PRACTICES 1505
L. Kvinikadze, N. Campbell, J. Crockett

THE ROLE OF DOCTORAL STUDENTS' MOTIVATION AND ANXIETY IN THEIR ENGLISH ACADEMIC WRITING 1515
W.M. Phyo, M. Nikolov, A. Hodi

FROM A PERSONAL TO A MORE SOCIAL VIEW OF STUDENTS' ACADEMIC PERFORMANCE: THE IMPORTANCE OF PEER SELECTION AT UNIVERSITY 1522
J.V. Tomás-Miquel, J. Capó-I-Vicedo, J. Capó-Vicedo

TEACHER'S PERSONAL AND PROFESSIONAL GROWTH THROUGH REFLECTION: RESULTS OF A LONG-TERM ONE CASE STUDY 1527
R. Bubnys, N. Kaunickienė

DESIGNING AND PROGRAMMING GAME-BASED LEARNING WITH HUMANOID ROBOTS: A CASE STUDY OF THE MULTIMODAL "MAKE OR DO" ENGLISH GRAMMAR GAME WITH THE PEPPER ROBOT 1537
I. Buchem, A. Mc Elroy, R. Tutul

THE SIMULATION OF SCIENTIFIC CONFERENCES AS A LEARNING TOOL IN THE SUBJECT OF ORAL IMPLANTOLOGY 1546
M.D. Gómez-Adrián, C. Larrazábal-Morón, J. Enciso-Ripoll, J. Barberá-Millán, J. Espinosa-Giménez, L. Miralles-Jordá, B. Gil-Marqués

360-DEGREE CURRICULUM REVIEW OF AN ONLINE PROFESSIONAL MASTER'S PROGRAM 1547
W. Lu, B. Zoghi

PROSPECTS FOR DATA CENTER INDUSTRY EDUCATIONAL OUTREACH PROGRAMS IN THE STATE OF TEXAS 1557
D. Day, R. Mody, B. Zoghi

THE CONCEPT OF QUALITY IN HIGHER EDUCATION FROM THE PERSPECTIVE OF STUDENTS: IMPLICATIONS FOR THE UNIVERSITIES QUALITY MANAGEMENT SYSTEM 1567
M. Varela, M.L. Neves, R. Fragoso

CREATING INNOVATIVE METHODOLOGIES FOR VET STUDENTS TO CARRY OUT VIRTUAL INTERNSHIPS IN TECHNOLOGY COMPANIES 1574
L. Gómez Estrada, L. Pietra, L. Gómez Estrada, S. Randaccio, C. Zoli, V. García Ortuño, R. Navarro Cerveró, J. S. Nunes, P. Carrolaggi, P. Karampelas, C. Solano Martínez, J.L. Gómez Ribelles, A. Soriano Martínez

INTEGRATING CULTURAL AWARENESS INTO THE ENGINEERING DESIGN PROCESS 1583
P. Gorder

RELATIONSHIPS AMONG TEACHER BELIEFS ABOUT STEAM EDUCATION, PERCEPTIONS OF SCHOOL CLIMATE, AND ENACTED PRACTICES 1591
J.P. Stein, J. Craven

GAMIFICATION IN ELECTRICAL / ELECTRONIC ENGINEERING EDUCATION: THE USE OF KAHOOT IN A COURSE ON TELECOMMUNICATIONS 1592
N. Voudoukis, G. Pagiatakis, D. Uzunidis

A POSSIBLE MASSIVE OPEN ON-LINE COURSE (MOOC) ON TELECOMMUNICATIONS 1598
N. Voudoukis, G. Pagiatakis, D. Uzunidis

EDUCATIONAL ESCAPE ROOMS: A BIBLIOMETRIC ANALYSIS 1603
A.S. Abdul Rahim, M.I. Ismail, A. Razali

JEWISH AND ARAB TEACHERS' ATTITUDES TOWARDS TEACHING SECOND AND FOREIGN LANGUAGE IN ISRAEL 1612
K. Kawar

A MENTORING PROGRAM FOR THE INTEGRATION OF NEWLY ARRIVED MIGRANTS INTO THE SCHOOL ENVIRONMENT OF THE HOST COUNTRY 1613
I. Xenophontos, P. Kosmas, E. Xeni

SR BATTLESHIP 1619
L. Square

GLOBALIZATION, ACCREDITATION, AND TEACHER EDUCATION IN THE EMIRATES 1626
K. Gallagher, A. Dillon, R. Tamim

APPLICATION OF LOW-COST SENSORS IN THE INNOVATION OF TEACHING BIOMEDICAL ENGINEERING 1631
J. Kúdelčík, P. Hockicko

IMPLICIT VALUES AND AUTOBIOGRAPHICAL OBJECTS: RAISING AWARENESS IN UNIVERSITY EDUCATIONAL CONTEXTS 1637
M. De Simone, F. Marone, A. De Simone

STUDYING OF ACTIVE LOW-PASS FILTERS VIA VIRTUAL ENVIRONMENTS IN ENGINEERING EDUCATION 1646
V. Raydovska

SPEAK YOUR MIND: INTRODUCING APTLY, THE SOFTWARE PLATFORM THAT TURNS IDEAS INTO WORKING APPS 1653
D.Y.J. Kim, A. Granquist, E. Patton, M. Friedman, H. Abelson

RESEARCH-BASED LEARNING APPLIED TO TEACHING IN BUILDING DEGREE COURSES 1661
C. Morón, D. Ferrández, M. Alvarez, J.P. Diaz Velilla

EUROPEAN PROJECTS MOTIVATE STUDENTS TO PARTICIPATE IN INTERNATIONAL CO-CREATION WORKSHOPS IN A DESIGN THINKING COLLABORATIVE LEARNING APPROACH 1668
M. Caetano, S. Mendes, R. Gamboa

GOALS FOR SUSTAINABLE DEVELOPMENT IN UNIVERSITY EDUCATION: COOPERATION THROUGH EELISA COMMUNITIES 1672
D. Ferrández, M. Fernández, A. Zaragoza, C. Morón

EXPERIENCES OF TEACHING AND LEARNING WITH SOCIAL ROBOTS 1678
S. Ekström

IMPROVING THE QUALITY AND INNOVATION OF HIGHER EDUCATION IN THE STUDY PROGRAM CRISIS MANAGEMENT 1686
K. Buganová, E. Mošková

ANALYSIS OF STUDENTS' OPINION ABOUT NECESSITY OF EDUCATION IN THE FIELD OF "NEUROREHABILITATION IN NEUROLOGICAL COMPLICATIONS OF COVID-19" 1693
R. Yoshinov, I. Koleva, B. Yoshinov

RELATIONSHIP BETWEEN THE IMPLEMENTATION OF PROFESSIONAL REFLECTION FREQUENCY AND THE DIFFICULTY OF APPLYING THE DIAGNOSTIC COMPETENCE OF MENTOR TEACHERS 1699
R. Orosová, M. Novocký, K. Petríková

COMPARISON OF FIRMS' INNOVATION DETERMINANTS IN THE ERA OF OPEN INNOVATION: CENTRAL EUROPEAN CASE FOR EFFICIENT UNIVERSITY-INDUSTRY COOPERATION 1706
L. Růžičková, V. Prokop, J. Stejskal, F. Ur Rehman

THE EFFECTS OF PUBLIC SUBSIDIES ON FIRMS' INNOVATION AS A FORM OF INDUSTRY-GOVERNMENT PARTNERSHIP: COMPARISON OF WESTERN AND CENTRAL EUROPEAN COUNTRIES 1713
M. Mazel, V. Prokop, J. Stejskal, F. Ur Rehman

ELECTRONIC LEARNING IN THE EDUCATIONAL MODULE "NEUROREHABILITATION IN NEURO-COVID" (WITH CLINICAL CASES) 1719
I. Koleva, B. Yoshinov, R. Yoshinov

THE HYBRID CLASSROOM: POST-COVID19 SUCCESS FACTORS AND SPECIFICATIONS FOR DUAL-MODE TEACHING AND LEARNING 1728
D. MacKevett, P. Feubli

INFORMATIVE CAPSULES AS A DISRUPTIVE TOOL FOR AUTONOMOUS STUDENT LEARNING IN UNIVERSITY ARCHITECTURE STUDIES 1736
P. Miguel-Sin Monge, A. San José Cabrero, S. Domínguez Gil, G. Ramírez Pacheco

THE STEAMONEDU ONTOLOGY: A SEMANTIC WEB ONTOLOGY FOR STE(A)M EDUCATION 1744
N. Spyropoulou, A. Kameas

IMPROVING SKILLS AND EMPLOYABILITY POTENTIAL OF UNIVERSITY STUDENTS 1754
M. Lusková, K. Buganová

CONTEMPORARY INFORMATION AND COMMUNICATIONS TECHNOLOGIES IN THE LEARNING PROCESS: CASE OF UNDERGRADUATE STUDIES IN TOURISM 1759
I. Tsener

PROFESSIONAL REFLECTION TYPES OF HIGH SCHOOL TEACHERS AS PREDICTORS OF BURNOUT 1763
M. Novocký, R. Orosová, K. Petríková

PRE-SERVICE TEACHERS ENGAGING IN CO-TEACHING: A TRANSFORMATIVE LEARNING PERSPECTIVE 1771
B. Lenong

PARENTS' VIEWS ON THE ORGANIZATION OF ONLINE EDUCATIONAL PRACTICE IN KINDERGARTEN 1778
S. Tomaš, M. Vrdoljak, D. Delić

ANATOMY TALKING BOOK AND PODCAST: ASSISTIVE TECHNOLOGY IN HIGHER EDUCATION CONTRIBUTING TO INCLUSIVE EDUCATION IN HEALTH COURSES 1787
T. Lima, L. Martins, C. Rodrigues, N. Pedro, L. Santiago, T. Oliveira, R.M. Mariani Braz

EXPLORING GLOBAL CONNECTIONS VIA PLACE- BASED IMMERSION WITHIN THE QUARTIER OF BELLEVILLE: AN URBAN REFUGE FOR REVOLUTIONARIES, BOHEMIANS, ARTISTS, AND IMMIGRANTS IN THE CITY OF LIGHT 1788
J. Strait

EXPERIENCES WITH A MULTIDISCIPLINARY PROJECT AT THE PREPARATORY COURSE FOR ENGINEERING STUDIES 1798
T. Schjem, V. Talmo, E. Krystad, H. Røli Karlsen

THE EFFECT OF THE COMPUTATIONAL ACTION PROCESS ON STUDENTS' SOFTWARE PROTOTYPE IDEAS 1804
H. N. Pang, R. Parks, C. Breazeal, H. Abelson

DIGITAL REALITIES IN EDUCATION: PROJECTS IMPLEMENTED USING AUGMENTED REALITY IN PORTUGAL 1815
P.N. Rito

AUGMENTED REALITY IN PORTUGAL: ITS USE, ITS DEVELOPMENT, AND CONTEXTS 1823
P.N. Rito

AN EXAMINATION OF SECONDARY READING INTERVENTIONS FOR SPECIAL EDUCATION AND THE RESULTING DEPARTMENT RESOURCE TO SUPPORT OUR STUDENTS 1831
J. Fundine

SIBLINGS OF STUDENTS WITH DISABILITIES: A (NON)EXISTENT CATEGORY OF STUDENT POPULATION? 1840
A. Blazevic Simic

DESIGN THINKING ONLINE IS FOR EVERYBODY EVERYWHERE 1848
C. J. Vallis

TEACHING PROGRAMMING ON ZOOM—LESSONS LEARNED FROM VIRTUAL CLASSES IN THE TIMES OF COVID-19 1849
X.Y. Suo

PILOTING THE LEARNING BY DEVELOPING ACTION MODEL PEDAGOGY IN FINLAND HEIS 1856
T. Lintilä, M. Zarb

MICROHISTORY, MUNICIPAL ARCHIVES AND DIGITIZATION: SOME OBSERVATIONS FROM BULGARIA 1866
H. Atanasov, P. Stamenova

ICT IN SERVICE OF COLLECTING INFORMATION ON THE ARCHIVAL DOCUMENTARY HERITAGE OF THE BULGARIAN REVIVAL 1872
H. Atanasov, Y. Nikolov, I. Marinova

ASSESSING THE LEVEL OF TEACHERS' COMPUTATIONAL THINKING SKILLS THROUGH TASK-BASED LEARNING IN SCRATCH 1880
V. Voinohovska, J. Doncheva

ASSESSMENT OF ALGORITHMIC AND LOGICAL THINKING OF FIRST- AND SECOND-YEAR COMPUTER SCIENCE STUDENTS AT J. SELYE UNIVERSITY IN ACADEMIC YEARS 2019/20 AND 2021/22 1888
L. Végh, Š. Gubo

STUDY OF USING SCRATCH AS AN INNOVATIVE TOOL OF ESTABLISHING CONDITIONS FOR AN INTERDISCIPLINARY-ORIENTED LEARNING PROCESS 1896
V. Voinohovska, J. Doncheva

BECOMING A REFLEXIVE PROFESSIONAL 1904
A. Kimberley

ACTIVITIES FOCUSED ON MATHEMATICAL PRE-LITERACY DEVELOPMENT USING THE BEE-BOT INTERACTIVE TOY 1916
M. Uhlířová, J. Laitochová, K. Skládalová

THE CONTRADICTION IN STUDENTS' DECISION-MAKING WHEN CHOOSING A FIELD OF STUDY AND THE REAL NEEDS OF EMPLOYERS ON THE LABOUR MARKET 1922
V. Blašková, H. Stojanova

VALUES EDUCATION WITH CONTEMPLATIVE PRACTICES FOR MEDICAL STUDENTS 1931
F. Marone, M. De Simone

WIDENING ACCESS INTERVENTIONS TO ENABLE ENGAGEMENT IN HIGHER EDUCATION 1941
C. O'Donnell, B. Murphy, B. Hunter, A. Toye

CREATING INTERACTIVE DATA DASHBOARDS TO INFORM WIDENING ACCESS POLICY AND PRACTICE DECISION MAKING AT ULSTER UNIVERSITY 1942
C. O'Donnell, B. Murphy

UNIVERSITY TUTORING BEFORE AND AFTER COVID-19: AN EXPERIENCE OF REDESIGN FROM THE UNIVERSITY OF PADUA (ITALY) 1944
R. Bonelli, A. Bonin, L. Da Re

THE "DOUBLE SELECTION" MECHANISM AND PUBLIC INTERVENTIONS AIMED AT STRENGTHENING STUDENTS' COMPETENCIES – THE CASE OF THE COMPETENCE DEVELOPMENT PROGRAMME IN POLAND 1953
M. Jelonek

RECOGNISING AND ADDRESSING MATHS ANXIETY WITHIN MATURE STEM STUDENTS AT A DISTANCE LEARNING UNIVERSITY 1954
S. Pawley, S. Organ

WORKING GENDERPRO(O)F IN ECEC 1955
L. Vandenbussche, E. De Latter, H. Van Liefferinge

E-SERVICE-LEARNING: A GERONTOLOGICAL SOCIAL WORK APPROACH 1956
D. Monteiro, C. Vieira da Silva

'THOSE EXCLUDED FROM WITHIN': BARRIERS TO LEARNING AND ETHNICITY IN THE BULGARIAN SOCIAL SPACE (AN EMPIRICAL CASE) 1957
M. Tasheva, R. Madgarova, A. Epitropova, S. Penkova

GENDER (IN)EQUALITIES IN EDUCATION: THE CASE OF BULGARIA 1963
S. Penkova, M. Kadieva, M. Tasheva, A. Epitropova

ABOUT SOME ASPECTS OF THE TEACHING OF INTERDISCIPLINARY UNDERGRADUATE SUBJECTS 1972
L. Kalandadze

RECOGNISING NEW TRENDS IN VET TOWARDS GREEN TRANSITION: EXPERIENCE FROM NORTH MACEDONIA 1978
M. Velkovska, V. Gecevska, R. Polenakovikj, T. Velkovski, B. Jovanovski, L. Polenakovikj, N. Shterjova Uzunovska, J. Kostikj

CHALLENGING THE BELIEFS THAT SYNCHRONOUS ONLINE LECTURE ATTENDANCE CORRELATES TO STUDENTS' OVERALL GRADE 1985
B.Y. Toh, N. Buchanan

EXAMINING STUDENT INNOVATIVE BEHAVIOR IN UNDERGRADUATE MAKERSPACE-BASED COURSES VIA INDUSTRY-BASED ENTREPRENEURIAL FRAMEWORK 1995
S. Supraja, F.S. Lim, S. Tan, S. Y. Ho, B.K. Ng, A.W.H. Khong

BUILDING BRIDGES – HOW CAN TEACHERS AND STUDENTS IN THE APPLIED SOCIAL SCIENCES FACILITATE EFFECTIVE LEARNING COMMUNITIES IN THE DIGITAL CLASSROOM? 2001
N. Weimann-Sandig

SYSTEMS THINKING AS A KEY COMPETENCE FOR SUSTAINABLE DEVELOPMENT AND DIGITAL TRANSFORMATION 2006
S. Armenia, G. Tsaples, J. Papathanasiou, F. Barnabé, S. Nazir

AFTER THE PANDEMIC, HOW MUCH "DIGITAL LITERACY EDUCATION" DO PRE-SERVICE TEACHERS WANT AND NEED? RESULTS OF A STUDENT SERVEY AND THE CONSEQUENCES FOR TEACHER TRAINING 2012
G. Marci-Boehncke, X.C. Meyer

LITERARY VALUES - DIGITAL TOOLS 2020
A. Pokrivčák

THE IMPACT OF INCLUSIVE EDUCATION ON NATIONAL DEVELOPMENT - EVIDENCE FROM NIGERIA 2024
R.A. Sijuola

DEVELOPING SCIENCE SKILLS IN PRESCHOOLERS: PRESENTATION OF THE PROJECT ERASMUS+ "N'EURO NEST 3.0" 2033
V.A. Gazdac, M.E. Cîmpean, M.D. Bocoș

LEARNING IN THE MUSEUM AND THE CHALLENGES OF STEAM LEARNING 2038
R. Lebedova, M. Sapundzhiev

LEARNING BY DOING – PROMPTING THE RESEARCH INTEREST AND CREATIVE PERFORMANCE OF STUDENTS 2044
R. Lebedova, M. Sapundzhiev

LONGITUDINAL STUDY OF LEARNING OUTCOMES DURING COVID FOR BACHELORS GRADUATES IN COMPUTER SCIENCE 2050
K. Berkling, D. Saller, C. Winter, J. Winkler

FUTURE CAREER EXPECTATIONS OF COLLEGE STUDENTS WITH AND WITHOUT LEARNING DISABILITIES AND/OR ADD/ADHD 2058
R. Michael, M. Zakai-Mashiach, P. Shavit

THE MORE SUPPORT UNDERGRADUATES RECEIVE, THE GRITTIER THEY ARE 2059
Z. Lu

INFORMATION TECHNOLOGIES IN FOREIGN LANGUAGE TEACHING AND LEARNING: META-ANALYSIS OF RESEARCH IN SLOVAKIA 2066
B. Horvathova

INTERNATIONAL TALENTS' LANGUAGE LEARNING AND INTEGRATION SUPPORTED WITH ONE-STOP SERVICE 2072
J. Viinanen

STRENGTHENING THE CRITICAL THINKING OF STUDENT TEACHERS BY APPLYING AN INTERVENTION PROGRAMME 2073
M. Kosturková

FACTORS IMPACTING THE APPLICATION OF FORMAL ASSESSMENTS IN INTERMEDIATE PHASE MATHEMATICS IN SOUTH AFRICA 2080
S. Sibanda, A. Rambuda

DEPARTMENT HEADS' MANAGEMENT OF TEACHING IN PRIMARY SCHOOLS 2081
P. Kalane, A. Rambuda

DEVELOPING AN INTEGRATED FRAMEWORK FOR ANALYZING WAYS OF REASONING IN MATHEMATICS 2082
S. Sevinc, I. Kohanová, M. Isiksal-Bostan, Z. Kubáček, I. Isler-Baykal, M. Lada, E. Cakiroglu, B. Di Paola

ORGANIZATIONAL CAPACITY BUILDING FOR ICT-MEDIATED TEACHING AND LEARNING PROCESSES IN A HIGHER EDUCATION INSTITUTION IN MEDELLIN, COLOMBIA 2090
J. Tabares-Quiroz, V. Salazar-Molina, S. Garcia-Gutiérrez, S. Gómez-Jaramillo

FROM INFORMATIVE PRACTICES TO COMMUNICATIVE PRACTICES IN THE MEDIATION OF INFORMATION AND COMMUNICATION TECHNOLOGIES (ICT) IN A HIGHER EDUCATION ORGANIZATION 2098
J. Tabares-Quiroz, J. Macías-Prada, J. González-Duque

REMARKS TO ORGANIZATIONAL FACTORS OF THE ACADEMIC ENGAGEMENT AT THE UNIVERSITY 2099
T. Corejova, A. Corejova

PARENTAL ENGAGEMENT IN SCHOOL: TRENDS, CHALLENGES AND OPPORTUNITIES 2107
D. Dias, R. Barroso

THE COGNITIVE DEVELOPMENT OF CHILDREN THROUGH RAVEN'S COLOURED PROGRESSIVE MATRICES: WHEN WHERE MATTERS 2114
R. Barroso, D. Dias

INTERNATIONAL PROJECT ABOUT THE INTRODUCTION OF TRADITIONAL KNOWLEDGE ON MEDICINAL PLANTS AMONG STUDENTS OF HEALTH SCIENCES 2121
J.R. Vallejo, H. Arco, S. Roque, J.A. González, M.C. Carrasco, M.E. Gómez-Navarro, S. Postigo-Mota

LEARNING MANAGEMENT SYSTEMS: IS IT TIME FOR A NEW GENERATION? 2122
A. Molinari

SUPPORTING STUDENTS THROUGH INCREASING THEIR SELF-EFFICACY 2131
K. Mullamaa

PEDAGOGY STUDENTS' AWARENESS OF THEIR OWN DIGITAL FOOTPRINTS 2136
J. Miková, R. Kárníková, H. Mičková

DUAL LANGUAGE POLICIES TO INTERNATIONALIZE JAPANESE HIGHER EDUCATION: LANGUAGE SEPARATION WITHIN INTERNATIONAL STUDENTS? 2143
M. Shibata, A. Staicov

SEXUAL DIVERSITY AND HEALTH SYSTEM HUMANIZATION. DESIGN, IMPLEMENTATION AND OUTCOMES ANALYSIS OF AN INNOVATIVE HIGHER EDUCATION CURRICULUM 2151
G. Giorgi, V. Carmona, C. Del Campo, M. Vazquez, B. López-Plaza, L.G. González-Rodríguez

CULTURE IN CRISIS: PRESERVING THE ROMAGNOLO LANGUAGE THROUGH EDUCATION, KNOWLEDGE, AND TECHNOLOGICAL IMPACTS 2159
A. Christie, T. Nailor, O. Baiocchi

INDUSTRY VERIFIED SKILLS BLOCKCHAIN SYSTEM (IVS) 2163
A. Elmessiry, M. Elmessiry, M. Elmessiry

GATELOG: EDUCATIONAL VIDEO GAME TO SUPPORT THE TEACHING OF DIGITAL ELECTRONIC CIRCUITS 2169
B.S. Vera Moreno, D.M. Rivera Pinzón

APPLICATION IN VIRTUAL REALITY FOR THE LEARNING OF CONCEPTS ASSOCIATED WITH SPATIAL SOUND 2176
M.L. Franco Rojas, D.M. Rivera Pinzón

"HEY, TEACHERS, LEAVE THE KIDS ALONE!" INCREASING STUDENTS' MOTIVATION FOR LEARNING ENGLISH 2185
D.E. Tutuianu

TWO HEADS ARE BETTER THAN ONE! PROJECT-BASED ENGLISH CLASSES – PARTICULAR BENEFITS FOR MILITARY STUDENTS 2186
D.E. Tutuianu

CZECH LEARNERS' FREQUENT MISTAKES IN ENGLISH WRITING 2187
M. Šikolová, L. Koláčková, M. Veselá

A NARRATIVE INQUIRY ON SOUTH KOREAN CULTURE EXPERIENCE OF GHANAIAN STUDENTS THROUGH CRITICAL MULTICULTURALISM 2192
Y.Y. Chen, C. Hur

CHILDREN'S RIGHTS IN THE PEDAGOGICAL ENVIRONMENT 2202
B. Ilieva, N. Shopova

CORRELATION OF CHARACTERISTICS OF PERSONAL SELF-DETERMINATION AMONG STUDENTS WITH DISABILITIES 2207
Y. Selivanova, A. Sharov, M. Konovalova, O. Hmelkova, E. Shchetinina

ENCOURAGING SOCIAL INTERACTION OF STUDENTS WITH VISUAL IMPAIRMENTS IN MAINSTREAM PRIMARY SCHOOLS IN THE REPUBLIC OF CROATIA 2211
A. Blazevic Simic, D. Noll

TEACHING ADVANCED PROGRAMMING WITH COMPETITIONS 2219
X.Y. Suo

GENDER IDENTITY OF PERSONALITY 2224
L. Osadcha, N. Komisarenko, O. Oliinyk, E. Polishchuk, L. Movchan

THE REMOTELY WORK CHALLENGES OF LATVIAN PHYSIOTHERAPISTS DURING THE CORONAVIRUS PANDEMIC PERIOD 2225
A. Kaupuzs, I. Kaminska, E. Gorbunova

TEACHING FINNISH AS A SECOND LANGUAGE TO INTERNATIONAL EXPERTS OF THE HIGHER EDUCATION 2232
A. Elg

INPUTS IN MY BLOCKS IN THE SCRATCH PROGRAMMING SECONDARY PUPILS 2233
M. Tomcsányiová

SHAPING PRE-SERVICE TEACHERS' BELIEFS ABOUT TEACHING ENGLISH GRAMMAR: LONGITUDINAL RESEARCH FINDINGS 2241
M. Siposova, P. Ostradicky

SUCCESSFUL ENGLISH GRAMMAR INSTRUCTION SHOULD BE MULTI-FACETED AND ECLECTIC 2250
M. Siposova, I. Jurikova

PICTURIZING STRATEGY: INTRODUCING A NEW PARTICIPATORY INTERVIEW TOOL IN RESEARCH WITH YOUNG CHILDREN 2260
R. Tkotzyk, J. Lategahn, G. Marci-Boehncke

INNOVATIVE METHODOLOGIES TO FACE HARASSMENT AND SCHOOL LEAVING AND STOP HATE SPEECH IN EUROPE 2266
J.L. Gómez Ribelles, R. Navarro Cerveró, V. García Ortuño, R. Sixto Iglesias, M. Ferré, M.J. Jiménez Cortiñas, F. Celdrán Martínez, P. Carrolaggi, M. Duarte Oliveira, N. Kovac, C. Zoli

CRISIS SITUATIONS AS AN INNOVATIVE ELEMENT OF GEOGRAPHICAL EDUCATION IN THE SLOVAK REPUBLIC 2272
H. Kramáreková, D. Jakusová, M. Nemčíková, D. Oremusová

LOCAL LANDSCAPE GEOGRAPHY TEXTBOOKS IN THE SLOVAK REPUBLIC EDUCATIONAL PRACTICE 2282
D. Oremusová, M. Nemčíková, H. Kramáreková, Z. Jenisová

A MODEL OF PERCEPTION OF INSTRUMENTAL MUSICAL WORKS IN PRESCHOOL AND PRIMARY SCHOOL AGE "TELL ME MUSIC" 2291
S. Smilkova

THE INTEGRATION OF 3D PRINTING AND ADVANCED INDUSTRIAL ROBOTICS IN TRADITIONAL MICRO AND SMALL ENTERPRISES THROUGH EDUCATION: ACCESS-3DP PROJECT 2298
A. Muñoz Puche, G. Cañavate Cruzado, J.C. Bañón Guillén, F.J. Melero Muñoz, J. Garrido Lova

LITHUANIAN LANGUAGE AND CULTURE COURSE AS A KEY FACTOR IN UKRAINIAN REFUGEES' INCLUSION 2304
J. Pivoriene, O. Merfeldaite, I. Palomo-Domínguez

A BIONIC APPROACH THROUGH EDUCATION - CREATION OF A TRAINING MATERIAL ON 4.0 TECHNOLOGIES, LEADERSHIP AND TALENT PROMOTION IN THE FRAMEWORK OF THE GIST PROJECT 2314
A. Muñoz Puche, F.J. Melero Muñoz, J.J. Ortega Gras, C. González González, J. Garrido Lova

WHAT TO PRIORITIZE IN BUILDING ACADEMIC DIGITAL CAPACITY: USING SELFIE TO SUPPORT DIGITAL DEVELOPMENT IN SCHOOLS 2321
C. Pulfrey, C. Caneva

USING VARIOUS TEACHING STRATEGIES TO KEEP STUDENTS ENGAGED DURING THE COVID-19 PANDEMIC 2322
S.S. Ling

UNIVERSITY-INDUSTRY COOPERATION IN AREA OF ADDITIVE MANUFACTURING: A CASE STUDY 2329
M. Ťavodová, M. Dado, M. Vargová, P. Beňo

BIOGAS OBTAINING FROM WASTES GENERATED IN UNIVERSITY CAMPUSES: PRACTICAL CASE STUDY BASED ON TRANSDISCIPLINARY LEARNING 2336
M. Gonzalez Alriols, A. Ibarrondo, A. García, A.P. Aravena, H. Otxandategi, E. Onaindia, J.D. Núñez, I. Barrio, M.M. Antxustegi

THE ROLE OF COGNITIVE FLEXIBILITY IN LINGUISTIC AND NUMERIC SKILLS AMONG KINDERGARTEN AND FIRST-GRADE CHILDREN 2340
D. Cohen, S. Shaul

EXPLORING THE CONTRIBUTION OF LINGUISTIC, COGNITIVE AND CULTURAL FACTORS IN SCIENCE TEACHING AND KNOWLEDGE BUILDING WITH A FOCUS ON MATHEMATICS AND COMPUTER SCIENCE 2341
M. Kritikou, D. Tsolis

IMPLICATIONS OF GENERATIVE DESIGN METHODOLOGY IN DESIGN EDUCATION PROCEDURES 2349
D. Medrán, M.M. Espinosa, R. Prádanos Del Pico, M. Domínguez

INTERCULTURAL COMPETENCE THROUGH TRANSFORMATION 2357
K. Schneider

DETERMINATION OF THE LEVEL OF READING LITERACY OF PRIMARY SCHOOL PUPILS IN AN INTERNATIONAL CONTEXT 2358
M. Žišková

WHAT IS THE EFFECT OF EMOTIONAL ENGAGEMENT AND BULLYING ON ACHIEVEMENT GAP: MULTILEVEL ANALYSIS 2363
S. Raiziene, D. Sevalneva, R. Erentaite

HUMAN CHALLENGES SCHOOLS FACE IN THEIR QUEST FOR DIGITAL INTEGRATION AND HOW TO OVERCOME THEM 2364
C. Pulfrey, C. Caneva

BUILDING PARTICIPATION IN THE CHILD PROTECTION SYSTEM THROUGH THE PROCESS OF CONSTRUCTION OF A CARE LEAVERS-LED POLICY. FIRST REFLECTIONS FROM THE EUROPEAN CARING PROJECT 2365
C.C. Montà

MOODLE DESIGN OF A MANDATORY MASSIVE PHYSICS COURSE FOR AGRONOMIC ENGINEERING DEGREE 2371
L. Amy, R. Eyheralde, P. Ferrúa

AMBIENT LEARNING SPACES: CHANCES AND CHALLENGES OF INTERACTIVE KNOWLEDGE MEDIA PLATFORMS FOR SCHOOLS AND MUSEUMS 2378
M. Herczeg

GENDER PERSPECTIVE IN A PROGRAMMING COURSE 2389
C. Manresa-Yee, J.M. Buades Rubio, A. Oliver, G. Moyà Alcover, S. Ramis, M. Orell

THE ORCA ECOSYSTEM - ADVANCING THE MISSION OF OER TOGETHER THROUGH COMPETENCES IN THE NETWORK 2395
A. Niemann, S. Schotemeier, C. Funk

COMBINING CRITICAL THINKING WITH DIGITAL SKILLS IN EUROPEAN CONTEXT: AN EXAMPLE OF PROJECT "PLATO'S EU" 2403
B. Ćurko, A. Kovačević, M. Pavlic

THE LEVEL OF KNOWLEDGE OF SECONDARY SCHOOL STUDENTS IN PROVIDING FIRST AID 2408
R. Lenková, I. Boržíková, T. Lukáčová

RISK FACTORS OF HEALTH-RELATED BEHAVIOUR OF SLOVAK UNDERGRADUATES AND THE POSSIBILITIES OF APPLYING PREVENTIVE EDUCATIONAL STRATEGIES 2415
I. Boržíková, R. Lenková, F. Pajonková

CROSS-CULTURAL AND LINGUISTIC INTERACTION IN THE CONTEXT OF TEACHING FOREIGN LANGUAGES AND MINIMISING STUDENTS' MISTAKES 2425
M. Egorova, T. Zapata Ruiz

CHRONICITY AT SCHOOL: FROM BARRIER TO LEARNING RESOURCE 2432
G. Cucuzza

COULD THE UNIVERSITIES AND PHILOSOPHY HELP US CREATE A MORE DEMOCRATIC SOCIETY? 2440
D. Kováčová, B. Baďurová, V. Strahovnik

ENTREPRENEURSHIP AND PEDAGOGICAL INNOVATION IN THE CLASSROOM THROUGH A SCRUM-BASED EDUCATIONAL METHODOLOGY: A PRACTICAL LEARNING EXPERIENCE IN AN UNDERGRADUATE COURSE IN SPAIN 2446
J.V. Tomás-Miquel, A.E. Fotă, P. Rodríguez-Máñez, A. Gajownik

THE ROLE OF LEADERSHIP IN PROMOTING SOCIAL RESPONSIBILITY IN HIGHER EDUCATION 2455
A. Albuquerque, S. Fernandes, P. Morais, A. Pereira

MANAGING STRESS IN ONLINE DISSERTATION STUDENTS: A MULTIPLE CASE STUDY OF FACULTY PERCEPTIONS OF LOWERING STUDENTS' AFFECTIVE FILTER 2465
L. Bedford, A. Babcock

DO ICT SELF-EFFICACY BELIEFS PREDICT ACTUAL DIGITAL LITERACY? EVIDENCE FROM LITERATURE IN THE SCHOOL CONTEXT 2470
T.L.A. Nguyen, A. Habók

LOOKING FOR ALTERNATIVE CONCEPTIONS ABOUT LIGHT IN COLOMBIAN RURAL STUDENTS 2475
L.C. Arboleda-Hernandez, C.P. Suarez Rodriguez, D.F. Becerra Rodríguez

USING SOCIAL MEDIA TO IMPROVE STUDENT ENGAGEMENT AND SUCCESS IN A LARGE INTRODUCTORY UNIVERSITY-LEVEL SCIENCE COURSE 2484
A. Fujimoto-Strait, R. Guida

KIELIBUUSTI (LANGUAGE BOOST) PROJECT: DEVELOPING BETTER LEARNING POSSIBILITIES OF FINNISH AND SWEDISH FOR INTERNATIONAL EXPERTS. PROJECT GOALS AND DEVELOPMENT PRINCIPLES 2485
S. Heinzmann

HARM MINIMIZATION: A TOBACCO REDUCTION FOR YOUTH PROGRAM 2486
N. Piquette, K. Haight, O. Awosoga

EDUCATIONAL ASPECTS OF THE PERCEPTION OF BILINGUAL VISUAL LANGUAGE USE AMONG HUNGARIANS IN SLOVAKIA 2487
K. Presinszky

THE MULTILINGUAL LINGUISTIC LANDSCAPE AS A MULTIDISCIPLINARY ELEMENT OF THE CURRICULUM 2493
K. Presinszky

DEVELOPMENT OF A 3D PRINTED MODEL OF A FULL SIZE HUMAN SKULL FROM A CT SCAN WITHOUT AN IV CONTRAST AGENT: ANATOMY TRAINING SIMULATOR FOR NURSING STUDENTS 2500
K. Budisalich, H. Schroer, C. Tverberg, D. Moeller, G. Maddux, B. Schroer

ANALYSIS OF THE OPPORTUNITIES FOR OBTAINING NEW KNOWLEDGE FROM ANCIENT MANUSCRIPTS 2510
K. Rasheva-Yordanova, I. Dimitrova, G. Dimitrov

3D PRINTED MODELS OF A COLLAPSED/PUNCTURED LUNG AND THE CORRESPONDING HEALED LUNG: DEVELOPMENT AND APPLICATION FOR ADVANCED NURSING STUDENT TRAINING 2516
K. Budisalich, C. Gunter, C. Tverberg, D. Moeller, G. Maddux, B. Schroer

SAFETY FROM THE PERSPECTIVE OF UNIVERSITY STUDENTS WITH DISABILITIES 2526
A. Hanakova, B. Hudcova, T. Hrudova, K. Krahulcova, K. Kroupova, M. Potmesil, V. Ruzickova, K. Simunkova, G. Spinarova, E. Urbanovska, V. Vachalova

SUPPORTING PARENTS AS PARTNERS IN EDUCATION: MEASURING THE IMPACT OF AN EXPERIENTIAL INTERVENTION PROGRAMME ON VIRTUAL LEARNING ENVIRONMENTS IN POST-PRIMARY SCHOOLS 2533
D. Qualter

ACCOUNTABILITY, PREEMPTION AND SCHOOL CHOICE: INTERGOVERNMENTAL TENSIONS AND THE CASE OF FLORIDA 2534
C. Herrington

USE OF A VOICE ASSISTANT TO SUPPORT THE DEVELOPMENT OF INFORMATION MANAGEMENT SKILLS 2539
G. De la Cruz Martínez, E. Cruz Hernández, S.M. Martínez Ramírez

INTRODUCING THE ENTREPRENEURIAL MINDSET, DELIBERATE PRACTICE IN A RURAL TOURISM CONTEXT: A CASE STUDY 2545
D. Wilborne, J. Ludwig, P. Hackbert

DOES STUDENT-CENTERED INSTRUCTION MATTER? INVESTIGATING UNDERGRADUATE STUDENTS' PERCEPTIONS ON PROOF 2553
Y.Y. Ko, A. Johnson, M. Rose

SO, YOU WANT TO SET UP A FAB LAB: REALIZATIONS IN RUNNING A MAKER SPACE IN A PHILIPPINE HIGH SCHOOL 2554
J. Alcarez

THE SUMMARY STRATEGY AND THE PERFORMANCE OF STUDENTS IN THE SUBJECT OF SCIENTIFIC RESEARCH METHODS 2564
J. Flores, R. Ordoñez, D. Anzules

THE SUSTAINABLE DEVELOPMENT OF THE AERONAUTICAL SECTOR FROM A SOCIO-ENVIRONMENTAL APPROACH 2570
R. Florencio da Silva, A.D. Torres-Rivera, R. Chavero López, J.O. Escobedo Alva, M.A. Mendoza Becerril, A.J. Mc Namara Valdes, D. Linares Ramíres

CULTURAL ACTIVITIES AS A TEACHING METHOD FOR ENVIRONMENT CONSERVATION IN VISTA HERMOSA, MEXICO CITY 2575
A.J. Mc Namara Valdes, L.A. Garcia-Serrano, R. Florencio da Silva

ACCESSIBILITY AND SAFETY IN THE CONTEXT OF PERSONS WITH DISABILITIES OR SPECIFIC NEEDS - A MONITORED ISSUE IN RESEARCH CONCEPTS 2580
A. Hanakova, B. Hudcova, T. Hrudova, K. Krahulcova, K. Kroupova, M. Potmesil, V. Ruzickova, K. Simunkova, G. Spinarova, E. Urbanovska, V. Vachalova, J. Zvedelikova

SHARING THE LEARNING BY DEVELOPING MODEL IN AN INTERNATIONAL CONTEXT 2590
M. Ekström, J. Aalto

MACHINE LEARNING TO EXPLOIT MASSIVE OPEN ONLINE COURSES LEARNING PROCESS DATA 2597
J. Toutouh, B. Bossavit

ELEMENTS OF POSITIVE PEDAGOGY, METHODS OF IMPLEMENTATION AND INFLUENCE IN THE EVOLUTION OF PERFORMANCE IN EDUCATION 2607
L.M. Popescu (Iacob), VA. Enachescu

INITIAL ASSESSMENT OF THE INFLUENCE OF THE WAR IN UKRAINE ON THE DEVELOPMENT OF PROFESSIONAL EDUCATION OF MILITARY ENGINEERING OFFICERS 2612
J. Kompan, J. Jančo, M. Hrnčiar

CHALLENGES FOR THE DEVELOPMENT OF THE MILITARY EDUCATION FOR THE DEPLOYMENT OF DECLARED FORCES IN UN PEACEKEEPING OPERATIONS 2618
M. Hrnčiar, J. Kompan

STUDENTS' SELF-ASSESSMENT OF ENTREPRENEURSHIP COMPETENCE IN THE STUDY PROCESS – LATVIAN CASE STUDY 2624
A. Slišāne, G. Lāma, A. Oļesika, Z. Rubene

MIND-MAPPING AS A DIDACTIC TOOL IMPLEMENTED IN E-LEARNING 2633
M. Piotrowska

OPPORTUNITIES AND CHALLENGES IN THE EDUCATION OF PRISONERS IN THE REPUBLIC OF CROATIA 2634
A. Jandrić Nišević

REFLECTIONS ON A COURSE ABOUT RADICAL DISCOURSES AND THE DIGITAL PUBLIC SPHERE AT A SOUTH AFRICAN UNIVERSITY 2642
L. Dalvit

LEVEL OF SELECTED ELEMENTS OF COMMUNICATIVE COMPETENCIES AMONG PRIMARY SCHOOL TEACHERS IN THE CZECH REPUBLIC 2643
R. Kárníková, J. Miková

ADAPTATION OF CRISIS MANAGEMENT STUDY PROGRAM TO THE NEEDS OF IMPROVING THE QUALITY OF LIFE OF THE POPULATION 2652
S. Strelcová, A. Kelíšek, J. Kubás, P. Prievozník

FROM PROMOTION TO PERSUASION: SUPPORT AS ESSENTIAL NEXT STEP FOR ESTABLISHING OPEN EDUCATIONAL RESOURCES AT UNIVERSITIES 2659
M. Kopp, N. Linschinger, K. Neuböck

INTERACTIVE OPEN-SOURCE SOFTWARE TOOL FOR TEACHING AND LEARNING CONTROL SYSTEMS DESIGN 2669
H. Meneses Navarro, J. Louzao, O. Arrieta, R. Vilanova

OPPORTUNITIES FOR THE DEVELOPMENT OF COMMUNICATIVE COMPETENCIES OF ELEMENTARY SCHOOLS TEACHERS IN THE CZECH REPUBLIC 2679
R. Kárníková, M. Fasnerová

HYBRID/VIRTUAL PHYSICAL COMPUTING PROTOTYPING HANDS-ON LABORATORY DURING COVID-19 PANDEMIC 2688
P. Perego, P. Bobrova

THE FOOD SYSTEM FACING THE CHALLENGE OF CLIMATE CHANGE: A ROLE PLAY 2696
D. Pereira, J. Urquijo-Reguera, M.T. Gómez-Villarino, P. Páez-Maldonado, J. López-Santiago, C.G. Hernández Díaz-Ambrona, A.I. García-García

OPENING A NEW DISCOURSE FOR ENTREPRENEURSHIP EDUCATION: MOVING BEYOND SQUARE PEGS IN ROUND HOLES 2703
C. Donaldson, J. Villagrasa

PRACTICAL INSIGHTS FOR ASSESSING STUDENT PROGRESS IN THE ENTREPRENEURIAL CLASSROOM 2711
C. Donaldson, J. Villagrasa, F. Sanchez

LEARNING THROUGH FASHION ARCHIVES: THE CASE OF THE GIANFRANCO FERRÉ ARCHIVE 2718
V. Cognini, F. Vacca

STUDENT SATISFACTION WITH VIRTUAL TOOLS AT UNIVERSITY 2726
M. Lara, J. Flores, S. van Der Meer, I. Bezemer

3D PRINTING FOR THE OPTIMISATION OF RESOURCES IN TEACHING PRACTICES IN THE PHYSICAL OPTICS LABORATORY 2727
C. Vázquez Ferri, J. Espinosa Tomás, J. Pérez Rodríguez, E. Perales Romero, B. Domenech Amigot, C. Hernádez Poveda

SPECIAL CITATION INDEX FOR EVALUATION OF SCIENTIFIC WORK TOPICALITY IN THE CONTEXT OF KNOWLEDGE TRANSFER 2728
V. L'vov, Y. Kikhaiev, I. Novikova, O. Bediukh

PERSONALIZED AND SELF REGULATED LEARNING AND ONTOLOGY-BASED KNOWLEDGE MODELS IN THE CLOUD 2737
T. Ivanova

TEACHER'S PROFESSIONAL DEVELOPMENT – CURRENT TRENDS AND CHALLENGES FOR TEACHERS IN SLOVAKIA 2747
J. Ferencova

ACTION RESEARCH – A METHOD OF SUPPORTING CHANGE IN SCHOOLS? 2755
J. Ferencova

SOCIOEMOTIONAL COMPETENCES DEVELOPMENT IN ARCHITECTURE DEGREE & MASTER STUDENTS IN SPAIN 2764
S. Domínguez Gil, P. Miguel-Sin Monge, A. San José Cabrero, G. Ramírez Pacheco

FEEDBACK ON A ROBOTIC PROJECT FOR COMPETENCY-BASED LEARNING IN FRENCH UNIVERSITY BACHELOR OF TECHNOLOGY 2769
N. Lardenois, J. Chevrie, L. Vermeiren

WIDENING THE HIGHER EDUCATION COMMUNITY: EXPANDING AND DIGITALLY ENHANCING CUSTOMER JOURNEYS FOR SMALLER-SIZED BUSINESSES THROUGH MASTERS PROJECTS AND THEN THROUGH PRESENTATIONS AT CO-WORKING COMMUNITY SPACES 2778
Y.H. Tsai, M. Macintyre, S. Street

THE STATE OF KNOWLEDGE OF TEACHERS AND EDUCATORS IN PRIMARY AND SECONDARY EDUCATION ON CYBER THREATS CHALLENGING STUDENTS ON A DAILY BASIS - PROPOSAL OF PREVENTION AND TRAINING AREAS 2781
D. Siemieniecka, K. Majewska

THE DISABLED CHILDREN'S PERCEPTION OF THEIR PARTICULAR HEALTH CONDITION: TRUTH OR CHALLENGE 2790
I.A. Maruşca

LESSONS LEARNED FROM TEACHING IN THE PANDEMIC: IMPACTS, RESPONSES AND WHAT WORKED 2795
M. Carroll, F. Constantinou

NON-STANDARD (PROSPECTIVE?) PLACES TO LEARN, I.E. SUPPORTING SCHOOLS ACTIVITIES WITH LOCAL ENVIRONMENT RESOURCES 2796
A. Kulpa-Puczyńska

LESSONS LEARNT FROM HAVING TO ADAPT TO THE COVID PANDEMIC IN A HIGHER EDUCATION INSTITUTION IN THE UK 2797
A. Battaglia

GAME DESIGN FOR TEACHING, LEARNING AND ASSESSMENT 2805
S. Bezzina, A. Dingli, A. Pfeiffer, T. Wernbacher

PERCEPTIONS BY TEACHERS-BEGINNERS OF THEIR PREPARATIONFOR PEDAGOGICAL WORK AT PRIMARY SCHOOL DURING STUDY AT HIGH EDUCATION ESTABLISHMENT IN LATVIA 2809
J. Davidova, S. Zariņa

ONLINE BIBLIOTHERAPY PUBLICATIONS IN BULGARIA: A TRAINING ELEMENT IN THE PERIOD OF GLOBAL PANDEMIC 2816
S. Eftimova

DESIGNING ONLINE ASSESSMENTS RELIABLY ROBUST TO CHEATING FROM QUESTION BANKS 2821
R. Pierce, M. Brenneman

THE INFLUENCE OF 21ST CENTURY SKILLS ON THE TRANSITION TO HIGHER EDUCATION 2822
K. Pap, M. Baars

IMPLEMENTING COMPUTATIONAL THINKING MODULES: PRE-UNIVERSITY STUDENTS IN REMOTE LEARNING 2828
S.L. Ong, J.P.W. Ling, W.L. Chang, N. Kamarudin

BACK TO THE DRAWING BOARD. THE CHOREOGRAPHY BEHIND RETURNING TO THE PHYSICAL ARCHITECTURAL DESIGN STUDIO 2838
S. Bors, L. Patachi

THE PHYSICAL EXAM IN A TELEMEDICINE SPHERE: AN ESSENTIAL BUT UNFAMILIAR SKILL 2845
C. Tamargo, G. Berkenblit, A. Apfel, J. Luckin, B. Garibaldi

HOW TO CREATE DIGITAL XML-ANNOTATED GLOSSARIES IN CLASS? A MULTIMODAL APPROACH TO TEACHING SPECIALIZED LANGUAGES ACROSS ALL LEVELS OF EDUCATION 2846
S. Araújo, M. Aguiar

GLOBAL WOMEN'S BREAKFAST AS AN OPPORTUNITY TO CREATE AN INTERNATIONAL SCIENTIFIC COLLABORATION NETWORK 2854
M.J. Ramalhosa, C. Soares, O. Matos Freitas, S. Teixeira, V. Cruz Fernandes, C. Delerue-Matos

INTERNATIONAL YEAR OF THE PERIODIC TABLE: CREATING AWARENESS OF THE CENTRALITY OF CHEMISTRY AND ITS ROLE IN SOLVING PROBLEMS OF HUMANITY FROM A PERSPECTIVE OF SUSTAINABLE DEVELOPMENT 2862
C. Soares, V. Cruz Fernandes, S. Teixeira, O. Matos Freitas, M. J. Ramalhosa, C. Delerue-Matos

SUSTAINABLE EDUCATION FOR FUTURE GENERATIONS 2868
M. Boras

DIGITAL TRANSFORMATION OF ADULT EDUCATION IN LATVIA: LESSONS LEARNT DURING THE COVID-19 PANDEMIC 2872
I. Jekabsone

ASSESSING THE STUDENTS' PROSPECTIVE PERCEPTIONS OF THE FINAL MASTER PROJECT IN ACTUARIAL SCIENCE 2877
M.C. Mayorga-Toledano, E. Trigo-Martínez, A. Fernández-Morales

THE IMPLEMENTATION OF AN OPEN-SOURCE ERP ONLINE SOLUTION TO SUPPORT LABORATORY CLASSES AND STUDENTS ASSESSMENT IN HIGHER EDUCATION DURING COVID-19 LOCKDOWN 2883
C. Batista, C. Alves

RETRIEVAL-BASED LEARNING AS A STRATEGY TO PROMOTE STUDENTS' CONCEPTUAL LEARNING ABOUT THE PRINCIPLE OF CONSERVATION OF ENERGY BY TRANSCODING OF AN ARTISTIC SIGN INTO A SCIENTIFIC CONCEPT 2892
M. Barros, C.E. Laburú, Y.B. Santos, J.P. Ribeiro

THE USE OF PASCAL AS TEACHING TOOL FOR PROTEIN ENGINEERING 2897
J. Sainz Pérez, M. Medina O'Donnell, F.J. Reyes Zurita

PERCEPTION OF THE CONCEPT OF 'QUALITY TEACHING' AMONG TEACHERS TAKING PART IN A TEACHING OBSERVATION PROJECT: INSIGHTS AND REFLECTIONS 2901
M. Milani

PEDAGOGICAL STRATEGIES IN DISTANCE EDUCATION FOR CYBERSENIOR KNOWLEDGE MULTIPLIERS: AN EXPERIMENT DURING COVID-19 2906
T. Grande, L. Rocha Machado, B. Slodkowski, P. Behar

DEVELOPING MATHEMATICAL LITERACY IN LEISURE-BASED EDUCATION FROM THE PERSPECTIVE OF PROSPECTIVE TEACHERS 2915
J. Laitochová, M. Uhlířová, K. Večeřová

INTERACTION BETWEEN EDUCATION AND THE BUSINESS IN BULGARIA – MODELS OF SUCCESSFUL COOPERATION 2921
K. Mincheva, D. Mladenova, H. Bogova, A. Tsvetkova

PROJECT MANAGERS COACH THEIR TEAMS IN PERFORMANCE AND CHANGEABILITY 2926
T. Tallgren, T. Uusitalo

LESSON LEARNED FROM THE DEVELOPMENT AND IMPLEMENTATION OF INTERACTIVE EDUCATIONAL MATERIAL IN THE 3RD GRADE'S HISTORY LESSON 2934
A. Noula, C. Pierrakeas

DEVISING A STANDARDISED, NATIONAL MANDATORY ONLINE TEACHING AND ASSESSMENT PROGRAMME FOR CLINICAL NURSE EDUCATORS (PRECEPTORS/ MENTORS): THE BENEFITS, CHALLENGES AND PROJECT BLUE PRINT DEVELOPED FROM THE STAKEHOLDERS EVALUATION 2941
E. McSharry, G. George, E. Fallon, B. Bradley, C. Rochford, F. Hunt

CONSIDERATIONS ABOUT THE FINAL DEGREE PROJECT (FDP) 2943
F.J. Reyes Zurita, J. Sainz Pérez, M. Medina O'Donnell

A PERFORMANCE EVALUATION OF PROJECT-BASED LEARNING IN A HIGHER EDUCATION SCIENCE COURSE 2944
M. Ibáñez, M.E. González-Benito, M. Pirredda, S. Mira, C. Martín

FROM THEORY TO PRACTICE: THE USE OF FLIPPED CLASSROOMS TO CREATE IMMERSIVE ENGLISH CLASSES FOR A1 LEVEL STUDENTS IN A UNIVERSITY IN ECUADOR 2945
E. Vargas-Caicedo, A. Guaman-Tumbaco

PERSONAL DATA PROTECTION APPLICABLE TO AN E-LEARNING SYSTEM USING AN INDIVIDUAL PROFILE 2952
Y. Anastasova, S. Toncheva-Pencheva

THE POWER OF LEARNING: PAST, PRESENT, AND FUTURE 2958
Y. Guan-Raczkowski

MOTHER TONGUE INTERFERENCE ON ENGLISH SPEAKING SKILLS: A CASE STUDY ON SCHOOL STUDENTS IN INDIA 2959
R.Z. Hauzel, T. Pattnaik, S. Nethi

PROFESSIONAL COMPETENCES OF TEACHERS OF SECOND CHANCE EDUCATION AND THEIR DEVELOPMENT 2967
V. Sutakova

PROJECT-BASED EDUCATION IN PRIMARY SCHOOL WITH THE USE OF VIRTUAL AND AUGMENTED REALITY 2975
K. Dimitrova

SPECIFICATION OF EDUCATION PROCESS OF ADULT LEARNERS IN SECOND CHANCE EDUCATION IN SLOVAKIA 2984
V. Sutakova

DEVELOPMENT OF KEY COMPETENCIES THROUGH GAMES, TEAM TASKS AND PROJECT WORK IN PRIMARY SCHOOL 2990
K. Dimitrova, R. Papancheva

THE DESIGN, VALIDATION AND USE OF CLASSROOM ASSESSMENTS FOR MULTIDIMENSIONAL SCIENCE PROFICIENCY 2999
J. Pellegrino

ENHANCING STUDENTS' ONLINE READING COMPREHENSION THROUGH COLLABORATION AND READING AS A PROBLEM SOLVING PROCESS 3000
I. Gaki, I. Spantidakis, A. Mouzaki

TRANSFORMING INTERNATIONAL EXCHANGE: ENHANCING CULTURAL COMPETENCY IN THE DOMINICAN REPUBLIC AND THE UNITED STATES 3006
C. Whann, S. Winn, L. Calix, M. Banks, L. Camacho, E. Moquete

INNOVATIVE DOCKERIZED WEBSITE BUILDER 3013
P. Bakonyi, M. Vančo, I. Kotuliak

A CASE STUDY OF SERIOUS GAMES WITH AUGMENTED REALITY FOR LEARNING FACILITATING IN CHEMISTRY 3017
K. Nanon, M. Vinnikov, M. Lee

DEVELOPMENT OF ENTREPRENEURSHIP SKILLS IN HIGHER EDUCATION 3027
R. Poceviciene

LET'S STOP MOTIVATING - LET'S HELP DISCOVER THE MEANING OF LEARNING 3035
R. Poceviciene

INTERPERSONAL MUSICAL PERCEPTION OF YOUNGER SCHOOL-AGE CHILDREN 3040
P. Kusý, I. Šuhajdová

MANAGING THE PROCEDURES OF A HIGHER EDUCATION INSTITUTION USING GOOGLE WORKSPACE 3051
M. Valverde Ibáñez, J. de la Casa Cárdenas, M. Gómez González, F.J. Iglesias Godino, A.B. López García, D. Martínez Muñoz, F. Suarez Guerra

THE USE OF MUSIC THERAPY AND MUSIC PHILETICS IN SLOVAK KINDERGARTENS 3062
P. Kusý

INTRODUCING PROJECT-BASED LEARNING AND REAL-WORLD METHODOLOGIES AND TOOLS EARLIER IN THE SOFTWARE DEVELOPMENT CURRICULUM 3071
D. Weaver, T. Bunch

PROGRESS OF THE INCLUSIVE SCHOOLING AGENDA: WHAT THE CRPD COMMITTEE'S CONCLUDING OBSERVATIONS SAY 3079
M. Winzer, K. Mazurek

EFFECTS OF A STEAM-6E AR PROGRAMMING DESIGN COURSE ON ELEVATING STUDENTS' LEARNING MOTIVATION AND COMPUTATIONAL THINKING: A CASE STUDY OF AR GAMES IN DIGITAL EXHIBITIONS 3084
Y.C. Tsai

RELATIONSHIP BETWEEN THE INDICATORS OF THE HIGHER EDUCATION QUALITY ASSURANCE SYSTEM AND THE ISO 9001:2015 QUALITY MANAGEMENT SYSTEM: A LITERATURE REVIEW 3091
A. Mena Vásquez, C. Devece Carañana

ONLINE TEST PRACTICES: INSIGHTS INTO THE USE OF MOODLE QUIZZES IN A BUSINESS SCHOOL CONTEXT DURING A PANDEMIC 3102
V. Fester

SELF-REFLECTION OF THE CONCEPT OF TEACHING: A VIEW OF MANAGERIAL SKILLS OF UNIVERSITY TEACHERS 3111
K. Němejc, K. Tomšíková, J. Šedivý

LESS MASSIVE BUT MORE EFFICIENT ONLINE LEARNING FOR EFL TEACHERS 3117
A. Kalizhanova, T. Shelestova

PREPARING FOR UNIVERSITY STUDIES IN FINLAND: STARTING FINNISH LANGUAGE STUDIES ALREADY IN YOUR HOME COUNTRY 3123
N. Helkiö

APPLYING COGNITIVE LOAD THEORY AND THE VIRTUAL MEDICAL TECHNOLOGY ACCEPTANCE MODEL (VMEDTAAM) TO THE DESIGN AND DEVELOPMENT OF A VIRTUAL REALITY ANATOMY MEDICAL CLASSROOM 3124
M.A.A. Mohd Hamizi, N.A. Mohamed Mokmin, U.H. Ariffin

WOLFRAM CLOUD AS AN INTERACTIVE TOOL TO SUPPORT SECONDARY SCHOOL TEACHING 3133
D. Nocar, J. Vaško, T. Zdráhal

CYBERBULLYING AS ONE OF THE POSSIBLE RISKS OF DISTANCE LEARNING 3138
H. Mičková, J. Miková, Z. Nováková, J. Šmída

EDUCATOR'S PERCEPTION OF USING AUGMENTED REALITY TO CREATE STEM LEARNING MATERIAL 3144
U.H. Ariffin, N.A. Mohamed Mokmin, M.A.A. Mohd Hamizi

3D AUDIO-TACTILE MAPS AND MODELS FOR PEOPLE WITH VISUAL IMPAIRMENT 3151
V. Ruzickova, A. Vondrakova, V. Vachalova, G. Spinarova, K. Kroupova

MANAGEMENT OF SMART CITY SERVICES FROM THE PERSPECTIVE OF QUADRUPLE HELIX 3158
L. Walletzký, L. Nencková, Z. Schwarzová

INTERNATIONAL SOFTWARE DEVELOPMENT PROJECT STUDY MODULE IMPLEMENTED IN VIRTUAL TEAMS IN COOPERATION WITH WORKING LIFE 3164
N. Sarrasin, T. Lintilä, N. Debons

AIRLAB – A HANDS-ON EXPERIENCE ON THE MEASUREMENT OF ATMOSPHERIC PARTICULATE MATTER FOR UPPER SECONDARY STUDENTS 3172
S. Hemmer, L. Conti, L. Mobilia

FACTORS AFFECTING SCIENCE LEARNING ASSESSMENT: THE TRENDS IN INTERNATIONAL MATHEMATICS AND SCIENCE STUDY CASE 3179
C. Santziakki, Z. C. Zacharia, N. Papadouris, CHR. TH. Nicolaou

THE ROLE OF CULTURAL MEMORY FOR THE CREATION OF AN INTERACTIVE EDUCATIONAL ENVIRONMENT 3186
D. Mladenova, K. Planska-Simeonova, A. Tsvetkova, S. Dimitrova

NON-PROFIT MARKETING LESSON TO DEVELOP AND REINFORCE APPLIED PROFESSIONAL SKILLS IN BOTH STUDENTS AND TEACHERS 3191
N. Sarrasin, M. Zumstein, N. Debons

USING SOCIAL NETWORKING MEDIA TO DESIGN AN ONLINE COURSE – A CASE STUDY 3198
D. Jaksic

BEST OF BOTH WORLDS: HOW CAN WE USEFULLY COMBINE ONLINE AND CLASSROOM TEACHING IN THE CONTEXT OF PROJECT-BASED LEARNING WITHIN THE FRAMEWORK OF INDUSTRY-UNIVERSITY COOPERATION? 3205
R. Groß, K. Freudenthaler, T. Ulrich

MINORITY NAME MANAGEMENT IN A SLOVAK-HUNGARIAN BILINGUAL ENVIRONMENT 3214
J. Bauko

TEACHING OF THRESHOLD AND COMPLEX CONCEPTS IN MECHATRONICS 3215
E. Mäkiö, J.R. de Oliveira Leo, M. Tareen, F. Freeha Azmat, B. Ahmad

TRANSITION FROM FACE-TO-FACE LEARNING TO REMOTE TEACHING –FACULTY PERSPECTIVE 3224
V. Haralanova, S. Khoshaba

POPULARISATION OF LINGUISTICS IN UNIVERSITY EDUCATION 3234
J. Bauko

TEACHERS' REASONING IN DIFFERENT TOPICS OF SCHOOL MATHEMATICS 3240
J. Michal, J. Novotná, M. Slavíčková

BLENDED LEARNING IN TERTIARY EDUCATION IN THE CZECH REPUBLIC – VISIONS FOR THE FUTURE 3244
H. Pavlisova

EDISON (EXPERIENCE DEMOCRACY IN SCHOOLS NOW) - LOCAL DEMOCRATIC SCHOOL DEVELOPMENT STRENGTHENING DEMOCRATIC COMPETENCES AND REALIZING INNOVATIONS AT SCHOOLS IN KOSOVO THROUGH FOLLOWING A PARTICIPATORY-DEMOCRATIC SCHOOL DEVELOPMENT APPROACH 3253
M. Retzl, V. Sylhasi

MAXIMISING TEAMWORK ENGAGEMENT BENEFITS VIA OPTIMISING TEAM MEMBER PERSONALITY MATCH 3261
N. Forman, J. Udvaros, K. Szabó, L. Szabó

CAMPUS PRAKTIKUM: HOW TO BRING THE UPV CLOSER TO THE FUTURE STUDENTS IN AN IMMERSIVE WAY 3268
E. Gimenez-Carbo, A. Veloso Padilla, M.A. Torralba Navarro, M.E. Gómez-Martín

EXPERIENCES AND PERCEPTIONS OF PORTUGUESE TEACHERS IN THE EARLY MONTHS OF THE COVID-19 PANDEMIC: REINTERPRETING THE PROFESSION 3275
D. Mesquita, I. Cabral, J.M. Alves

THE IMPORTANCE OF TEACHING DRONES IN LOGISTICS 3286
J. Udvaros, N. Forman, L. Szabó, K. Szabó

FORMATION OF RESEARCH COMPETENCIES OF MASTERS' STUDENTS 3291
G. Podnebesova, K. Zvyagin, L. Yuzdova, M. Kulakovich, I. Balandina, T. Moskvitina

METHODOLOGY FOR TEACHING FUNDAMENTALS OF COMPUTER PROGRAMMING FOR ENGINEERING AND HIGH SCHOOL STUDENTS NON-SPECIALISTS IN COMPUTER SCIENCE 3296
J.R. Pérez Beltrán, R.P. Ñeco García, N.M. García Aracil, J.M. Catalán Orts, I. Fabra Ramón

BLENDED LEARNING ON TWITTER SOCIAL NETWORK: ONLINE, PERSONALISED AND FLIPPED LEARNING 3305
T. Balcarova, L. Pilařová

CONTRIBUTION OF PEER-TO-PEER EVALUATION IN COLLABORATIVE EDUCATION BY PROJECTS DEVELOPED IN THE FIELD OF UNIVERSITY TRAINING OF ENGINEERS 3313
I. Gil, I. Domínguez, M.M. Espinosa, R. Prádanos Del Pico, M. Domínguez

A ROCKY OUTCROP IN THE LABORATORY: FLIPPED CLASSROOM FOR LEARNING GEOMECHANICAL STATIONS 3320
R. García-Luna, J. González Galindo, J.G. Gutierrez-Ch, R. Jimenez Rodriguez, L. Jordá Bordehore, C. López Fernández, Á. López-Puigcerver Soler, J. Page Antequera, L.A. Pando González, S. Senent Domínguez

ORGANIZATIONAL COMMITMENT IN PORTUGUESE HIGHER EDUCATION TEACHERS 3327
M. Ribeiro, C. Antão, V. Lebres, A. Fernandes

EXPERIENCES IN THE USE OF WIKIS AS A COLLABORATIVE TOOL FOR TEACHING COMPUTER SCIENCE 3335
J.R. Pérez Beltrán, R.P. Ñeco García

DEVELOPING A CHALLENGE: THE DESIGN OF GREEN BUS STOPS AS A TOOL FOR INTERNATIONAL AND INTERDISDIPLINARY COLLABORATION IN FACE-TO-FACE SUMMER SCHOOLS 3341
D. Gawryluk, M.A. Flórez de la Colina, P.C. Izquierdo Gracia, D. Jankauskienė, D. A. Krawczyk, E. Brezgytė

ASSESSING PUPILS' ACHIEVEMENTS IN TECHNOLOGY EDUCATION: PERCEPTIONS OF PUPILS AND TEACHERS 3352
B. Zygaitiene, A. Guoba, I. Kepalienė

MODELING THE EDUCATION OF THE FUTURE WITH THE HELP OF ROBOTIC PROCESS AUTOMATION 3360
M.I. Vulpe, V.A. Enăchescu

A MULTIDIMENSIONAL VIEW OF JOB SATISFACTION IN A PORTUGUESE PUBLIC HIGHER EDUCATION INSTITUTION 3366
M. Ribeiro, C. Antão, V. Lebres, A. Fernandes

MODELS FOR CREATING VISUAL CULTURE IN THE SPHERE OF HIGHER EDUCATION 3376
D. Mladenova, E. Zdravkova-Velichkova, K. Boyanov

USE OF ONLINE QUESTIONNAIRE TOOLS AND THEIR CORRELATION WITH THE EVALUATION OF DENTISTRY STUDENTS 3381
L.A. Moreno-López, A. Domínguez-Gordillo, R. Cerero-Lapiedra, L. Hernando-Calzado, M. Muñoz-Espina, G. Esparza-Gómez

EXPLORING THE USE OF MACHINE LEARNING TO IMPROVE STUDENT ENGAGEMENT AND RETENTION 3385
I. Ogbuchi, E. Kiely, C. Quigley, D. McGinty

DIFFERENCES IN MOTOR ABILITIES OF PRESCHOOL CHILDREN CONCERNING THEIR ADDITIONAL ENGAGMENT IN SPORT ACTIVITIES 3391
J. Alić, V. Valjan Vukić, D. Kuna

APPLICATION OF "FLIPPED LEARNING" METHODOLOGY IN CHEMICAL ENGINEERING USING YOUTUBE AS TEACHING TOOL 3398
M. Moya, M.T. Ocaña, I. Romero, F. Espínola, C. Cara

A CONSTRUCTIVIST APPROACH IN THE PROCESS OF LEARNING MECHATRONICS 3408
D. Fait, V. Mašek, R. Čermák

STUDENT PREFERENCES WITH GAMIFICATION SYSTEMS IN EDUCATION IN DENTISTRY: IMMEDIATE VERSUS DEFERRED ACTIVITIES 3414
A. Dominguez-Gordillo, L.A. Moreno-López, G. Esparza-Gómez, E. Blanco-Malanda, M. Esparrago-Diaz, R. Cerero-Lapiedra

BLENDED LEARNING AS A NEW METHODOLOGY FOR SHARING KNOWLEDGE AND COLLABORATING TO CREATE A SMALL URBAN OBJECT 3415
P.C. Izquierdo Gracia, M.A. Flórez de la Colina, D. Gawryluk, K. Rawski, W. Matys, J.A. Capitan, I. Bach, D.A. Krawczyk, D. Jankauskienė, V. Vaičekauskienė, I. Kuklys

THE DESIGN THINKING MODEL APPLIED TO AN ARTISTIC PROJECT IN THE CONTEXT OF EUROPEAN UNIVERSITIES 3424
P. Macedo, L. Recnik, C. Munk

THE INTERNET: A NEW RENAISSANCE FOR THE UNIVERSITY 3430
M.A. Garito

ONLINE ASSESSMENT CHALLENGES IN ENGINEERING GRAPHICS AND DESIGN 3431
C.S. Masoabi

RECOGNIZING SOCIAL DISADVANTAGE IN THE PROCESS OF ADDRESSING EDUCATIONAL INEQUALITIES 3437
Z. Němec, L. Felcmanová

MAJOR ROLES OF SCHOOL COUNSELLING PROFESSIONALS IN PROVIDING SUPPORT FOR STUDENTS FROM SOCIALLY DISADVANTAGED BACKGROUNDS 3444
Z. Němec, A. Kubíčková

TECHNOLOGICAL WATCH IN MANUFACTURING INDUSTRY: IDENTIFYING TRAINING NECESSITIES 3451
J.J. Ortega Gras, J. Garrido Lova, B. Puche García, O. Olivier Garnier, M. Daddiza

THE COMPETENCY-BASED APPROACH IN THE STUDY OF THE SUBJECT 'TECHNOLOGY' - A COMPARISON OF THE CASES OF LITHUANIA AND LATVIA 3452
A. Strode, B. Zygaitiene

SELF-ADVOCACY AMONG COLLEGE STUDENTS WITH AND WITHOUT LEARNING DISABILITIES: THE CONTRIBUTION OF ACADEMIC SELF-EFFICACY AND SUPPORT 3461
P. Shavit, R. Michael

EVOLUTION OF STUDENT APPROACH TO LEARNING IN A DEGREE LEVEL SUBJECT 3462
N. Andrés-Colás, M. Leiva-Brondo

MACHINE LEARNING MODEL USAGE TO ANALYZE MOTIVATION AND PREDICT STUDENTS' PERFORMANCE DURING COVID-19 IN HIGHER EDUCATION 3471
A. Zabolotskikh, T. Dugina

THE ROLE OF UNIVERSITIES IN SUPPORTING THE DEVELOPMENT OF COMPETENCES 4.0 THROUGH UNIVERSITY-BUSINESS COLLABORATION 3479
P. Poszytek, J. Fila, M. Jezowski

ASSESSMENT OF ALGORITHMIC THINKING OF SLOVAK AND HUNGARIAN SECONDARY SCHOOL STUDENTS 3484
Š. Gubo, L. Végh

PERCEPTION OF SMART CITY IDEA IN SMALLER MUNICIPALITIES AND ITS IMPACT ON MULTIDISCIPLINARY EDUCATION 3494
Z. Schwarzová, L. Walletzký

THE NEED TO ENHANCE INTERNATIONAL BLENDED MOBILITY IN SOUTH ASIA HIGHER EDUCATION: THE CASE OF MALAYSIA, INDONESIA, BANGLADESH, AND VIETNAM BEFORE AND DURING THE OUTBREAK OF COVID-19 3500
I. Juknyte-Petreikiene, N. Gudelienė, R. Valutytė, I. Žalėnienė, C.Z. Lamagna, F. Hassan

A COMPARATIVE STUDY OF UNDERGRADUATE STUDENTS' ATTITUDES TOWARDS MATHEMATICS, ITS LEARNING AND TEACHING 3510
G. Pranaitytė, B. Narkevičienė

COMPREHENSION MONITORING ACROSS LANGUAGES – DOES FEEDBACK WORK? 3511
L. Temelman-Yogev, A. Prior, T. Katzir

REVIVING LEGACY LAB COURSE EXPERIMENTS WITH INEXPENSIVE COMMODITY HARDWARE AND A STATE-OF-THE-ART DATA ANALYSIS WORKFLOW – A CASE REPORT 3512
C. Mayer

EXECUTIVE FUNCTIONS AND READING COMPREHENSION IN ADULTS WITH ADHD 3513
V. Markovich, T. Katzir, E. Tirosh

COLLABORATIVE LEARNING AND TECHNIQUES FOR ENCOURAGING ACTIVE PARTICIPATION IN THE CLASSROOM: AN EXPERIENCE OF UNIVERSITY TEACHING INNOVATION IN THE PERIOD 2010-2020 3514
A. Martinez Serrano

COMPARISON OF STUDENT'S APPROACH TO LEARNING IN TWO SUBJECTS OF BIOTECNOLOGY DEGREE PER STUDENT BASIS 3520
M. Leiva-Brondo, C. Esteras, J. Blanca, J. Cañizares

INTERDISCIPLINARY INVESTIGATION OF THE IMPACT OF A BEHAVIORAL INTERVENTION ON THE TOTAL DISTANCE COVERED IN SMALL-SIDED SOCCER GAMES 3526
R.M. Pop, V.T. Grosu, M.N. Ordean, A.S. Rusu

THE EFFECTIVENESS OF TEACHING AIDS FOR MATHEMATICS TEACHING THROUGH THE EYES OF PROSPECTIVE TEACHERS 3535
R. Dofková, J. Wossala, V. Scheichenostová

A STUDY OF COGNITIVE ABILITIES IN THAI CHILDREN 3541
P. Visessuvanapoom, J. Wintachai

THE IMPLEMENTATION OF THE CAPS FOR SEVERE INTELLECTUAL DISABLED LEARNERS – A SUCCESS STORY? 3548
H. Louw, J. Rens

AN INTEGRATIVE REVIEW ON THE EXPERIENCES OF INTEGRATION OF QUALITY ASSURANCE SYSTEMS IN UNIVERSITIES 3549
L. Mion

THINKING THE FUTURE IN THE PRESENT - THE WAY TO A MORE COMPETITIVE AND DIGITAL INDUSTRY 3560
A. Fabre, S. Pelayo

ENSURE THE CONTINUITY OF INTERNATIONALIZATION AND AN ON-GOING DEVELOPMENT OF GLOBAL CITIZENSHIP COMPETENCIES IN A DUTCH TAUGHT HEALTH CARE BACHELOR 3565
G. Foendoe Aubel

SOCIAL INEQUALITIES THAT AFFECT TRANSITION PROCESSES FROM GRADE 7 TO GRADE 8 WITHIN AN INCLUSIVE SOUTH AFRICAN EDUCATION SYSTEM 3570
P. Engelbrecht, J. Rens, H. Louw

VIEWS OF INCLUSION ACROSS TIME AND SPACE: FIVE YEARS OF PERSPECTIVES FROM UNIVERSITY TUTORS ON ACCESSIBILITY AND INCLUSION 3571
K. Lister, V.K. Pearson, E. McPherson, A.M. Gallen

THE EFFECT OF GOVERNMENT SUBSIDY ON TECHNICAL SECONDARY SCHOOLS' CURRICULUM DELIVERY IN SOUTH AFRICA 3581
C. Mphojane

APPLICATION OF GAMIFICATION ELEMENTS IN UNIVERSITY EDUCATION TO IMPROVE THE LEARNING PROCESS 3582
C. Goldmann, R. Woll

ICT IN WORK WITH CHILDREN WITH DEVELOPMENTAL DISORDERS IN PRIMARY AND PRE-PRIMARY EDUCATION 3591
V. Gabaľová, V. Stoffová, J. Kočišová

NEW TRENDS AND EXPERIENCES OF SUPPLEMENTARY EDUCATION 3599
H. Moisander, M. Tanskanen

RETHINKING SCHOOL BUSINESS PARTNERSHIPS TO DRIVE INNOVATION AND TEAM LEADERSHIP IN PUBLIC SCHOOLS AMID THE NEW NORMAL: A CASE OF SOUTH AFRICAN PUBLIC SCHOOLS IN LIMPOPO PROVINCE 3603
M. Lamola

IDENTIFYING THE CHALLENGES OF COMMUNICATION WITHIN VIRTUAL TEAMWORK 3609
C. Goldmann, A. Wolter, R. Woll

THE STUDY OF INTERMEDIAL FEATURES IN LITERATURE 3616
L. Lutas

METHODOLOGICAL CHALLENGES IN PRACTICE-ORIENTED RESEARCH: CLOSING THE GAP BETWEEN EDUCATIONAL RESEARCH AND TEACHING PRACTICE 3623
M. Utterberg Modén, M. Tallvid, J. Lundin, B. Lindström

TEACHING IN THE TIMES OF PANDEMIC 3624
M. Tomovic, C. Tomovic

FACE-TO-FACE AND DISTANCE FORM OF PROGRAMMING TEACHING 3629
V. Gabaľová, V. Stoffová, H.I. Oppenbergerová

BULLYING PREVENTION IN SCHOOLS 3638
J. Ďurica, V. Šoltés, V. Adamová

THE IMPORTANCE OF SOCIAL-EMOTIONAL COMPETENCE FOR FIRST-YEAR TEACHERS' PROFESSIONAL DEVELOPMENT 3645
T. Kazarnovski

HOW ARE STUDENTS ENGAGING IN DIFFERENT TYPES OF ONLINE DISCUSSION BOARDS? 3651
C. Vallis, C. Prieto Alvarez, N. Arthars

MOTIVATION AND STUDENTS' GRADES IN HYBRID (IN-PERSON AND ONLINE) TRAINING 3658
I. Getova, N. Yanev, Y. Anastasova, M. Trifonova

A TECHNOLOGICAL INTERVENTION FOR PROMOTING EYE CONTACT AMONG BOYS WITH AUTISM SPECTRUM DISORDER: CAN METACOGNITIVE SKILLS MAKE A DIFFERENCE? 3663
O. Tova, A. Shamir, S. Eden, S. Horovitz, N. Munits, M. Amon

REPLICATION ON COGNITIVE LOAD DURING FIRST CONTACT WITH MIXED REALITY USING HEAD-MOUNTED DISPLAYS 3668
R. Kockord, O. Bodensiek

A THEORY OF CONDITIONAL SOCIAL EQUALITY IN LEARNINGS GROUPS 3678
H. Ahl, J. Hedegaard

STUDY OF THE EFFECTIVENESS OF PRE-LABORATORY VIDEOS ON ENHANCING STUDENTS' SKILLS AND PERFORMANCE IN THE ANALYTICAL CHEMISTRY PRACTICAL CLASSES 3679
E. Palacio, A. Figuerola, M.A. Vargas-Muñoz, L. Ferrer, J.G. March

PEDAGOGICAL SUPERVISION FOR STUDENT SUPPORT IN HIGHER EDUCATION 3684
D. Stieģele, I. Miķelsone, D. Bethere, I. Griškēviča

ENGLISH FOR TOURISM AND HOSPITALITY PURPOSES IN HIGHER EDUCATION: SOME INSIGHTS FROM ENGLISH FOR SPECIFIC PURPOSES 3693
S.R. Pereira, V. Costa

FEATURES OF TEACHING LISTENING SKILLS IN ENGLISH (AT THE SENIOR STAGE OF EDUCATION) 3699
E. Harkova, K. Bashkirova

DEVELOPING SCHOOLS AS LEARNING ORGANISATIONS IN LATVIA: UNDERSTANDING AND IMPLEMENTATION PRACTICE IN LOCAL GOVERNMENTS 3704
I. Lusena-Ezera, D. Kleina

THE PERCEPTIONS OF SCHOOL LEADERS ABOUT THE IMPLICATIONS OF THE COVID-19 PANDEMIC ON TECHNOLOGICAL, ORGANIZATIONAL, CULTURAL, AND PEDAGOGICAL LEVELS: AN EXPLORATORY STUDY IN PORTUGAL 3705
M. Araujo, D. Mesquita

USE OF MODERN TECHNOLOGIES IN TEACHING ENGLISH SPEAKING (AT THE SENIOR STAGE OF TRAINING) 3714
E. Harkova, K. Bashkirova

PROJECT BASED LEARNING FOR INCREASING ATTRACTIVITY OF TECHNICAL EDUCATION AT ELEMENTARY SCHOOLS AND HIGH SCHOOLS 3721
R. Čermák, R. Teplý, V. Mašek, D. Fait

ENGLISH FOR TOURISM AND HOSPITALITY AS A BOOSTER FOR GLOBAL CITIZENSHIP EDUCATION 3728
S.R. Pereira, V. Costa

PHOTO-RESEARCH(ING): APPLICATIONS, OPPORTUNITIES AND CRITICAL ISSUES IN USING PHOTOGRAPHY IN EDUCATIONAL RESEARCH 3736
L. Carriera

RELEVANT SKILLS FOR A SUCCESSFUL TRANSITION TO HIGHER EDUCATION: STUDENTS AND TEACHERS' PERSPECTIVES 3743
M. Lara, P. Dekkers, J. Brouwer, T. Bom, M. Baars

PERSONALIZED ADAPTIVE LEARNING TECHNOLOGY: SUPERCHARGING SECOND LANGUAGE LEARNING 3744
S. Wyatt, M. Redmon

TRAINING INTANGIBLE CULTURAL HERITAGE PROFESSIONALS IN ENTREPRENEURIAL AND DIGITAL SKILLS: THE NICHE CASE 3749
P. Polymeropoulou, R. Chaliampalias, N. Ntaliakouras, C. Pierrakeas, A. Kameas

IMPLEMENTING AN EARLY PREVENTION ANALYTICS MODEL ON SUPPORTING STUDENT SUCCESS 3757
J. Wang

THE USE OF A VIRTUAL IMAGE AS AN EDUCATIONAL RESOURCE FOR THE OPHTHALMIC OPTICS LABORATORY 3763
E. Perales Romero, J. Espinosa Tomás, E. Chorro, B. Domenech Amigot, K. Huraibat, C. Vázquez Ferri, V. Viqueira

BLOOMING PERSONALITIES: ON THE IN-PERSON AND INTEGRATED EDUCATIONAL APPROACH IN HIGHER EDUCATION – A CASE STUDY FROM JAPANESE STUDIES DEPARTMENT OF SOFIA UNIVERSITY "ST KLIMENT OHRIDSKI", BULGARIA 3764
V. Nikolova, G. Petkova

PRESENTATION OF AN EDUCATIONAL DECISION SUPPORT TOOL USING ARTIFICIAL INTELLIGENCE TECHNIQUES IN THE PROFESSIONAL LEARNING COMMUNITY CONTEXT 3772
A. Villeneuve, A. Huot

UPSKILLING THE PROFESSIONALS IN CULTURAL HERITAGE: A METHODOLOGY IN DESIGNING ONLINE COURSES 3778
P. Polymeropoulou, C. Pierrakeas

APPLICATION OF PROJECT-BASED LEARNING IN ANIMAL HUSBANDRY USING FLIPPED CLASSROOM AND VIRTUAL REALITY 3786
A. Chikurteva, T. Atanasova

A SERVICE-LEARNING EXPERIENCE TO FOSTER STEM VOCATIONS AND PROMOTE EQUAL OPPORTUNITIES 3796
B. Muñoz-Medina, M. García Alberti, S. Blanco, A. Enfedaque, R. Muñoz Pavón

ACCOUNTABILITY & TIME MANAGEMENT: AN INNOVATIVE APPROACH 3803
R. Abreu, F. Caetano, F. Carreira, A.C. Borrego, S. Loureiro

RE-FOUNDING THE TRANSDISCIPLINARY DOCTORAL SCHOOL: CO-CREATED EDUCATION FOR CONNOISSEURSHIP 3811
Z. Baracskai, K.A. Németh, B. Tamas

EVALUATION OF THE SUSTAINABILITY OF AN ENGINEERING DEGREE APPRENTICESHIP PILOT IN NEW ZEALAND AND THE IMPLICATIONS FOR FUTURE EXPANSION 3815
J. Mackay, H. Cadzow

GENERATION OF AN AUTOMATIC-PERSONALISED ACADEMIC CALENDAR 3826
R. Muñoz Pavón, P. Carames, J. Jerez, M. García Alberti, A. Enfedaque, B. Muñoz-Medina, S. Blanco

PROPER DRESS CODE: USING CASE STUDIES ON FINNISH TEXTILES COMPANIES TO DISCUSS PROACTIVE LAW, TRADEMARKS, AND SUSTAINABILITY 3831
S. Monseau, K. Sorsa

DIGITAL COGNITIVE TECHNOLOGY OF DISTANCE LEARNING BASED ON A UNIFIED ARTIFICIAL IMMUNE SYSTEM 3841
G. Samigulina, Z. Samigulina

MENTORING OF PEDAGOGICAL PRACTICE - A STARTING POINT IN THE QUALITY OF EDUCATION 3842
E.L. Mara

PSYCHOMETRIC PROPERTIES OF THE TEST OF EARLY ARABIC LITERACY SKILLS 3847
E. Hassanein

THE "JUST YOUTH. HAVING A SAY IS A SUSTAINABLE ACTION" EXPERIENCE: FIRST REFLECTIONS ON THE METHODOLOGY OF A UNIVERSITY ORIENTATION PROGRAM 3848
C.C. Montà, L. Carriera, E. Biffi, S. Malatesta

INNOVATIVE ACTIVE LEARNING METHODOLOGIES APPLIED TO HEALTH AND AGING-RELATED BACHELOR'S THESES TO ACHIEVE SUSTAINABLE DEVELOPMENT GOALS: THE RESULTS OF IKASASUN-ODS PROJECT 3853
T. Teresa Morera-Herreras, M. Torrecilla, AM. Ochoa de Retana, G. Puras, A. Fernández-Quintela, C. Miguelez, L. Sáenz-Del-Burgo, I. Fernández, MP. Portillo, J. Ciriza, E. Sevillano, E. Eraso, A. Vallejo, S. Gómez-Zorita, L. Aguirre, S. Ballesteros, E. Mateo, I. Milton, C. Bruzos-Cidón

ATTITUDES TO THE THERAPEUTIC POTENTIAL OF READING IN ATYPICAL SITUATIONS: A SCIENTIFIC PROJECT FROM BULGARIA IN THE MIDDLE OF ITS IMPLEMENTATION 3854
S. Eftimova

ESP WITH ITALIAN DOCUMENT MANAGERS – TEACHING STRATEGIES AND ADAPTATIONS 3861
M. Cronin

THE PROSPECTIVE PRIMARY EDUCATION TEACHERS' VIEW ON THE DEVELOPMENT OF MATHEMATICAL LITERACY IN THE NEW CONCEPT OF INFORMATICS IN THE CZECH REPUBLIC 3870
J. Wossala, R. Dofková, P. Seidlová

MATHEMATICS, LITERATURE AND ART: GETTING PASSIONATE ABOUT MATHEMATICS THROUGH THE USE OF DIGITAL TECHNOLOGIES 3877
A. Amirante, L. Tortorelli, I. Veronesi

TRANSFORMING ASSESSMENT FROM BURDEN TO JOY 3885
T. Campbell, M. McMartin

PARTICIPATION OF BACHELOR AND MASTER STUDENTS FROM THE SPECIALTIES OF ARCHIVAL AND DOCUMENTARY STUDIES, UNIVERSITY OF LIBRARY STUDIES AND INFORMATION TECHNOLOGIES IN THE "STUDENT PRACTICES - PHASE 2" PROJECT 3889
S. Eftimova

DO CHILDREN WHO LEARNED TO READ DURING COVID 19 READ BETTER FROM SCREENS? 3895
S. Dotan, T. Katzir

DIGITAL PRESENTATION OF ARCHIVE-DOCUMENTARY HERITAGE - RESPONSE TO THE EXPECTATIONS AND NEEDS OF USERS AND LIBRARY SPECIALISTS 3896
E. Tsvetkova

LATVIAN HIGHER EDUCATION STUDENTS' SELF-ASSESSMENT OF THE INNOVATIVE COMPETENCE IN THE STUDY PROCESS 3905
A. Oļesika, S. Slišāne, G. Lāma, Z. Rubene

HELPING DIGITAL NATIVES TO BECOME DIGITAL NATIVES THROUGH PRODUCTION STANDARDS, RESEARCH AND QUALITY SYSTEMS? 3913
A.K. Mertineit, D. Burdinski, B. Zulauf, H. Hackradt, N. Meuter, C. Bohrmann-Linde, K. Schaper

HACKATHONS FOR SCHOOLS: COLLABORATIVE INNOVATION EVENTS AS A CONTEXT FOR THE DEVELOPMENT OF THE DIGITAL CAPACITY OF SCHOOLS 3921
N. Giannoutsou, T. Nanaieva, A. Brolpito

REFLECTIONS ON DISTANCE EDUCATION MANAGEMENT IN BRAZIL: CASE STUDIES ON THE DEVELOPMENT OF DIDACTIC MATERIAL IN DISTANCE EDUCATION IN CORPORATE UNIVERSITIES 3922
E. Naime, A.P. Afonso, M. Vieira

USING TASK-BASED LANGUAGE TEACHING (TBLT) APPROACH TO IMPROVE THE READING PROFICIENCY OF MATURE STUDENTS 3927
S. Adjei-Mensah, N. Boakye

DEVELOPMENT OF PROFESSIONAL COMPETENCE OF DESIGN TECHNOLOGY STUDENTS IN MANUFACTURING INTERNSHIP 3934
S. Mezinska

AUTHENTIC MATERIALS – GOOD EXAMPLES OF THE NATIVE SPEAKERS' SENSITIVITY TO DIFFERENT ACCENTS AND VARIETIES 3943
J. Bérešová

EXPERIENCES AND BEST PRACTICE IN ACCREDITATION AND QUALITY PROCESSES AT FSE UNIZA 3947
E. Sventekova, M. Vandlickova

MUSEUM PODCASTING POSSIBILITIES FOR INTERCULTURAL EDUCATION 3954
A. Kalizhanova, T. Shelestova

ARE STUDENTS' WORRIES JUSTIFIED WITHOUT STATISTICAL EVIDENCE? 3959
J. Bérešová

MODELS AND PRACTICES OF ELEARNING USE AT THE CATHOLIC UNIVERSITY OF MOZAMBIQUE: A CASE STUDY 3964
M. Salite, A.P. Afonso, L. Morgado

THE INFLUENCE OF THE THEORY OF EMBODIED COGNITION ON THE DEVELOPMENT OF THE LANGUAGE OF SMALL PRESCHOOLERS 3974
M.C. Manea, M.D. Bocoș

TO NURTURE A MULTILINGUAL MIND. FOREIGN LANGUAGE INTRODUCTION IN PRE-SCHOOL. CASE STUDY: BAMBINI BICOCCA KINDERGARTEN 3975
P. Lefterov

INTERCULTURAL SKILLS FOR FUTURE SIGNAL PROCESSING ON HEALTHCARE: HOW COLLABORATIVE ON-LINE INTERNATIONAL LEARNING TRAINS ENGINEERS 3982
B. Lopez, R.C. Guido, A. Betts, K. Zerva

ACADEMIC PERFORMANCE, GRADE INFLATION AND REGULATORY EXCEPTIONS IN HIGHER EDUCATION DURING THE PANDEMIC 3990
D. Toro

INFLUENCE OF COVID-19 ON THE LEARNING OUTCOMES OF UNDERGRADUATE STUDENTS: THE ROLE OF GAMIFICATION 3995
M. Vega-Zamora, R. Barreda-Tarrazona

THE PROFESSIONAL UNIVERSITY DEGREE OF ACTUARY THROUGH BLOOM'S TAXONOMY 4006
A. Arsuaga-Uriarte, J.I. De-la-Peña-Esteban, A. Garayeta-Bajo, O. Gómez-Pérez-Cacho, R. Moreno-Ruiz, E. Trigo Martínez

CHANGE OR DIE: ORGANIZATIONAL FACTORS THAT FACILITATE OR BLOCK ORGANIZATIONAL SURVIVAL DURING DISRUPTIVE CHANGE 4012
I. Mikhailova

CURRENT SAFETY AND SECURITY TOPICS AND BEST PRACTICES OF THEIR IMPLEMENTATION IN STUDY PROGRAMS 4017
E. Sventekova, J. Kapusniak

FOLK CRAFTS IN WORK ACTIVITIES AT PRIMARY SCHOOL 4023
M. Hubalovska, A. Kubankova, T. Milova

DIVERSITY AND SOCIAL JUSTICE: REVIEW OF POTENTIAL CHALLENGES OF BUILDING DIVERSE AND INCLUSIVE WORKFORCE IN GHANA'S TERTIARY INSTITUTIONS 4031
E.K. Honu, D. Dzansi, L. Dzansi, K. Boemah

BLAST – BUILDING LEADERS FOR ADVANCING SCIENCE AND TECHNOLOGY: A PARTNERSHIP BETWEEN THE VIRGINIA SPACE GRANT CONSORTIUM AND THE UNIVERSITY OF VIRGINIA, VIRGINIA POLYTECHNIC INSTITUTE, AND OLD DOMINION UNIVERSITY 4039
C. Tomovic, M. Sandy, J. Back, V. Jovanovic, K. Lester, E. Murphy, S. Mckinney, M. Tomovic

APPLICATION OF AUGMENTED REALITY IN TEXT-BASED LEARNING ENVIRONMENTS 4046
D. Djulovic, B. Ramic-Brkic

FOUNDATION YEAR 1 DOCTORS AS MEDICAL EDUCATORS – A PROGRAMME INTRODUCING NEWLY QUALIFIED DOCTORS TO UNDERGRADUATE TEACHING THROUGH A WORKSHOP AND DEDICATED NEAR-TO-PEER TUTOR SCHEME 4056
H. Knifton

PERCEPTIONS OF TEACHER CANDIDATES ABOUT SCIENCE AND SCIENTISTS 4057
Ş. Kösem

HOW EDUCATION IS IMPROVING SOCIAL INTERVENTIONS IN RURAL AREAS 4067
L. Pinto, D. Pereira, M. Ferreira

IMPACT OF ECONOMIC CRISIS ON EDUCATION 4072
B. Xie

CRITICAL THINKING AND PROBLEM SOLVING 4073
B. Xie

LINGUISTIC AND EMOTIONAL EFFECTS OF ANIMAL-ASSISTED LITERACY INTERVENTION PROGRAM AMONG ELEMENTARY SCHOOL STUDENTS WITH READING DIFFICULTIES 4078
A. Bufman, O. Lipka, T. Katzir

SMARTEX PROJECT-TRANSNATIONAL COOPERATION BETWEEN UNIVERSITIES 4079
P. Díaz-García, L. Capablanca-Francés, R. Belda-Anaya, M. Tufali, B. Zahid, A.W. Rajput

CO-CREATING WARWICK UNIVERSITY COMMUNITY 4085
T. Olaofe, S. Mortazavi, B.N. Karaca, C. Gramadevathepura-Shivamadappa, C. Green, M. Macintyre

CIRCULAR ECONOMY OF FIBROUS COMPOSITES AND TECHNICAL TEXTILES E-LEARNING 4090
P. Díaz-García, L. Capablanca-Francés, R. Belda-Anaya, D. Mikucioniene, L. Indrie, N. Dimopoulou, G. Priniotakis

LESSONS LEARNED FROM THE DEVELOPMENT OF MASSIVE OPEN ONLINE COURSES ON INNOVATIVE STRATEGIES FOR THE REHABILITATION OF BUILT HERITAGE 4095
M. Philokyprou, S. Thravalou

RISK FACTORS IN THE RELATIONSHIPS BETWEEN PARENTS OF CHILDREN WITH DISABILITIES AND EXPERTS 4102
Z. Haiclova, I. Grohmann, J. Michalik, P. Hajkova, L. Novakova

EDUCATING FOR SAFETY AT SCHOOL: ACCIDENT PREVENTION AND ACTION IN CASE OF BURNS 4109
G. Colaço, H. Simões, A. Lucena, J.M. Freitas

VALIDATING THE DEVELOPMENT OF SOFT SKILLS SENSITIVITY IN SPECIAL EDUCATORS AND COUNSELLORS 4116
P. Jurkovicova

BREAKING DOWN BARRIERS FOR COOPERATION BETWEEN ACADEMIA AND INDUSTRY - 10 YEARS OF MAKING UNIVERSITY-INDUSTRY TRAINING ARENAS HAPPEN 4117
F.R. Johansen, G. Andersson, B.G. Hauge

RESEARCH ON CHANGES IN THE VALUE SYSTEM AND LEVEL OF WELL-BEING OF STUDENTS AND THE ELDERLY POPULATION AS A RESULT OF THE COVID-19 PANDEMIC 4118
P. Voborník, V. Strnadová, K. Provazníková

THE ROLE OF EARLY CHILDHOOD EDUCATORS' WELL-BEING IN THEIR RELATIONSHIP WITH CHILDREN 4128
S. Tatalović Vorkapić

MAPPING GOOD PRACTICE IN THE SYSTEM OF SUPPORTING THE INDEPENDENCE OF YOUNG ADULTS WITH DISABILITIES – PARTIAL RESULTS 4138
P. Jurkovicova, V. Ruzickova

QUIZZES AND EDUCATIONAL VIDEOS TO IMPROVE PERFORMANCE LEVELS IN TRAINING IN BUILDING STRUCTURES 4146
B. Orta, C. Olmedo, M. A. Benito, D. Mencías-Carrizosa, V. Pascual, A. Marín, J. Antuña

H5P-PANDEMIC: COLLABORATIVE DEVELOPMENT OF INTERACTIVE AND PORTABLE EXERCISES IN A GENETIC ENGINEERING GAME 4154
A. Sánchez Torralba, C. Blázquez Ortiz, O. Cañadas Benito, B. García-Fojeda García-Valdecasas, G. Guevara Acosta, M.T. López Conejo, M. Lorente Pérez, J.M. Mateo Mendoza, L. Nogués, R. Ranz Valdecasa, S. Rayego Mateos, M. Ruiz Ortega, T. Sánchez Velasco, G. Velasco Díez, J.M. Navarro Llorens

ORGANIZATION OF THE LEARNING CONTEXT IN TIMES OF PANDEMIC: STUDENT PERCEPTIONS 4160
P. Morales Bueno, R. Santos Rodas

DEVELOPING AN ONLINE HOME LABORATORY COURSE WHERE STUDENTS MAKE THEIR OWN EQUIPMENT 4165
J. Mackay

GRATITUDE INTERVENTION PROGRAM AS A COPING STRATEGY IN UNIVERSITY PROFESSORS 4166
J. Beltran-Sanchez, O. Nava-Manzo, G. Martinez-Ramirez, A. Guardiola-Ramirez, A. Valle-de la O

DESIGN OF A PHYSICS DYNAMICS LESSON FOR AGRONOMY ENGINEERING BASED ON CRITICAL THINKING AND COOPERATIVE LEARNING 4174
L. Amy

THE EFFECTIVENESS OF ONLINE EDUCATION: THREE COMPARATIVE STUDIES 4175
R.S. Carlisle

PREPARING STUDENTS FOR THE FUTURE THROUGH ROBOTICS FOR K12 4185
A. Codera, Jr., C. Saulo, J. Caro

JAPANESE TEXTBOOK ANALYSIS: A DISCOURSE-BASED APPROACH 4195
V. Fester, A. Fester, K. Umeda

TOTAL QUALITY MANAGEMENT PRACTICES RELATED TO HUMAN TALENT MANAGEMENT AND THE GENERATION OF INNOVATION IN THE HIGHER EDUCATION INSTITUTIONS: A LITERATURE REVIEW 4203
A. Mena Vásquez, C. Devece Carañana

AUGMENTED REALITY FOR THE TEACHING OF STEM COURSES IN SENIOR HIGH SCHOOL 4213
J. Caro, J.C. Boque, P. Yang-Ed

FOSTERING CHILDREN'S IMAGINATION AND CREATIVE PROCESSES THROUGH MAKING ACTIVITIES TAKING PLACE IN A MAKERSPACE 4220
I.M. Santos, L. Menano, C. Habak

ANALYSIS OF FUNCTIONAL REQUIREMENTS OF E-LEARNING AND KNOWLEDGE MANAGEMENT SYSTEMS AND ASSESSMENT OF THEIR EFFICIENCY 4221
I. Blagoev, G. Vassileva, V. Monov

THE INVESTIGATION OF STUDENTS WITH HIGH MATHEMATICS ACHIEVEMENTS ATTITUDE TOWARDS TEACHING, LEARNING AND TEACHING - LEARNING CONDITIONS 4231
B. Narkevičienė

DIDACTIC COMPETENCES OF STUDENTS OF THE TEACHER EDUCATION PROGRAMME TO PLAN A LESSON IN THE CONTEXT OF THE DEVELOPMENT OF PUPILS' CRITICAL THINKING 4232
I. Ištvan

DESIGNING AND IMPLEMENTING A SEMINAR FOR B.ED. STUDENTS FROM MATHEMATICS AND SCIENCE EDUCATION: TEACHING INQUIRY USING THE STEM APPROACH 4238
R. Segal, O. Eldar

SELECTED COOPERATIVE METHODS AND THEIR USE TO DEVELOP CRITICAL THINKING IN UNDERGRADUATE TEACHER EDUCATION 4245
I. Ištvan

ADAPTING THE TEACHING METHODS FOR EDUCATIONAL PROGRAMS "ADVERTISING AND PUBLIC RELATIONS" AND "PUBLISHING AND EDITING" IN TIME OF CRISIS 4252
V. Kasianchuk, O. Levchuk, S. Fiialka, O. Holovko, A. Lytvyn, I. Pobidash

CITIZEN VS. PROFESSIONAL DEVELOPERS: DIFFERENCES AND SIMILARITIES OF SKILLS AND TRAINING REQUIREMENTS FOR LOW CODE DEVELOPMENT PLATFORMS 4257
R. Bernsteiner, S. Schlögl, C. Ploder, T. Dilger, F. Brecher

SUMMER CAMPS AND THE FORMAL EDUCATION OF NATURAL SCIENCES IN PRIMARY EDUCATION 4265
M. Díaz-Rodriguez, A. Ortuzar-Iragorri

PRAGMATISM AS A TEACHING APPROACH FOR ENGAGING STUDENTS IN COMPUTING EDUCATION 4270
S. Sohail, G. Salter

APPLICATION OF PRODUCTION-ORIENTED APPROACH IN THE ENGLISH COURSE FOR NON-ENGLISH MAJOR POSTGRADUATES IN CHINA 4274
X.Y. Chen, M. Cao, Q. Xie

PSYCHOMETRIC TESTING OF THE ADAPTED COMPUTATIONAL THINKING TEST IN GREEK CULTURE: ENSURING ITS RELIABILITY, STRUCTURE AND CONVERGENT VALIDITY 4281
P. Kakavas, F.C. Ugolini

QUO VADIS? THE PROCESS OF EDUCATION, PREPARATION AND TRAINING OF CADETS – LEADERSHIP IN THE ARMED FORCES ACADEMY OF GEN. M. R. STEFANIK 4290
M. Petrufová, L. Belan

INITIAL TEACHERS EDUCATION: THE ETWINNING EXPERIENCE IN FIVE ITALIAN UNIVERSITIES 4301
E. Gabbi, I. Ancillotti, M. Ranieri, F. Fabbro

LEARNING ANALYTICS VIEW OF TEACHERS' ACTIVITY IN A LARGE ONLINE PROFESSIONAL COMMUNITY 4308
E. Gabbi

THE USE OF INTERACTIVE TABLETOP SURFACE IN SUPPORTING STUDENTS' COLLABORATIVE WORK: INTERACTION AND INTERFACE DESIGN 4315
S. Sulaiman, D.R. Awang Rambli, S. Mahamad, S. Basri

OVERDIMENSION OF THE CURRICULUM AS AN OBSTACLE TO ACHIEVING THE QUALITY OF THE TEACHING PROCESS 4316
J. Varecha

STUDENT WITH INTELLECTUAL GIFTEDNESS AND ATTENTION DEFICIT HYPERACTIVITY DISORDER IN THE PROCESS OF READING COMPETENCE ACQUISITION 4321
L. Lukáč, B. Hlebová, J. Kožárová

LEARNING STYLES AND THEIR INFLUENCE ON QUALITY OF EDUCATION 4329
J. Varecha

ONLINE EXAMINATIONS DURING COVID-19 4330
T. Vilner, E. Zur

AUDIOVISUAL MATERIAL FOR THE AUTONOMOUS LEARNING OF SKILLS IN THE LABORATORY COURSES OF THE BACHELOR'S DEGREE IN CHEMISTRY 4334
R. Casasnovas, M. Adrover, A. Costa, V. Eim, L. Mariño, J. Ortega-Castro, E. Palacio, C. Palomino, A. Uceda, M. Umaña, B. Vilanova

READING COMPETENCE OF PUPILS OF THE 4TH YEAR OF BASIC EDUCATION IN THE CZECH REPUBLIC 4340
M. Fasnerová, J. Petrová, M. Žišková, J. Trávník, K. Barancová, R. Kárníková

TEACHING FOREIGN LANGUAGES FOR THE ADAPTATION PERIOD: METHODOLOGICAL CHALLENGES 4346
M. Burima

ORGANISING A CHALLENGE-BASED LEARNING EXPERIENCE IN HIGHER EDUCATION: PRE-SERVICE TEACHERS TRAINERS' VIEWS 4355
A. Cerveró-Carrascosa, E. González Quiza, A. Chover Lafarga, E. Vidal Prades

DEVELOPMENT AND ASSESSMENT OF A TEACHING PROPOSAL FOR THE COMPREHENSION OF THE MEASUREMENT DIVISION MODEL IN FRACTION-BY-FRACTION DIVISION PROBLEMS BY PRIMARY SCHOOL STUDENTS IN GREECE 4362
P. Kakavas, A. Papapouliou, N. Manesis

READING COMPETENCE ISSUES IN STUDENTS WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER IN YOUNGER SCHOOL AGE 4372
L. Lukáč, B. Hlebová, J. Kožárová

THE VALUE OF AESTHETIC EXPERIENCE: TEACHER BELIEFS, KNOWLEDGE AND SKILLS IN AESTHETICALLY-INFUSED INQUIRY-BASED LEARNING (AIIBL) IN SINGAPORE SCHOOLS 4380
P. Costes-Onishi, A. Azlan

COMMON TEACHING AND ITS EFFECTS IN THE IMPLEMENTATION OF THE CROSS-CULTURAL COMPETENCE COURSE 4381
J. Bylica

TRANSFERABLE SKILLS DEVELOPMENT DURING THE PHD - EVALUATION OF DOCTORAL SUMMER SCHOOLS IN CIRCULAR ECONOMY 4387
S. Khodaei, M. Bechtold, A. Abdelrazeq, J. Hildenbrand, M. Smol, G. Melo, E. Pirard, I. Isenhardt

IMPLEMENTATION OF THE SOTO MODEL AS A SUCCESSFUL AND FUN LEARNING STRATEGY IN ELEMENTARY SCHOOL 4393
F. Jannah, R. Sari, R. Fahlevi, R. Radiansyah, N. Kartika Sari, P. Mega Puspita

SPATIAL PERCEPTION OF THE SOLAR SYSTEM: A 3D VISUALIZATION E-LEARNING MODULE 4401
V. Georgiev, A. Nikolova, J. Stoikov

SCHOOL COLLECTIVE SELF-REFLECTION AS A BASIS FOR DIGITAL CAPACITY DEVELOPMENT 4406
C. Herrero

HAPTIC TECHNOLOGIES IN VIRTUAL UPSKILLING AND TRAINING SCENARIOS: AN UMBRELLA REVIEW 4411
F. Norouzinia, L. Paz, N. Peters, M. Müller, D. Werth

IMPROVING GENDER BALANCE THROUGH A COMBINED STEM DEGREE 4419
E. McPherson, A. Clarke, A.M. Gallen, M. Keys, P. Wolf

TUNEHOP: THE MOBILE APPLICATION FOR LEARNING MUSICAL INSTRUMENTS 4429
E. Kuš, M. Čarapina

DIGITAL JOB ONBOARDING 4437
F. Niederl, E. Krainz, B. Reiter

INTEGRATION OF NEWCOMERS INTO THE LATVIAN EDUCATION SYSTEM: ANALYSIS OF EXPERIENCE AND OPPORTUNITIES 4442
L. Danilane, S. Usca, J. Dzerviniks, I. Prudnikova, V. Dzervinika

PROJECT BASED LEARNING ON DESIGN FOR 3D PRINTING ASSEMBLY 4450
P. Bolzan, A. Ascani

APPLIED HEALTH LITERACY IN RELATION TO SOMATIC CHARACTERISTICS AMONG FUTURE EDUCATORS 4457
T. Sofková, M. Hřivnová

G-CORE AS AN INNOVATIVE TOOL TO SUPPORT REFLECTION IN A HIGHER EDUCATION ONLINE COURSE 4461
A. Isaksson, J. Lindgren, P. Nilsson

LEARNING BY DOING: INVESTIGATING THE INTEGRATION OF DESIGN THINKING RESEARCH METHODS INTO AN AUTO-CONSTRUCTION DESIGN WORKSHOP FOR THE DEVELOPMENT OF LIVING ENVIRONMENTS FOR SENIORS 4466
S.M. Gramegna, R. Valušytė

VOLUNTARY QUIZZES AS A MEANS TO SUPPORT SELF-DIRECTED LEARNING AND EXAM PREPARATION 4474
S. Eberl, S. Schlögl, T. Spieß

BLENDED LEARNING: A NEW TREND IN EDUCATION 4484
A. Baquero, R. Escortell

HOW DO THIRD GRADE CHILDREN AND THEIR MOTHER'S PERCEIVE PARENTAL INVOLVEMENT IN READING AND IS IT RELATED TO READING ACHIEVEMENT? 4492
B. Segal, T. Katzir, M. Shany

THE IMPACT OF A SHIFT IN THE TEACHING ENVIRONMENT OF HANDS-ON ORIENTED COMPUTER NETWORKS COURSE 4493
N. Kasunic, D. Bjelobrk Knezevic

COVID-19 AND WAR EMERGENCY REMOTE TEACHING SHIFTS IN UKRAINE: CHALLENGES FACED AND LESSONS LEARNED 4499
I. Andrusiak, O. Kolesnyk, M. Slyvka, A. Kolesnyk

PRIMARY SCHOOL PRINCIPALS' PERSPECTIVE ON THE IDEA OF SOCIAL SUPPORT THROUGH HELPFUL AND CONSTRUCTIVE INTERACTIONS WITH COLLEAGUES AS A FACTOR IN RESILIENCE 4507
A. Znidarec Cuckovic

PARAMETRIC MODELING FOR ADDITIVE CLAY MANUFACTURING AS A VECTOR FOR SUSTAINABILITY/CIRCULARITY IN DESIGN EDUCATION 4516
A. Ascani, L. Cipriani, P. Bolzan

UNIVERSITY - INDUSTRY COLLABORATION EXPERIENCES FROM LINNAEUS UNIVERSITY 4525
S. Khoshaba, V. Haralanova

ADDED VALUE OF THE PL@NTNET SMARTPHONE APPLICATION FOR THE MOTIVATION AND PERFORMANCE OF LOWER SECONDARY SCHOOL STUDENTS IN SPECIES IDENTIFICATION 4534
V. Lang, A. Šorgo

THE LEVEL OF KNOWLEDGE AMONG FUTURE TEACHERS ABOUT COVID-19 IN THE CONTEXT OF THE REVISION OF THE EDUCATIONAL FIELD HEALTH EDUCATION IN THE CZECH REPUBLIC 4541
M. Hřivnová, T. Sofková

GROUP DESIGN OF INFOGRAPHICS, AN INEXHAUSTIBLE VISUAL RESOURCE FOR THE UNIVERSITY TEACHING OF DRAWING 4550
M.V. Esgueva López, M.P. Santiago Martín de Madrid, V. Santamarina-Campos, L. Fuster López

EVALUATION OF THE IMPLEMENTATION OF PROJECT-BASED LEARNING IN THE MASTERS IN TEXTILE ENGINEERING AT THE UPV 4557
I. Montava Seguí, E. Bou Belda, P. Díaz García, L. Capablanca Francés, J. Gisbert Payá, R. Belda Anaya

PEDAGOGICAL MODEL OF ACHIEVING PLANNED EDUCATIONAL OUTCOMES BY PRIMARY SCHOOL STUDENTS BY BLENDED LEARNING FORMATS 4561
K. Zvyagin, I. Kozlova, L. Makhmutova, L. Yuzdova, T. Moskvitina, I. Balandina

ANALYSIS OF THE RESULTS OBTAINED THROUGH INDICATORS AFTER THE APPLICATION OF THE PBL METHODOLOGY IN THE MASTER'S DEGREE IN TEXTILE ENGINEERING UPV 4566
I. Montava Seguí, E. Bou Belda, L. Capablanca Francés, P. Díaz García, J. Gisbert Payá, R. Belda Anaya

EDUCATION AND SCIENCE COMMUNICATION TRAINING: A STUDY WITHIN A RESEARCH FELLOWS NUCLEUS 4572
S. Ambrósio, R. Torres, S. Santos

RESULTS OF APPLYING THE JIGSAW PUZZLE FOR LEARNING NETWORK TOPOLOGIES 4581
M. Dolz, M. Castillo, V. Tomás

MASTER STUDENTS' PERCEIVED VALUE OF AN ELECTIVE COURSE THROUGH THEIR REFLECTIVE STATEMENTS 4587
M. Gallarza, Y. Ouazzani, I. Colin-Lachaud, K. Picot-Coupey

DYNAMIC ASSESSMENT OF E-LEARNING IN FOREIGN LANGUAGES PROGRAMS IN SUSTAINABLE AND EMERGENCY DIGITIZATION FORMATS 4589
R. Makhachashvili, I. Semenist

LEARNINGS FROM GENDER IN TEACHING COURSES: MAIN NEEDS AND RESISTANCES 4595
E. Mas de les Valls, M. Peña, N. Olmedo-Torre, A. Lusa

DATA MODELING - LEARNING OUTCOMES AS THE FINAL METHOD OF EVALUATING THE ACQUIRED KNOWLEDGE AT THE UNIVERSITY NORTH 4602
T. Horvat, L. Havaš, D. Srpak, V. Šac

HOLISTIC MODEL OF ENHANCING PERSONALITY IN SOCIAL MEDIA EDUCATION FOR HIGHER INSTITUTION STUDENTS 4608
N. Omar, R. Embong, Z.J. Mohammad Yusoff, F.Z. Ismail, R. Abdul Rashid, I.R. Ismail

INNOVATING PRACTICAL SKILLS-ORIENTED TRAINING FOR SECURITY PROFESSIONALS IN THE AREA OF PRIVATE SECURITY 4614
Z. Zvakova, M. Boros

SPORTS EVENTS AS AN EDUCATION AREA WITH STUDENTS-PUPILS COLLABORATION 4619
H. Wöllik

TEACHER BEING THE LEADING ROLE: INTRODUCING COMPARATIVE LITERATURE MECHANISM IN LITERATURE TRANSLATION COURSE 4624
T. Zhang, Z. Du

ANALYSIS OF THE IMPACT OF THE TEACHER'S PRESENCE IN AN ONLINE TRAINING SESSION ON STUDENTS USING THE EYE TRACKING TECHNIQUE 4629
J.E. Sandubete, A. Rodríguez-Fuertes, P. Reinares-Lara

PISANKA: THE MOBILE APPLICATION FOR LEARNING HOW TO WRITE UPPERCASE LETTERS 4639
F. Čulig, M. Čarapina

PRACTICAL TRAINING OF SECURITY MANAGERS AND SECURITY PROFESSIONALS IN THE FIELD OF PROTECTION AGAINST EXPLOSIVE SYSTEMS 4647
Z. Zvakova, L. Figuli

ONLINE TEACHING AND LEARNING IN UNCERTAIN TIMES: CHALLENGES AND WAYS OF COPING WITH THE NEW REALITY IN HIGHER EDUCATION 4651
R. Wadmany, N. Davidovitch

THE USE OF SCREENCAST FEEDBACK IN UNDERGRADUATE DIGITAL DESIGN TEACHING PRACTICE 4657
M. Green

SOCIAL NETWORKS AS AN EFFECTIVE WAY TO IMPROVE THE INTERCULTURAL COMMUNICATION SKILLS OF CHINESE RUSSIAN LEARNERS: A CASE OF TEACHING COMPLIMENTS 4665
Z. Du, T. Zhang

THE SIGNIFICANCE OF TEACHING COMPLIMENTARY TRANSLATION IN LITERARY TRANSLATION COURSES - TAKING CHINESE RUSSIAN LANGUAGE STUDENTS AS EXAMPLE 4670
T. Zhang, Z. Du

COMMUNICATING ABOUT THE PANDEMIC IN EARLY CHILDHOOD: THE ALT-ER 2.0 PLATFORM 4671
F.M. Dagnino, T. Clavero, M. Haggis-Burridge, R. Jablonskyte, K. Johnson, S. Koivisto, B. Martin, H. Pedersen, A. Postari

APOLLONIUS' PROBLEM LCC AS A STIMULUS FOR STUDENTS TO APPLY DIFFERENT GEOMETRIC KNOWLEDGE 4680
D. Nocar, J. Vaško, T. Zdráhal

DIGITALLY MEDIATED LEARNING OF ACCOUNTING STUDENTS AMID COVID-19 PANDEMIC: A UNIVERSITY OF TECHNOLOGY CASE STUDY 4687
M. Mokhampanyane

STUDENT-TEACHER RELATIONSHIP AND CHILDREN'S ATTACHMENT – IS THERE A CONNECTION? 4688
S. Tatalović Vorkapić, I. Mihić, A. Smolić Batelić

RECONSTRUCTING THE QUALITY DEBATE USING INSTITUTIONAL AUDITS IN A COVID-19 CONTEXT: LESSONS FROM THE SOUTH, THE UNISA EXPERIENCE 4699
K. Ndlovu, L.L. Lalendle, E. Johannes, M. Matshoba

EVALUATION OF THE EXPERIENCE IN SERVICE-LEARNING ACTIVITIES OF NURSING STUDENT 4706
S. Cebada-Sánchez, M.L. Moratalla-Cebrián, R. Bartolome-Gutiérrez, I. Marcilla-Toribio, C. Berlanga-Macías, M. Martínez Andrés

LEARNING POWER SYSTEM SIMULATION IN AN INTERNATIONAL FRAMEWORK 4707
A. Honrubia-Escribano, L. M. Ramos de Oliveira, M. Cañas Carretón, E. Gómez-Lázaro, N. Alguacil Conde, J. M. Arroyo, J. Contreras Sanz, R. García Bertrand, R. Zárate Miñano, M. Carrión Ruiz-Peinado, S. Martín Martínez, R. Villena-Ruiz, E. Artigao Andicoberry

MICROWAVE FILTER DESIGN AND FABRICATION FOR TEACHING IN ENGINEERING DEGREES 4717
E. G. Marin, A. Toral-Lopez, A. Medina-Rull, F. G. Ruiz, A. Godoy, F. Pasadas

HOLISTIC THOUGHTFUL CLASSROOM FOR PROMOTING HIGHER ORDER THINKING SKILLS IN THE 21ST CENTURY LEARNING 4718
R. Embong, W.M. Wan Yusoff, S. Che Seman, H.A. Hashim, H. Md Lateh @ Junid

OVERCOMING THE CHALLENGES TO THE ACCESSIBILITY OF DIGITAL LEARNING FOR THE SOCIAL CARE WORKFORCE 4726
S. Freeman, L. Lord, S. First

COMMUNICATION ASPECT OF PEDAGOGUE'S COLLABORATION WITH THE SCHOOL PRINCIPAL AND TEACHERS 4731
A.M. Iveljić

MAPPING HIGHER JOURNALISM EDUCATION IN EUROPE: DEVELOPMENT OF AN OPEN ACCESS INTERACTIVE DIGITAL REPOSITORY 4742
T. Vukić

HUMANISTIC INTEGRATIVE LEARNING APPROACH TO HOLISTIC STUDENT DEVELOPMENT FOR THE POST-PANDEMIC WORLD 4753
R. Embong, A. Awang Abd. Rahman @ Jusoh, N. Nordin, H.A. Hashim, A.D. Md Zain

COLLABORATIVE TRANSLATIONS OF EARLY MEDIEVAL ENGLISH LITERARY TEXTS: PROJECT-BASED LEARNING AND THE DEVELOPMENT OF KEY COMPETENCES IN ENGLISH STUDIES 4754
F.J. Minaya Gomez

FROM SECONDARY EDUCATION TO HIGHER EDUCATION: THE INFLUENCE OF SOCIAL-EMOTIONAL LEARNING DURING EDUCATIONAL TRANSITION 4759
P. Dekkers, M. Lara, M. Baars

BUILDING A VIRTUAL LABORATORY BENCH TO EXAMINE HEAT TRANSFER PROCESSES 4760
A. Parushev, A. Chekichev, R. Popov

EDUCATION OF CRISIS AND SECURITY MANAGERS FOCUSED ON PSYCHOSOCIAL RISKS RESULTING FROM PRACTICE 4765
V. Moricová, Z. Zvaková, D. Kováčová

THE ADVANTAGES OF A VIRTUAL LABORATORY FOR FOREIGN LANGUAGE TEACHING AT UNIVERSITY LEVEL: THE CASE OF ENGLISH FOR SPECIFIC PURPOSES 4772
I.A. Drobot

A SERVICE-LEARNING PROJECT AS A TEACHING TOOL TO FIGHT AGAINST HYPERTENSION 4778
A.A. Sánchez-Pina, A. Agis-Torres, S. Benedito, C. Contreras, A. Gómez Del Val, M. Hernández-Martín, M.V. Hernández, J.A. Isaa, V.S. Leite Fernandes, M.P. Montenegro, M. Muñoz-Picos, J. Navarro-Dorado, N.F. Pascual, D. Prieto, R. Raposo, P. Recio, R. Redondo-Castillejo, L. Rivera, J.M. Bravo, V. Cachofeiro, J.A. García Baró, D. Gómez Garre, R. Gredilla, N. de las Heras, V. Hurtado-Carneiro, A. López-Calderón, A.I. Martín Velasco, E. Martínez-Martínez, A. Moreno-Rupérez, E. Nebot, S.D. Paredes, T. Priego, R. Rodrígues-Díez, A. Sánchez-Aguilera, M. Sancho, G. Segovia, F. Das Chagas Vasconcelos, M.A. Vicente-Torres, M.E. López-Oliva

REMOTE PRACTICE EXAM TESTING ON DOCKER 4784
J. Jurc, M. Sterbak, P. Segec

CHANGES IN THE RELATIONSHIP OF HIGH SCHOOL STUDENTS WITH SELF AND OTHERS, THROUGH INVOLVEMENT IN EXTRACURRICULAR EDUCATIONAL ACTIVITIES 4789
A. Fantana, D. Opris

BUILDING A VIRTUAL INSTRUMENT FOR RESEARCH AND ANALYZING FILTERS IN LABVIEW AND MATLAB 4795
A. Chekichev, A. Parushev, R. Popov

VIRTUALIZATION IN EDUCATION USING THE VIRTUAL ROUTER TOOL 4801
J. Jurc, M. Sterbak

WORKSHOP ON LIFE STREAMING SHOPPING: ENGAGING PSYCHOLOGY STUDENTS INTO THE MEASUREMENT OF A NEW CONSUMER EXPERIENCE 4807
M. Gallarza, N. Araujo de Oliveira, D. Charris Farrera, A. Ciarlantini, B. De Castro Gomez, J. Hsieh, L. Vilas Boas, T. Panchetti, A. Zenari, Y. Ouazzani, I. Colin-Lachaud, K. Picot-Coupey

FUTURE INNOVATION: DEVELOPING COGNITIVE DIVERSITY THROUGH UNIVERSITY-INDUSTRY COLLABORATION 4809
J. Davidson, C. Chase

IMPROVING LEARNING THROUGH THE CREATION AND RESOLUTION OF CLINICAL CASES ONLINE 4818
C. Guinot-Barona, C.M. Ferrer Serrador, L. Galán López, A. Lanuza García

THE STRATEGY OF EDUCATION IN ETHICS TO ACQUIRE SOFT SKILLS IN SECURITY SCIENCES 4819
D. Kováčová, J. Studená, V. Moricová

THE CHALLENGES AND BENEFITS OF MOVING MUSICAL IMPROVISATION ONLINE: LESSONS FOR EDUCATIONAL DESIGN AND PRACTICE 4824
S. Wilson

LINKING THEORY TO PRACTICE: HOW GAME EXPERIENCE CAN CONTRIBUTE TO REVISING AND INCREASING UNDERSTANDING OF THE PARADIGMS OF LEARNING 4831
B.J. Godejord

INCREASE MARITIME CYBER SITUATIONAL AWARENESS AT A STRATEGIC LEVEL 4836
G. Potamos, E. Stavrou, S. Stavrou, J.C. Lopez, A. Eyzaguirre, C.A. Runyan-Beebe, P. Macias

SAFETY PARK LEARNING ENVIRONMENT AND DIGITAL TECHNOLOGIES FOR TRAINING OCCUPATIONAL SAFETY IN CONSTRUCTION AND ENGLISH FOR PROFESSIONAL COMMUNICATION 4846
E. Selezneva

MORAL VALUES AND THE QUANTITATIVE DIMENSION OF THE FRIENDSHIP RELATIONSHIP BETWEEN ADOLESCENTS 4853
D. Opris, M. Opris, A. Fantana

EXPERIENCE WITH SEVERAL QUALITATIVE EVALUATION METHODS IN EDUCATION 4859
P. Fanta, D. Skokanová

AN INTERDISCIPLINARY PATH TO THE EXPLORATION OF THE UNIVERSE WITH THE USE OF TECHNOLOGIES FOR PRIMARY SCHOOL STUDENTS 4865
C. Aramo, I. Veronesi

WEB-ASSESSING FOREIGN LANGUAGE ACQUISITION OF MIXED ABILITY PRIMARY SCHOOL PUPILS TO ENHANCE DIFFERENTIATED FLIPPED BLENDED LEARNING 4871
S. Gkika, N. Zygouris, I. Galantomos, P. Oikonomou, G. Dimitriou, S. Kopsidas, G. Stamoulis

EXPLORING PEDAGOGICAL CONTENT KNOWLEDGE OF ENTREPRENEURSHIP EDUCATION, TECHNICAL VOCATIONAL EDUCATION, AND TRAINING LECTURERS IN THE CONTEXT OF KNOWLEDGE OF CONTENT AND STUDENTS 4881
M.S. Motsoeneng

THE LEVEL OF DEVELOPMENT OF DIGITAL COMPETENCE AMONG TEACHER TRAINING STUDENTS 4882
K. Harangus, A. Kakucs

INTERDISCIPLINARY COLLABORATION ENHANCED BY A SHARED GOAL ON MULTIPLE BACHELOR'S THESIS: A CASE STUDY FOCUSED ON SUSTAINABLE URBAN DRAINAGE SYSTEMS 4889
M. Garmendia, A. Gredilla, A. Laurenz, E. Madrazo-Uribeetxebarria, M. Meaurio

THE ROLE OF AUTOMATED STUDENT ADVISING WHEN INCENTIVISING STUDENT SUCCESS 4896
R. Rawatlal

A VIRTUAL WORLD EDUCATIONAL GAME FOR TEACHING NEW ICT SKILLS TO TEACHERS: CHALLENGES AND OPPORTUNITIES 4897
P. Athanasiou, K. Dimitropoulos, E. Voyiatzaki, I. Hatzilygeroudis

ALGORITHMIC AND SIMULATION-BASED TEACHING OF COMPUTER SCIENCE AND MATHEMATICS IN HIGHER EDUCATION 4904
N. Annuš, O. Takáč

THE USE OF VIRTUAL REALITY TO PRACTICE PUBLIC SPEAKING IN A FOREIGN LANGUAGE: A CASE STUDY WITH PORTUGUESE HIGHER EDUCATION STUDENTS 4912
C. Tavares, G. Chorão, P. Duarte

ENQER VIEW - AN ANALYTICAL DASHBOARD FOR THE COMPARISON OF UNIVERSITIES' ENTRY QUALIFICATIONS ON EXIT RESULTS 4921
N. Paltalidis, Z. Hong

INTERACTION BETWEEN A DIGITAL ELEMENT AND TRADITIONAL TEACHING IN HIGHER EDUCATION CLASSES: LITHUANIA'S CASE 4930
I. Piščikienė, V. Mickevičienė

SAP VIEW - ANALYTICAL DASHBOARD SOFTWARE FOR THE ANALYSIS OF STUDENTS' ACADEMIC PERFORMANCE 4940
N. Paltalidis, Z. Jin

TEACHER PERCEPTIONS ON IMPLEMENTING MOBILE AR FOR THE TEACHING OF ITALIAN AS A FOREIGN LANGUAGE 4948
M. Manna

SELF-ASSESSMENT OF TEACHERS IN DIGCOMPEDU SUB-AREAS 4949
P. Bohackova, K. Kilianova, L. Klubal, P. Kockova, K. Kostolanyova

ADDRESSING LOW MOTIVATION IN STUDENTS THROUGH THE ANALYSIS OF THE MOTIVATION PROFILE IN HIGH EDUCATION 4953
B. Martínez Pabón, L. Raya, J.J. García Rueda, M. Angulo, B. Saínza Fraga

DISCIPLINARY DIFFERENCES IN DIGITAL COMPETENCE IN ONLINE ASSESSMENT: A EUROPEAN CROSS-COUNTRY AND INTERDISCIPLINARY NEEDS ANALYSIS FOR THE ERASMUS+ PROJECT 'DIGITALHEIGHTS' 4962
N. Souleles, M. Samdanis, E. Papageorgiou

AN INTERACTIVE APPROACH TO CHILDREN'S CRITICAL MEDIA LITERACY EDUCATION: DEVELOPING THE MINDING MEDIA VIDEO TRAINING LIBRARY 4972
V. O'Rourke, J. Blue

EFFECTS OF DIFFERENT VIDEO PLAYBACK SPEEDS ON THE ACQUISITION OF NEW SKI KNOWLEDGE 4979
D. Kuna, M. Marinovic, M. Babic

ASCERTAINING RESEARCH: GRADUATE RESEARCH ASSISTANTS ONE YEAR JOURNEY 4986
J. Harding Middleton

PROBLEMS AND COUNTERMEASURES OF ONLINE TEACHING DURING THE EPIDEMIC 4991
Q. Bai, Y. Cao, Y. Huang

PARENTAL PARTICIPATION AND FUNCTIONING OF ASYLUM-SEEKING PARENTS IN THE EYES OF KINDERGARTEN TEACHERS AND THERAPISTS IN KINDERGARTENS 4998
S. Bar-On

TEACHING COMPUTER SCIENCE FOR THE GENERATION Z – WHY WE NEED MORE PROBLEM-BASED TEACHING IN CS CURRICULA 4999
E. Krainz, A. Öffl, J. Feiner, H. Schwab, M. Knoll, W. Zugaj

TRANSITION SKILLS IN HIGHER EDUCATION 5006
E.W. de Vries

LIVED EXPERIENCES OF PRE-SERVICE ACCOUNTING TEACHERS DURING COVID-19 ERA IN INSTITUTIONS OF HIGHER LEARNING 5011
L. Mphatsoane

APOLLONIUS' PROBLEM CCC AS A STIMULUS FOR NEW SOLUTION METHODS USING MATHEMATICAL SOFTWARE 5015
D. Nocar, J. Vaško, T. Zdráhal

MODELLING A CO-DESIGN PROCESS TO ENVISION DESIGN DIDACTICS IN A POST-PANDEMIC TIME - THE CASE OF THE SCHOOL OF DESIGN, POLITECNICO DI MILANO 5022
A.G. Manciaracina, I. Bollati, M. Mazzarello, A. Taverna

EXPLORATION OF DISTANCE LEARNING OF FOREIGN LANGUAGES UNDER MOBILE LEARNING DURING THE EPIDEMIC 5030
Q. Bai, Y. Cao, Y. Huang

ANALYSIS OF THE NEED FOR INTERDISCIPLINARY ART CURRICULUM 5037
Y. Cao, Q. Bai, M. Mishatkina

THE IMPORTANCE OF MOTIVATION IN COMPUTER SCIENCE TEACHING 5044
A. Acalin, K. Pavlina, A. Pongrac Pavlina

WHAT DO THEY KNOW ABOUT THE EARTH SYSTEM AND GEOETHICS? PORTUGUESE 11TH-GRADE STUDENTS AND SENIOR CITIZENS' CONCEPTIONS 5050
T. Ribeiro, C. Vasconcelos

MODEL CONSTRUCTION FOR THE SYNTHESIS OF THE SUBJECT NATURAL SCIENCES I 5059
A. Ortuzar-Iragorri

THE RETURN TO THE CLASSROOM: OFFERING SCAFFOLDING JOINT CLASSES TO PREPARE FOR FLIPPED WORKGROUPS 5060
C. Tromp

THE LABORATORY WORK AND THE RELEVANCE OF GOWIN'S V: PORTUGUESE MIDDLE SCHOOL SCIENCE TEACHERS' PERCEPTIONS 5069
D. Lima, C. Vasconcelos

HOW EYE-TRACKING TECHNOLOGY CAN BE USED IN DYSLEXIA RESEARCH: AN OVERVIEW 5076
N. Dostálová

PRESENTING MEANINGFUL MATHEMATICAL TASKS THROUGH STORIES FROM HISTORY OF MATHEMATICS: EXAMPLES FROM THE ISLAMIC CONTEXT 5077
H. Haydar, B. Durmaz

ON THE HIGHER EDUCATION QUALITY AND IMPLICATIONS FOR SUSTAINABLE DEVELOPMENT 5086
I. Chiyon Carrasco, S. Sastre-Merino, C. Garay Rondero, J.C. Mosquera Feijoo

FOSTERING COLLABORATIVE ONLINE LEARNING: PRE-SERVICE STUDENTS' PERSPECTIVES 5096
N.M. Majola, B. Lenong, G. Hlumbane

A JOURNEY FROM THE SCHOOLYARD TO THE MOON AND BEYOND: DISCOVERING WAYS TO "GROW" THROUGH RISKY PLAY 5103
M. Galafti, C. Georgiou, D. Daskalaki, M. Dagkli, E. Markou, A. Griva, M. Liapi, K.-A. Oungrinis

RESEARCH TRENDS IN THE USE OF SOCIAL MEDIA AS A TEACHING AND LEARNING TOOL IN HIGHER EDUCATION: CONTENT AND BIBLIOMETRIC ANALYSIS 5112
E. Perez, S. Manca, R. Fernández-Pascual, C. Mc Guckin

A SENSORY GARDEN FOR ENVIRONMENTAL EDUCATION AND LIFE QUALITY IMPROVEMENT 5117
I. Naama Ferreira Lopes, A. Santos de Souza, A. Colares Soares, A.G. Gomes Travassos, V.M.L. Guida, L.S. Paes, J. Mesquita Vidal Martínez de Lucena

SOCIAL EMOTIONAL ENVIRONMENT COMPONENT OF SELF-DIRECTED LEARNING SKILLS DEVELOPMENT IN PRIMARY SCHOOL (GRADES 1-3) 5124
I. Pelnēna, A. Medveckis

EVALUATION OF THE STUDENTS' PRACTICE FROM THE COMPANIES' POINT OF VIEW 5131
M. Kuncova, D. Frendlovska, J. Seknickova

CONCRETE DOSAGE: FROM TRIAL-AND-ERROR TO THE USE OF PERSONAL COMPUTERS, WHICH METHOD IS BETTER FOR UNIVERSITY STUDENTS? 5138
E. Gimenez-Carbo, C. Mozo, H. Coll, L. Soriano

LIVED EXPERIENCES OF ACCOUNTING TEACHERS IN SELECTED SCHOOLS ON ONLINE LEARNING: SUSTAINABLE CURRICULUM PRACTICE APPROACH 5143
L. Mphatsoane

THE EFFECT OF ART HISTORY TRAINING ON ARTISTIC CRITICAL THINKING DURING COVID-19 LOCKDOWN 5144
B. Tamas, A. Barta, B. Galfi

INFOGRAPHICS AS AN INSTRUMENT OF CONTINUOUS EVALUATION: A PROPOSAL FROM THE EXPERIENCE OF USING THE TOOL AS A GROUP PRACTICAL ACTIVITY 5149
D. Catala-Perez, M.B. De Miguel-Molina, M. De Miguel-Molina, V. Santamarina-Campos

FACTORS AFFECTING E-LEANERS' SATISFACTION ON DISTANT LEARNING: A CASE OF LOMONOSOV MOSCOW STATE UNIVERSITY GRADUATE PROGRAMS 5156
A. Kisil, M. Ulyanova

COUPLING CULTURALLY RESPONSIVE TEACHING AND STEAM EDUCATION: EXAMINING GLOBAL AND LOCAL HERITAGE SITES TO DEVELOP STEAM PROFICIENCIES 5164
C. Maguire, T. Hogan

POTENTIALS FOR TECHNOLOGY-SUPPORTED TEACHING AND LEARNING IN CONTINUING EDUCATION: INSIGHTS FROM A MIXED METHODS STUDY 5165
L. Häßlich

PYTHON COURSE FOR GAME DEVELOPMENT: AN INITIATIVE OF WOMEN IN STEM 5175
C. B. Souza, E. H. Q. V. Costa, J. C. C. Duarte, M. G. Moreira, S. M. B. S. B. Fraga, V. Rodrighero, L. R. Santos, C. A. Martins, F. A. Pereira, I. B. Henriques, M. M. Silva, M. M. S. Matsumoto, N. Jodas, S. S. D. Custódio, L. K. Teles, K. D. Fook

AVOIDING MISSING IMPORTANT STEPS IN EDUCATIONAL MANAGEMENT 5183
G.M. Moraru

FOSTERING TRANSNATIONAL RESEARCH, INNOVATION AND EDUCATION THROUGH AN INTERNATIONAL EUROPE AND AFRICA COLLABORATION PROJECT 5190
I. Mocanu, O. Cramariuc, K. Bierwirth, H. Lebik, B. Kodom, M. Mecklin

LEVERAGING THE INTERNET OF THINGS TOWARDS RAISING ENVIRONMENTAL AWARENESS IN EUROPEAN CLASSROOMS 5195
T. Kouvara, A. Fanariotis, V. Fotopoulos, C. Karachristos, T. Orphanoudakis

THE RELATIONSHIP BETWEEN EMPATHY AND EMOTIONAL EXHAUSTION IN UNIVERSITY PROFESSORS 5203
G. Martinez-Ramirez, O. Nava-Manzo, A. Guardiola-Ramirez, J. Beltran-Sanchez, A. Valle-de la O

INCLUSIVE DESIGN TO BRIDGE THE DIGITAL DIVIDE AND TO INCREASE ACCEPTANCE OF OLDER ADULTS FOR SMART MEDICATION COMPLIANCE DEVICES 5209
I. Mocanu, O. Cramariuc, K. Bierwirth, K. Piotrowicz, A. Mocanu

EDUCATION AND INCLUSION OF FORCED MIGRANTS THROUGH SPORT: UNDERSTANDINGS FROM POLITICS AND PRACTICE 5216
B. Valongo, T. Silva Dias, S. Marques da Silva

PROFESSIONAL TRAINING OF LAST YEAR ENGINEERING STUDENTS USING THE CASE STUDY METHOD 5217
G.M. Moraru

TRANSITION UP, OUT AND BACK; CONTEXTUALISING INCLUSIVE STUDENT LIFECYCLE INTERVENTIONS AGAINST GRADUATE LIMINALITY 5223
A. Amayo

POETIC INSIGHT INTO STUDENT MOTIVATION AND EXPERIENCE 5224
L. Robson

EXAMINING THE RESULTS OF FINAL PAPERS IN MECHANICAL ENGINEERING DURING THE COVID-19 PANDEMIC 5228
G. Kiss, E.C. Berecz

AN INSIGHT IN THE DIMENSIONS OF INSTRUCTION QUALITY IN ENGINEERING EDUCATION 5233
J.C. Mosquera Feijoo, S. Andrés Martínez, D. Santillán Sánchez, L. Cueto-Felgueroso Landeira

THE IMPACT OF A SHARED SCREEN ON A TEACHER'S ACTIVITIES IN A COMPUTER-SUPPORTED CLASSROOM 5243
R. Shaikh, H. Raval

FINDING POETRY IN YOUR DATA 5244
L. Robson

SELF-REPORTED INAPPROPRIATE NEGOTIATION STRATEGIES QUESTIONNAIRE COMPARISONS AMONG BUSINESS VERSUS SOFTWARE ENGINEERING STUDENTS 5245
D. Brannon, M. Manshad, V. Iyer

THE RELATIONSHIP BETWEEN CHEMISTRY AND TELECOMMUNICATIONS ENGINEERING AS A DRIVING FORCE AND MOTIVATION FOR UNDERGRADUATE THESIS WITH IMPROVED TRANSVERSAL SKILLS 5246
M. Azkune, I. Moreno-Benítez, I. Castellanos, A. Fidalgo, J. Sánchez Bodón, J. Cepeda, J J. Esteban, L. Ruiz Rubio

A NEW SET OF TOOLS FOR ADAPTIVE SELF-PACED LEARNING IN COMPUTER-AIDED DESIGN FOR ENGINEERING 5251
F. Salmerón Medina, M. Alcalde Rico, F. Gómez-Estern Aguilar, F. Valderrama Gual

DIGITAL LITERACY & MOTIVATION: CREATING PERSONAS WITH MIXED-METHODS TO TAILOR ONLINE TRAINING TO THE CRAFT INDUSTRY 5261
M. Tasliarmut, D. Langer, J. Birke, S. Zeiner-Fink, A.C. Bullinger

EDUCATIONAL RESEARCHERS AND SCIENCE COMMUNICATION: THE CASE OF A BIWEEKLY COLUMN PUBLISHED IN REGIONAL NEWSPAPER 5269
S. Ambrósio, M.H. Araújo E Sá, C. Guerra

FACILITATION OF COMPETENCE ACQUISITION THROUGH FORMATIVE E-ASSESSMENT 5270
R. Meissner, C. Ruhland

MICROCREDENTIALS FOR IN SERVICE MATHEMATICS TEACHERS AND AMBITIOUS TEACHING PRACTICES: UNDERSTANDING THE STRENGTHS AND BARRIERS 5278
H. Haydar

AUTOMATED GRADING IN COMPUTER-AIDED DESIGN FOR ENGINEERING 5279
F. Salmerón Medina, M. Alcalde Rico, F. Gómez-Estern Aguilar, F. Valderrama Gual

CONCEPTION OF TEACHING THE COURSE NUMERICAL METHODS AND STATISTICS AT THE FACULTY OF MECHANICAL ENGINEERING, UNIVERSITY OF ŽILINA AND ITS TRANSFORMATION DURING THE COVID 19 PANDEMIC 5290
I. Pobočíková, M. Michalková, Z. Sedliačková, V. Guldan, R. Chupáč

INTERACTIVE INNOVATION BROKER: A CONSENSUAL FRAMEWORK FOR MULTI-ACTOR APPROACH PRACTICAL IMPLEMENTATION 5298
O. Bernardez, J. Domingues, N. Rodriguez-Aubo, W. Filipowska, C. Cotelo

STUDENTS' SATISFACTION IN THE ACCOUNTING AND ADMINISTRATION GRADUATION: FACTORS THAT AFFECTED THE EXPERIENCE OF DISTANCE LEARNING CONTEXT 5303
A. Monteiro, R. Bertuzi, C. Pereira, R. Soares

SPACES FOR YOUTH PARTICIPATION IN DECISION-MAKING: A PEDAGOGICAL REFLECTION BASED ON A CONTENT ANALYSIS OF EUROPEAN AND INTERNATIONAL YOUTH STRATEGIES 5311
D. Bianchi, L. Carriera, C.C. Montà

WHAT ABOUT SCHOOL PROFESSIONALS? SELF-ASSESSMENT OF THEIR SOCIO-EMOTIONAL COMPETENCIES 5316
T. Maglica, A. Grčić, M. Ljubetić

CREATING GLOBAL CITIZENS: DIVERSITY, EQUITY, AND INCLUSION IN GENERAL EDUCATION CURRICULUM 5326
A. Dominguez

BEYOND A BLURB ON THE RESUME: IMPROVING THE ACADEMIC VALUE OF FIELD EXPERIENCES THROUGH STRUCTURED REFLECTION 5336
M. Finkenberg

ASSESSING CHANGE: ASSESSMENT, ACCREDITATION AND CURRICULUM DESIGN 5337
A. Dominguez

EXPLORING SOCIAL MEDIA USES AND INTERNET ADDICTION DURING THE PANDEMIC 5338
P. Silveira

WHAT LIES BENEATH? USING A MULTIMODAL INQUIRY FRAMEWORK TO EXAMINE LECTURERS' SEMIOTIC CHOICES IN THE DESIGN AND DEVELOPMENT OF MULTIMODAL SCREENCASTS TO TEACH DISCIPLINARY CONCEPTS IN HIGHER EDUCATION 5342
G. McDermott

REMOTE TEACHING METHOD FOR HUMAN-ROBOT COLLABORATION ON THE FACTORY FLOOR 5350
W. Souza Picanço, G. Soprano Machado, M. Melo de Carvalho, F. Antonio de Carvalho Ayres Junior, R. Landau Paiva de Medeiros, V. Ferreira de Lucena Junior

DISTANCE LEARNING MODEL FOR EXERCISE INTERVENTION IN ADOLESCENTS WITH ANGINA PECTORIS 5360
M. Guan, B. Pu, R. Cao, H. Jingbo

CLASSROOM MANAGEMENT WITHOUT TEARS: SOCIAL EMOTIONAL LEARNING AS SUSTAINABLE APPROACH TO BEHAVIORAL CHANGE 5366
R. Pelton

THE IMPACT OF A FIRST-YEAR ORIENTATION TEAM BUILDING EXERCISE 5367
J. Smallwood, C. Allen

FOREST PEDAGOGY AS ONE OF THE APPROACHES TO SUSTAINABLE DEVELOPMENT IN EDUCATION 5374
D. Kollárová, S. Borisová

ADAPTATION OF TEACHING METHODOLOGIES IN ADULT EDUCATION: APPLICATION IN THE SENIOR CLASSROOM OF THE UNIVERSITY OF MURCIA 5381
A. Martinez Serrano

THE EFFECTIVENESS OF LEARNING MODEL GAWI MANUNTUNG TO INCREASE HIGH ORDER THINKING SKILLS AND DIGITAL LITERACY SKILLS ELEMENTARY SCHOOL STUDENTS 5389
A. Suriansyah, A.R. Agusta, N. Ngadimun, I. Sin, M.F. Mohd Yaakob, A. Aslamiah, D.A. Pratiwi, N. Noorhapizah, R. Purwanti, B.B. Wiyono

SUSTAINABILITY CHALLENGE AS A MOTOR FOR THE DEVELOPMENT OF TRANSVERSAL SKILLS IN MATERIALS SCIENCE AND UNDERGRADUATE THESIS IN CHEMISTRY: SUSTAINABLE MATERIALS FOR WIND TURBINES 5401
I. Moreno Benítez, A. Veloso, M. Azkune, C. Calabrese, A. Lasheras, I. Ayesta, I. Usabiaga, J.L. Vilas-Vilela, L. Ruiz Rubio

ENGINEERING INNOVATIVE WAYS TO SUSTAIN LEARNING FOR PRE-SERVICE ECONOMIC AND MANAGEMENT SCIENCE TEACHERS IN CURRICULUM PRACTICE 5405
M. Mphuthi, M. Tshelane

ANALYSIS OF THE TRANSITION FROM ONLINE EDUCATION TO FACE-TO-FACE EDUCATION IN TEXTILE ENGINEERING AFTER THE COVID 19 PANDEMIC 5413
A. Buhu, L. Buhu

THE RELATIONSHIP BETWEEN BULGARIAN PRIMARY TEACHERS' EMPATHY AND ITS "PROFESSIONAL EMPATHY" IN THE ASPECT OF DESIGN THINKING AS AN EDUCATIONAL APPROACH 5419
N. Kaloyanova, D. Donev

PERCEPTION OF THE EFFECTIVENESS OF CHEMISTRY TEACHERS' E-COMMUNICATION WITH STUDENTS, PARENTS AND COLLEAGUES 5420
S. Milković Šipek, D. Černi, O. Martinis

CREATING ACCESSIBLE ACADEMIC SUPPORT PROGRAM ACCOMMODATIVE OF THE NEW NORMAL IN CURRICULUM PRACTICE FOR PRE-SERVICE TEACHERS 5427
M. Mphuthi, M. Tshelane

IN FAVOR OF CHANGE: USING THE COM-B MODEL TO CHARACTERIZE TRAINERS' BEHAVIOR DURING THE DIGITIZATION PROCESS OF VOCATIONAL TRAINING 5428
J. Birke, M. Tasliarmut, I. Friedrich, S. Zeiner-Fink, A.C. Bullinger

AMBIPOLAR RADIOFREQUENCY APPLICATIONS FOR THE NEXT GENERATION OF MICROWAVE ENGINEERS 5437
F. Pasadas, A. Medina-Rull, A. Toral-Lopez, F. G. Ruiz, A. Godoy, E. G. Marin

IMPLEMENTING UNIVERSAL DESIGN FOR LEARNING TO PROMOTE LANGUAGE PARITY IN ONLINE COURSES: A PILOT TRANSLATION INITIATIVE 5438
M. Redmon, S. Wyatt, W. Howard

AUTOMATION OF KAHOOT! BY THE HUMANOID ROBOT PEPPER 5442
A. Dannecker, D. Hertig

INCLUSIVE PEDAGOGY IN PRACTICE: THE POINT OF VIEW OF TEACHERS 5450
M. Passarelli, F.M. Dagnino, S. Ivanov, D. Persico

EDUTAINMENT TECHNOLOGIES IN PRIMARY SCHOOL EDUCATIONAL PRACTICES 5459
B. Shao

THE ROLE OF PRESCHOOL TEACHERS IN PROMOTION OF CHILD MENTAL HEALTH 5464
S. Skočić Mihić, K. Babić Milih, R. Čepić

PROJECT-BASED LEARNING TO UNDERSTAND THE STERIC EFFECT OF CHEMICAL LIGANDS BY A WEB-SERVER 5472
A. Poater

INTEGRATING CITIZEN OBSERVATORIES INTO SCHOOL ENVIRONMENTAL EDUCATION FOR SUSTAINABILITY: DESIGN AND EVALUATION OF A CASE STUDY ENGAGING STUDENTS WITH PL@NTNET AND ODOURCOLLECT 5479
M. Daskolia, M. Pappa, A. Joly, P. Bonnet, R. Arias, J. Piera, K. Soacha

PERCEIVED TEACHERS' INCLUSIVE COMPETENCIES AND PROFESSIONAL DEVELOPMENT 5490
S. Skočić Mihić, K. Jurčić Malinarić, R. Čepić

THE FUTURE OF EAP IN HIGHER EDUCATION: AN ITALIAN PERSPECTIVE 5498
A. Romagnuolo

THE INCREASE IN ACTIVE TEACHING METHODOLOGIES AND THEIR DOCUMENTARY FRAMEWORK 5507
M.M. Silva, M.J. Ferreira, D.R. Alves

SCHOOL DROPOUT: CHARACTERIZATION OF THE CONDITIONS OF STUDENTS AT A PORTUGUESE HIGHER EDUCATION INSTITUTION 5514
M. Lopes, P. Sismeiro Pereira, P. Fortunato Vaz

METHODS OF TEACHING USING SOFTWARE APPLICATIONS AND TRUE EFFECTS OF THESE METHODS 5523
J. Jánský, J. Jekl, V. Růžička

UNIVERSITY SUPPORT, STUDENTS' SKILLS AND ENTREPRENEURIAL INTENTIONS: A PLANNED BEHAVIOUR APPROACH 5533
C.S. Marques, C.P. Marques, C. Leal

HOW DO ACADEMICS PERCEIVE THE BENEFITS AND COSTS OF COLLABORATING WITH INDUSTRY? 5534
C. Marques, C.S. Marques, C. Leal

ROMANIAN AS A MOTHER TONGUE AND AS A FOREIGN LANGUAGE - COMPARATIVE STUDY ROMANIA - REPUBLIC OF MOLDOVA 5535
G. Ciobotaru

"STUDY FRIENDS": AN INNOVATIVE TUTORING INTERVENTION PROJECT IN MIDDLE SCHOOLS 5536
I. Coppola, C. Rivella, F. Lagomarsino, A. Modugno, N. Rania

THEMES OF NATURE IN CHILDREN´S PHILOSOPHICAL LITERARY STORIES AS ONE OF THE POSSIBILITIES OF FORMING A RELATIONSHIP WITH NATURE 5541
S. Borisová, G. Pintes

FROM MOTIVATION TO INTENTION TO BE AN ENTREPRENEUR – DOES THE UNIVERSITY SUPPORT MATTER? 5547
C. Leal, C. Marques, C.S. Marques

FRONT WINNERS A PROJECT FOCUSED ON THE RESKILLING PROCESS OF MENTORS FOR STUDENTS WITH DISABILITIES 5548
M. Potes Barbas, P. Matos, E. Casimiro

DESIGNING A CONSTRUCTIVIST PROBLEM BASED-LEARNING (PBL) STRATEGY THROUGH VIDEO IN PATHOPHYSIOLOGY 5553
M. Hernández-Martín, A. Gómez del Val, R. Redondo-Castillejo, J. Navarro-Dorado, M. Muñoz-Picos, N.F. Pascual, M.P. Montenegro, C. Contreras, J.J. Merino, A. Sánchez-Pina, A. Agis-Torres, B. Climent, P. Recio, R. Raposo, S. Benedito, L. Rivera, D. Prieto, M. Hernández, M.E. López-Oliva, V.S. Leite Fernandes

TEACHING INTEGRATED MUNICIPAL SOLID WASTE MANAGEMENT TO PEOPLE IN THE HUERTO ROMA VERDE, CDMX, MEXICO 5559
D. Linares Ramírez, P. Barandiarán, B.E. Gutiérrez Barba, Y. Cuetero Martínez, J. Rodríguez Gutiérrez, R.F. da Silva

BEE-BOT & BLUE-BOT: FROM MINDLESS TAPPING TO ALGORITHM CREATION 5565
K. Kilianova, P. Kockova, P. Bohackova, L. Klubal, K. Kostolanyova

FLIPPING THE CLASSROOM IN ADVANCED COURSES: IS IT EFFECTIVE? 5573
G. Abio, M. Alcañiz, C. Patxot, M. Gómez-Puig, G. Rubert, M. Serrano, A. Stoyanova

THE IMPACT OF COVID-19 ON ENGINEERING STUDENTS IN ITALY: PROFILE AND PERFORMANCE CHANGE FROM 2019 TO 2021 5578
E. Bottani, G. Casella, S. Filippelli, B. Bigliardi

E-LEARNING EXPERIENCES FOR THE ENTREPRENEURIAL EDUCATION OF STUDENTS 5587
E. Pecheanu, A. Cocu, I. Susnea, L. Kevelaerts

DESIGN & DEVELOP A SMART LEARNING CITY ENVIRONMENT FOR SUSTAINABILITY 5595
M. M. Marques, L. Pombo

A SERVICE-LEARNING EXPERIENCE BASED ON SUSTAINABLE DEVELOPMENT GOALS IN SECONDARY AND HIGHER EDUCATION 5602
I. Blanco-Gutiérrez, J.R. Ferrer, S. Benito, J. Ruiz, S. Seoane, P. Almendros-Garcia, F. Revuelta

EMPLOYABILITY OF UNIVERSITY GRADUATES IN CHANGING LABOUR MARKET CONDITIONS: CASE OF LATVIA 5611
I. Jaunzeme, S. Busule

TEACHING INTERCULTURAL COMMUNICATION AS A PATH TO INCLUSIVE AND OPEN SOCIETY: ANALYSIS OF TEXTBOOKS AND CURRICULA 5612
A. Romanovska, T. Bogdanovica

REALIZATION OF AN APPLIED LEARNING GAME FOR A WORK TASK SIMULATION SUPPORTING TRAINING OF WORK DESIGN SKILLS DURING QUALIFICATIONS-BASED LEARNING 5620
R. Srbecky, S.A. Wetzel, D. Delvos, B. Kres, K. Overdiek, W. Fraas, M. Winterhagen, J. Dettmers, M. Hemmje

APPROACHING THE ANALYSIS OF TEACHING ACTIVITY THROUGH COLLABORATIVE SELF-REFLECTION FROM THE PERSPECTIVE OF TEACHERS' SOCIAL INTERACTIONS 5630
A.M. Cioloca, L.I. Verdeș, M. Bocoș

IMPACTS OF INCLUSIVE MAKER PROGRAMMING ON STUDENTS' ENGINEERING KNOWLEDGE AND INTEREST 5637
S. Gardner, A. Woods, L. Jackson, A. Riccio, W. Martin

CRITICAL THINKING AND RAISING SOCIAL AWARENESS REGARDING REFUGEE CRISIS IN ENGLISH LANGUAGE TEACHING THROUGH DIFFERENTIATED INSTRUCTION– A CASE STUDY BASED ON "THE BEST WE COULD DO" BY THI BUI 5645
C. Tziovara, V. Golfinopoulou, S. Kaldi

EVIDENCE-BASED GOOD TEACHING SUCCEEDS FACE-2-FACE AND ONLINE 5650
A. Dannecker, U. Hanke

WEB-BASED INTERVENTION TO HELP NURSES TO MANAGE WORK-RELATED STRESS (WBI-WRS) IN SAUDI ARABIA: A FEASIBILITY STUDY 5657
Y. Allehyani, H. Wharrad, H. Blake

UNDERGRADUATE TEACHER TRAINING FOR WORKING WITH A DYSLEXIC PUPIL 5658
J. Petrová, M. Fasnerová

POP-ITS IN EARLY CHILDHOOD EDUCATION TO ENCOURAGE THE DEVELOPMENT OF MATHEMATICAL LOGICAL THINKING 5666
A.A. Magreñán, L. Orcos, I. Palacios, D. Lapresa

INCARCERATED STUDENTS' EXPERIENCES ON FACTORS INHIBITING EFFECTIVE LEARNING IN A COMPREHENSIVE OPEN DISTANCE E-LEARNING INSTITUTION IN SOUTH AFRICA 5676
M.G. Mlambo

CO-CREATING DIGITAL SOLUTIONS FOR ALZHEIMER INFORMAL CAREGIVERS: A PILOT TRAINING COURSE 5685
C. Soares, R. Madeira, G. Colaco, P. Macedo

A REVISITED PARETO ANALYSIS FOR RANKING STUDIES, JOURNALS AND AUTHORS IN SYSTEMATIC LITERATURE REVIEWS 5686
E. Bottani, G. Casella, S. Filippelli, B. Bigliardi

THE INFLUENCE OF FREQUENT QUIZ-BASED EXAMS ON LEARNING PERFORMANCE AMONG COMPUTER SCIENCE STUDENTS 5693
I. Pesovski, V. Trajkovik

TEACHING APPLIED THROUGH REMOTE BOOT CAMP: AN EXPERIENCE REPORT 5700
A.M. Loureiro, V. Bremgartner, L.M. Silva, P.S. Fernandes

PROTOCOL FOR RESEARCH-ORIENTED FINAL PROJECTS 5705
M.M. Capobianco-Uriarte, J. Tarifa Fernández, E. Carmona Moreno

DEVELOPMENT OF AN INITIAL MATHEMATICS COURSE FOR STUDENTS OF THE FIRST YEAR OF TEACHER OF PRIMARY EDUCATION DEGREE 5706
A.A. Magreñán, L. Orcos, M.A. Hernández-Verón, J. A. Ezquerro

ROBOTSOLUTION: A KIT FOR THE DEVELOPMENT OF COMPUTATIONAL THINKING SKILLS IN HIGH SCHOOL STUDENTS 5716
D. Marinho, V. Bremgartner, A. Loureiro, L. Silva

TRANSDISCIPLINARITY AND INTERDISCIPLINARITY IN THE TEACHING OF PSYCHOLOGY 5723
M.V. Zerbes, V.S. Neamu, L.G. Popescu, A. Olteanu

ENHANCING STEM EDUCATION THROUGH PROJECT-BASED LEARNING COMBINED WITH VIRTUAL AND AUGMENTED REALITY 5730
P. Petrov, T. Atanasova

INCLUSIVE TEACHING AND LEARNING FOCUSED ON PUPILS WITH CONDUCT DISORDERS 5737
M. Kaleja, E. Satinská

START IT: ENTREPRENEURSHIP AND DIGITAL SKILLS 5738
H. Bollaert, J. Hautamaki, J. Isohanni, J.C. Monteiro, K. Podlaski, P. Possemiers, D. O'Reilly, K. Simbeck, Z. Stawska

SUSTAINABLE URBAN MOBILITY WORKSHOP FOR YOUNG PEOPLE 5742
H. Gonzalo-Orden, M. Miguel-Borge, A.M. Aguilar López, H. Pérez-Acebo

WORKLOAD ALLOCATION, THE CASE OF THREE SOUTH AFRICAN HIGHER EDUCATION INSTITUTIONS 5752
B. Masiye, L.L. Lalendle, M. Molapo, S. Ndlovu

INCLUSIVE HIGHER EDUCATION SYSTEM: IS IT A QUESTION OR A CHALLENGE? 5757
M. Kaleja, E. Satinská

DEVELOPMENT OF A PROJECT TO IMPROVE THE NUTRITIONAL MODEL OF CHILDREN IN A PRESCHOOL INSTITUTION IN ROMANIA 5758
M.V. Zerbes, F. Brudea, L.G. Popescu, A. Olteanu

NEUROTECHNOLOGY AND ITS ETHICAL IMPLICATIONS FOR TEACHING AND RESEARCH IN DIVERSE EDUCATIONAL ENVIRONMENTS 5765
M.M. Capobianco-Uriarte, G.M. Marin Carrillo, J.M. Berbel Pineda, J.M. Ramírez Hurtado, M.P. Casado Belmonte

DESIGN AND IMPLEMENTATION OF A WEB-BASED TOOL TO INTEGRATE NATURAL LANGUAGE FEEDBACK IN AUTOMATED ASSESSMENT 5769
R. Bimazubute

MUSICAL MIRRORS AT GENERAL EDUCATION SCHOOLS IN POLAND – AN EXPERIMENTAL STUDY 5775
V. Cohen, G. Konkol, A. Kalarus

A CASE STUDY APPROACH FOR IT HONOURS STUDENTS TO ENGAGE WITH CORPORATE ENVIRONMENTS REGARDING SOFTWARE DEVELOPMENT METHODOLOGIES 5776
L. Drevin

PERSPECTIVES OF LEARNERS AND EDUCATORS REGARDING THE INCLUSION OF PREGNANT LEANERS IN MAINSTREAM EDUCATION 5786
P. Tsilo, A. Makura

COMMUNITY INVOLVEMENT IN PUPILS' LEARNING IN RESPONSE TO COVID-19 CRISIS: A CASE OF AKU-IED EA'S INTERVENTIONS IN SOUTHERN TANZANIA, LINDI REGION 5787
N. Mrutu, F. Mtenzi, P. Kajoro, E. Kibga, J. Kova, H. Nkota, A. Hoka

EDUCATIONAL TASKS IN THE PRACTICAL TEXTBOOK FOR TEACHING ABOUT FOREST WITH CONNECTIONS TO BLOOM'S TAXONOMY OF COGNITIVE GOALS 5796
D. Kollárová, A. Nagyová

PUPILS WITH DUAL EXCEPTIONALITY 5802
K. Jůzová, D. Jirotková

PIVOTING ONLINE DURING COVID-19: LESSONS LEARNED INFORMING STELLENBOSCH UNIVERSITY'S HYBRID LEARNING STRATEGY 5807
A. Van Der Merwe, D. Ramjugernath

TEACHING ABOUT FOREST – INNOVATIVE TEACHERS' EDUCATION AS A TOOL FOR PROFESSIONAL COMPETENCIES IMPROVEMENT 5808
D. Kollárová, A. Nagyová

EVALUATING A QUALITY ASSURANCE INSTRUMENT IN THE ADVENT OF REMOTE TEACHING, LEARNING AND WORKING ENVIRONMENTS 5816
L.L. Lalendle, R. Tsephe, I. Naidoo

COVID19 IMPACT ON ELEARNING AS AN ECOLOGICAL SYSTEM 5824
F. Chacon, J. Shaw

IDENTIFICATION OF PREDICTIVE FACTORS FOR STUDENT FAILURE IN STEM ORIENTED COURSE 5831
V. Čotić Poturić, I. Dražić, S. Čandrlić

THE IMPLEMENTATION OF SCHOOL FEEDING PROGRAM IN A CONTEXT OF FEE-FREE EDUCATION POLICY TO ENHANCE EARLY CHILDHOOD LEARNING: A CASE OF TWO PRIMARY SCHOOLS IN IRINGA MUNICIPAL, TANZANIA 5838
N. Mrutu, F. Mtenzi, H. Nkota, P. Kajoro, J. Kova, E. Kibga, A. Hoka

OPEN EDUCATIONAL RESOURCES: USERS, PLATFORMS AND METADATA 5847
O. Gröblinger, J. Schindler, A. Parschalk

INTERPROFESSIONAL EDUCATION FOR OCCUPATIONAL THERAPY, PHYSICAL THERAPY, AND CONSTRUCTION MANAGEMENT STUDENTS IN DEFINING HOME 5855
D. Todorov, C. Sunderlin, R. Panetta

IMPLEMENTATION OF A MOOT TRIAL AS AN EXPERIENTIAL LEARNING FOR ENVIRONMENTAL ENGINEERS 5862
S. Todorova

VALUED CHARACTER STRENGTHS OF A LEADER AS REFLECTED IN MILITARY TRADITIONS AND MEMOIRS 5863
O. Heřman, D. Ullrich

ARTIFICIAL NEURAL NETWORK MODEL FOR FORECASTING STUDENT FAILURE IN MATH COURSE 5872
V. Čotić Poturić, A. Bašić-Šiško, I. Lulić

INTERDISCIPLINARY TEACHING: A MONTESSORI APPROACH TO UNIVERSITY CLASS ASSIGNMENTS 5879
P.J. Cuadros Solas, M. Fernandez-Moya, A. Álvaro, C. Salvador Muñoz

TEACHING OBJECT ORIENTED PROGRAMMING: PROGRAMMING LANGUAGE CHALLENGE 5880
D. Krpan, S. Mladenović, G. Zaharija

FEEDBACK STRATEGIES FOR A SOCCER TRAINING SCENARIO IN VIRTUAL REALITY 5888
A. Lozano-Tarazona, D.M. Rivera Pinzón

DEVELOPMENTAL CONSIDERATIONS FOR DIGITAL PLATFORMS: EFFECT OF PERCEPTUAL BACKGROUNDS ON COGNITIVE TASK ENGAGEMENT 5894
C. Habak, I.M. Santos, K. Sung, M.L. Woolsey, M.L. Seghier, M.A. Fahim, M. Melkonian

THE IMPACT OF SELECTED FACTORS ON STUDENTS' TEST SCORES DURING INTEGRATION OF ENGLISH LANGUAGE INTO MATHEMATICS LESSONS 5895
J. Wossala, E. Kočařová

UNIVERSITY-INDUSTRY COLLABORATION IN AN OPEN INNOVATION PERSPECTIVE: RESULTS FROM A BIBLIOMETRIC AND KEYWORDS ANALYSIS 5904
B. Bigliardi, V. Dolci, S. Filippelli, A. Petroni, B. Pini, L. Tagliente

DEVELOPMENT OF PUPILS' MATHEMATICAL LITERACY OUTSIDE THE REGULAR CLASSROOM FROM THE PERSPECTIVE OF STUDENTS OF PEDAGOGICAL DISCIPLINES 5913
J. Wossala, I. Mrňová

CREATIVITY IS YOUR LIFELINE: THE HEALTH OF A NATION 5921
M.S. Rogers, J.P.D. Rogers

A "SKETCHY PEOPLE" VIRTUAL WORKSHOP FOR CREATIVITY AND DESIGN THINKING 5927
W. Genereux, D. Satterfield

TEACHING SEARCH ALGORITHMS FOR DIFFERENT AGE GROUPS IN ELEMENTARY SCHOOL 5935
G. Zaharija, M. Laća, S. Mladenović, D. Krpan

VISUAL COMFORT FROM LIGHTING PERSPECTIVE IN WORK-FOCUS LEARNING' INTERIOR ENVIRONMENT 5942
N. Sami Abdelaziz Mahmoud

INNOVATIVE START-UPS: THE HUMAN ROLE WITHIN AN OPEN INNOVATION APPROACH 5950
B. Bigliardi, V. Dolci, S. Filippelli, A. Petroni, B. Pini, L. Tagliente

RED PAZ UNAL OR AN ORGANIZATIONAL TRANSFORMATIONAL LEARNING STRATEGY TO SUPPORT TERRITORIAL PEACE IN COLOMBIA FROM WITHIN THE UNIVERSITY 5951
D. Santos

MANAGEMENT OF ACTIVE FAMILY - SCHOOL COLLABORATIVE PARTNERSHIP 5952
A. Klimentova

UNIVERSITY PATENTING IN AN OPEN INNOVATION ECOSYSTEM 5960
B. Bigliardi, V. Dolci, S. Filippelli, A. Petroni, B. Pini, L. Tagliente

PARENTS AND THE FLIPPED CLASSROOM APPROACH IN K-12 TEACHING 5970
M. Loizou

THE INCORPORATION OF THE GENDER PERSPECTIVE IN THE TEACHING OF ARCHITECTURE 5979
M.I. Alba Dorado

COMBAT MODEL SITUATIONS AS A DIDACTIC TOOL IN A VIRTUAL ENVIRONMENT 5986
M. Novák, D. Ullrich, J. Stříbrný

COMBATING CYBERBULLYING AT THE UNIVERSITY 5987
T. Fisenko, R. Segol, O. Baliun, O. Husak

TEACHING TRANSMEDIA COMMUNICATION THROUGH WEB SERIES: A FRAMEWORK TO APPLY AT CLASSROOMS 5994
M. Cappelletti

STUDENTS' ATTITUDES ON SOCIAL RESPONSIBILITY AS BUILDING BRICKS IN THE IMPROVEMENT OF ENTREPRENEURIAL EDUCATION 5995
B. Hegyi

IMMEDIATE EFFECTS OF NUTRITION ON COGNITIVE FUNCTION UNDER STRESSFUL CONDITIONS; IMPLICATION FOR CIVILIAN AND MILITARY STUDENTS 6004
J. Stříbrný, D. Mac Gillav, D. Ullrich

THE EFFECTIVENESS OF TEACHING COGNITIVE EMOTION REGULATION STRATEGIES ON REDUCING AGGRESSION IN A ROMANIAN DELINQUENT POPULATION: A PILOT STUDY 6005
L.M. Sabareanu, C.E. Oprea

LEARNING-BY-CODING – CHALLENGES AND EXPERIENCES IN ESTABLISHING A CODING LAB FOR CHILDREN 6010
E. Krainz, H. Schwab, F. Niederl, K. Kotal

COMPREHENSIVE MODEL IN DIGITAL PLATFORMS EDUCATION 6016
M. Zagar, K. Soric, N. Anticic, B. Mihaljevic

MACHINE TRANSLATION AS AN AID FOR WRITING BY COMPUTER SCIENCE UNIVERSITY STUDENTS 6023
J.M. Arriola

IMPROVING ATTITUDES TOWARD MATHEMATICS THROUGH GAMIFICATION 6028
E.G. Rincon-Flores, D. Velarde-Camaqui, B. Santos-Guevara, N. Rodríguez-Rodríguez, H. Quintana-Cruz, A. Matsuura-Sonoda

INNOVATIVE START UPS, DIGITALIZATION AND OPEN INNOVATION: A REVIEW OF THE LITERATURE 6033
B. Bigliardi, V. Dolci, S. Filippelli, A. Petroni, B. Pini, L. Tagliente

FACE DRAWING: AN EXPERIMENTAL APPROACH TO DISTANCE LEARNING USING OPEN EDX 6040
F. Antunes, P. Ferreira, H. Gallo, M. Tognon, H. Mendes Pereira

CREATIVITY AND DESIGN THINKING FOR STUDENT PROJECTS 6048
D. Skokanová, P. Fanta

HOW DO ADOLESCENTS EVALUATE POSTS ON INSTAGRAM? MEDIA AND INFORMATION LITERACY IMPLICATIONS FOR LEARNING FROM SOCIAL MEDIA 6053
M. Papageorgiou, E. Kyza

THE IMPORTANCE OF FOREIGN LANGUAGE SKILLS FOR UNIVERSITY GRADUATES CONCERNING SUCCESSFUL EMPLOYMENT ON THE LABOUR MARKET 6054
A. Klimentova, K. Klimentova

THE SILVER LINING OF COVID-19: LOCKDOWN AS A WAY-UP. ACADEMIC PROJECT PRODUCTIVE ACTIVITIES AT THE JAPANESE STUDIES DEPARTMENT, SOFIA UNIVERSITY IN UNPRECEDENTED TIMES 6061
S. Zhivkova, G. Petkova, V. Nikolova, M. Dimitrov

ASYNCHRONOUS ONLINE LEARNING ACTIVITIES IN ENGINEERING DEGREE APPRENTICESHIPS: A CASE STUDY 6069
S. Fieldhouse, F.H. Villa-Lopez

FUTURE OF WORK IN TELECOMMUNICATION SECTOR: CHALLENGES FOR EDUCATION AND TRAINING 6079
R. Preglej Garić, D. Tipurić, A. Aleksić

APPLICATION OF ANTCONC FOR DATA EXTRACTION BY UNDERGRADUATE STUDENTS OF ENGLISH STUDIES. A STEP TOWARDS DIGITAL HUMANITIES 6087
Z. Vincela

THE DIVERSE PHILOSOPHY OF EXHIBITION DESIGN AS A DEVELOPMENT OF THE INTERIOR DESIGN CURRICULUM 6095
G. Elsayed Ali Elsamanoudy

ON A BALANCE BETWEEN CLASSICAL MATHEMATICAL STUDY AND CONTEMPORARY TENDENCIES IN HIGHER EDUCATION FOR ENGINEERING STUDENTS 6103
I. Dzenite, E. Ligere, S. Cernajeva, T. Kabisa

FACTORS INFLUENCING THE FINANCIAL LITERACY OF YOUNG PEOPLE – STUDY FROM THE CZECH REPUBLIC 6111
D. Kubíčková, V. Nulíček, I. Jindrichovska

POTENTIAL OF 3D AND 4D SIMULATION AS EDUCATIONAL RESOURCES TO OPTIMISE THE DESIGN, IMPLEMENTATION, AND CONTROL OF CONSTRUCTION SAFETY MANAGEMENT PLANS 6112
A. González, M.E. Bulla-Ruiz, E. Cortés-Paez, A. Bustos, N. Escobar

THE CHAOS AND CATASTROPHIC IMPACT OF COVID-19: EXPLORING EDUCATIONAL INSIGHTS THROUGH BRAZILIAN AND UK INTERNATIONAL COLLABORATION 6122
M.S. Rogers, A. Grunewald Nichele

SUSTAINABLE DEVELOPMENT GOALS FROM UNIVERSITY TO HIGH SCHOOL: A CASE OF SERVICE-BASED LEARNING 6128
C. López, S. García-Marco, F. Revuelta, P. Almendros-Garcia

DECONTEXTUALIZATION OF BODY PERCEPTION IN MODERN SOCIETY: EXPRESSION OF FACTORS FROM THE PERSPECTIVE OF BIOPEDAGOGY 6137
A. Laužonytė

ACADEMIC LITERACY AS STRATEGY AGAINST SCIENTIFIC FAKE NEWS 6142
J. Brasil Lopes, A. Graziela Gomes Travassos, V. Marília Lima Guida, K. Gomes Lima, J. Ramires Rodrigues Silva, M. Martínez de Lucena, J. Mesquita Vidal Martínez de Lucena

ASSESSMENT OF SKILLS TO FACILITATE THE LEARNING OF READING AND WRITING: A STUDY IN THE 1ST YEAR OF SCHOOLING IN THE CONTEXT OF THE COVID-19 PANDEMIC 6149
P. Fortunato Vaz, V. Gonçalves, C. Teixeira

TOWARD A MODEL FOR PRACTICING CULTURALLY AND LINGUISTICALLY RELEVANT TEACHING: A REVIEW OF RESEARCH-BASED TEACHING METHODS 6154
H. Hamza

WORK-LIFE CONFLICT: PERCEPTIONS OF FEMALE ACADEMICS DURING COVID-19 6155
C. Araneda Guirriman, G. Sepúlveda Páez

PREFERENCES OF DISCUSSION AND LECTURE IN REMOTE, ONLINE, AND FACE-TO-FACE LEARNING DURING COVID AMONG GRADUATE AND UNDERGRADUATE NURSING STUDENTS 6160
A. Bowser, M. Kazakoff, E. Moon, B. Kameg, J. Dunbar-Jacob

IDEALISM OR CRISIS MANAGEMENT? CHALLENGES OF POLICY MAKING IN EDUCATION DURING REFUGEE CRISIS IN TURKEY 6161
E.S. Demir

FROM FACE TO FACE LEARNING TO REMOTE LEARNING AND BACK (TO THE FUTURE) 6162
G. Goldenberg

GRAPHIC DESIGN AND SCIENTIFIC DISSEMINATION OF THE THEORIES OF THE MOLECULAR ORIGIN OF LIFE (PANSPERMIA AND ENDOSYMBIOSIS) 6167
A.M. Rizo Rubalcava, M.M. Arellano Lara, R.J. Tovilla Quesada, G.C. Carrillo Alejo, M.A. Villarreal Gutiérrez, A.M. Madrigal González

MANAGING THE PEOPLE SIDE OF COLLABORATIVE PROJECT WORK 6172
I. Mikhailova, N. Barley

THE IMPACT OF DIGITAL HUMANITIES AND THEIR METHODOLOGY ON THE EFL AND LITERARY STUDIES IN THE SLOVAK CONTEXT: A META-ANALYSIS OF THE RESEARCH STUDIES 6177
Z. Sucháňová

MODERN INFORMATION, COMMUNICATION AND EDUCATIONAL TECHNOLOGIES IN TEACHER TRAINING 6182
V. Stoffová, J. Obonya

APPLICATION OF THE SPARKPLUS TOOL IN LABORATORY CLASSES: A CASE STUDY OVER TIME 6189
J. Tudella, C. Santos

KNOWLEDGE MANAGEMENT AS CONTRIBUTION TO INNOVATION IN THE PUBLIC SECTOR 6197
C. Gjellebæk

TEAMS AND GROUPS IN PHYSICAL ACTIVITY: INFORMAL LEARNING PROMOTING LIFE SATISFACTION 6198
N. Codina, R. Valenzuela, J.V. Pestana

DESIGN AND CREATION OF DIGITAL ENVIRONMENTS TO FAVOR EDUCATIONAL PROCESSES IN THE 4.0 CLASSROOM 6203
A.M. Rizo Rubalcava, M.M. Arellano Lara, R.J. Tovilla Quesada, M.G. Carrillo Alejo

INTRODUCTION TO QUANTUM PHYSICS AND USE OF WAVE OPTICS ANALOGY BASED ON CURRENT LEARNING THEORIES 6204
L. Bartosovic, P. Demkanin, R. Bohm

ICONIC AND BLOCKS PROGRAMMING FOR TEACHING PROGRAMMING BASICS FOR PRIMARY SCHOOL PUPILS 6212
V. Stoffová, M. Zboran, V. Gabaľová

COVID 19 AND EMERGENCY REMOTE TEACHING: A COMPARATIVE EXPLORATORY STUDY IN PORTUGUESE AND BRAZILIAN HIGHER EDUCATION 6222
D. Franco, M.M. Fonseca, M.N. Gonçalves, F. Duarte, M. Araújo

PROJECT-BASED LEARNING (PBL): APPLICATION OF ACTIVE METHODOLOGY IN THE ELECTRONIC WASTE INTEGRATION PROJECT 6227
I. Rodrigues de Souza Fausto, A. Alves, F. Rodrigues Leta, R.M. Mariani Braz

A PRACTICE ACCEPTANCE MODEL BEYOND TECHNOLOGY WHEN PROGRAMMING AND MATHEMATICS CONVERGE 6228
A. Fuentes Martinez

DIGITAL LITERACY IN TIMES OF PANDEMIC. WHAT LEARNING? AN EXPLORATORY STUDY WITH SECONDARY SCHOOL STUDENTS 6238
E. Santo, M.M. Fonseca, M.N. Gonçalves

INITIAL AND CONTINUING TRAINING COURSE IN EDUCATIONAL ROBOTICS IN BASIC EDUCATION 6239
I. Rodrigues de Souza Fausto, F. Rodrigues Leta, R.M. Mariani Braz

LEARNING ABOUT THE INFLUENCE OF DEMOGRAPHIC FACTORS ON THE EMERGING MATERIALS DESIGN PROCESS 6240
J. Alarcón, J. Brañes Alarcón, J. Brañes Alarcón

THE MIT D-LAB PARTICIPATION TOOLKIT: A SUITE OF TOOLS FOR UNDERSTANDING, CHARACTERIZING AND IMPLEMENTING PARTICIPATION IN DEVELOPMENT AND HUMANITARIAN CONTEXTS 6245
A. Smith, M. Thompson

ECO-INNOVATIVE SOLUTIONS BASED ON ACADEMIC RESEARCH PROJECTS 6255
J. Alarcón, J. Brañes Alarcón, J. Brañes Alarcón

INTELLECTUAL PROPERTY AND AMERICAN HIGHER EDUCATION: AN ANALYSIS OF INTELLECTUAL PROPERTY UNITS AT SELECTED R1, R2, AND R3 INSTITUTIONS 6261
N. Brown, T. Clark, H. Aubrey, K. Anderson, T. Jordan, D. Hill-Eley, H. Swanson, E. Cameron

SAFEGUARDING STUDENT MENTAL HEALTH: MINDFUL ASSESSMENTS FOR ART HISTORY SURVEYS DURING COVID 6267
H. McCune Bruhn

BEYOND TECHNICAL SKILL: AUGMENTING STUDENT LEARNING THROUGH PLACE-BASED PEDAGOGY 6272
J. Walker

CHALLENGES OF GOING BACK TO CLASS AFTER THE PANDEMIC 6273
D. Morin, H. Al Maleh, J. Mondragon

TRAINING GRADUATE STUDENTS IN CO-CREATION TOOLKIT TO EXPAND PARTICIPATION IN THE HUMANITARIAN SECTOR 6280
M. Thompson, A. Smith, K. Leith

A STRATEGY FOCUSED ON THE SOCIAL, EMOTIONAL AND MENTAL HEALTH OF STUDENTS 6281
I. Pkhakadze, T. Kordzadze, R. Gvenetadze, M. Sturua

THE PERSISTENCE OF VACCINATION HESITANCY: AN ANALYSIS OF THE INFLUENCE OF SOCIAL DETERMINANTS AMOUNG AFRICAN AMERICAN FAMILIES AND YOUTH 6282
T. Clark, N. Brown, H. Aubrey, K. Anderson, T. Jordan, D. Hill-Eley, H. Swanson, E. Cameron

PERFORMANCE EVALUATION IN SPECIALIZED TRAINING TOOL FOR SMES' EMPLOYEES 6292
E. Mitan

INTEGRATING FLOW THEORY IN FREIREAN PEDAGOGY BASED WORKSHOPS FOR FORMATIVE ASSESSMENT 6299
W. Mahfouz, H.D. Wuttke

DEVELOPMENT OF A NEW COMPETENCE FRAMEWORK FOR AN "INNOVATION MANAGER +" 6310
U. Kaschka, J. Kirch

CALIBRATING THE NEW NORMAL IN ACADEMIC EDUCATION - HOW DIFFERENT GROUP WORK METHODS CAN BE USED EFFECTIVELY IN VOLATILE ENVIRONMENTS 6317
J. Kirch

AGGIORNAMENTI: A PROJECT FOR THE TRAINING OF JUNIOR HIGH SCHOOL TEACHERS 6325
V. Fanti, A. Embriaco, G. Cibinetto, G. Signorielli, G. Tagliente, I. Postuma, L. Servoli, M. Tuveri, M. Andreotti, N. Protti, S. Zavatarelli, S. Marcellini, S. Bertelli, A. Beraudo

FACTORS THAT PROVOKE BURNOUT OF ARCHITECTURE STUDENTS AT UNIVERSIDAD JUÁREZ AUTÓNOMA DE TABASCO 6331
S.G. Gomez Jimenez, A.C. Lizardo Perez, R. Rodriguez Bastarmerito, A.R. Pulido Tellez, F.J. Martinez Romero

CULTURAL CENTER FOR INDIGENOUS LANGUAGES: EDUCATION FOR THE CARE OF THE NATIONAL CULTURAL AND LINGUISTIC HERITAGE 6338
A.C. Lizardo Perez, S.G. Gomez Jimenez, A.R. Pulido Tellez, F.J. Martinez Romero, R. Rodriguez Bastarmerito

TACIT KNOWLEDGE YIELDING TO EXPONENTIAL FUNCTION AT LOWER SECONDARY SCHOOL SCIENCE 6344
L. Bartosovic, P. Demkanin, A. Slovak

LEARNING OUTSIDE THE SCHOOL, LEARNING BEYOND THE CURRICULA: THE LEARNING EXPERIENCE OF STUDENTS DURING THE COVID-19 EMERGENCY REMOTE SCHOOLING 6345
R. Cachia, A. Velicu, S. Chaudron, R. Di Gioia

CONTRIBUTION OF ARTIFICIAL INTELLIGENCE IN LEARNING INDUSTRY 6346
P. Teodorescu, E. Mitan

DEVELOPING ENVIRONMENTAL AWARENESS COMPETENCIES THROUGH A SENSORIAL ESCAPE ROOM 6357
J. Reuter, G. Mello, M. Ferreira Dias, M. Amorim

RESPONSIBLE BIOSCIENCES: HOW ORGANIZATIONS IMPLEMENT EDUCATIONAL ACTIONS 6366
D. Elster

DEVELOPING THE INDIVIDUALIZED LEARNING ENVIRONMENT IN FOREIGN LANGUAGE STUDY PROGRAMMES THROUGH MULTIMODAL STUDY SUPPORT 6375
S. Pokrivcakova

DIGITAL MULTIMODAL COMPOSITIONS IN FOREIGN LANGUAGE TEACHER TRAINING 6376
S. Pokrivcakova

THE DIGITAL COMPETENCE OF THE UNIVERSITY PROFESSOR: A SYSTEMATIC REVIEW 6377
E. Flores

PROGRAM TO RAISE AWARENESS OF ETHICAL BEHAVIOR THROUGH THE USE OF TECHNOLOGICAL MEDIA 6387
S. Montañez, E. Flores

THE VALUE OF BICHRONOUS ONLINE FACILITATION TO PROMOTE STUDENT ENGAGEMENT IN A TEACHER EDUCATION COURSE 6393
R. Best

AI BASED GESTURE AND SPEECH RECOGNITION TOOL FLOW FOR EDUCATORS 6395
H. Hübert, V. Taliaronak, H.S. Yun

ARCHITECTS NOT ILLUSTRATORS | DESIGN-BUILDS AS PEDAGOGICAL SYNTHESIS 6401
J. Kroft, L. De Bartolo, J. Levy, A. Weiss, V. Hui

VALUING AND DECISION MAKING IN THE CONTEXT OF EDUCATION FOR SUSTAINABLE DEVELOPMENT 6410
M. Ternieten, D. Elster

THE EFFECT OF INTERNET ADDICTION ON SOCIAL AND EMOTIONAL LONELINESS IN UNIVERSITY STUDENTS 6420
G. Sart, F.H. Sezgin

ANALYSIS OF UNIVERSITY STUDENTS' PERCEPTIONS OF INNOVATIVENESS IN TERMS OF ENTREPRENEURSHIP LEVELS 6427
G. Sart, F. H. Sezgin

DEVELOPING EDUCATIONAL LEADERSHIP IN THE CONTEXT OF LIBERAL ADULT EDUCATION – FINNISH CONTEXT 6435
L. Snellman

THE CULTURAL QUOTIENT SCALE: IN SEARCH FOR A CONSISTENT PREDICTOR OF ACADEMIC PERFORMANCE 6447
J.C. Del Ama, M. Mealy, Y. Kim

I'M A MILLIPEDE… I'M DIFFERENT… SO WHAT? - A PROPOSAL FOR TEACHING AND LEARNING STATISTICS 6454
H. Campos, A. Matos, S. Ricardo

THE PERCEPTIONS OF SCHOOL TEACHERS ON THE IMPACT OF E-LEARNING AND PSYCHO-EMOTIONAL TOOLS AND METHODOLOGIES IN THEIR TEACHING PRACTICE: THE D-MANED ERASMUS+ PROJECT 6461
D. Vlachopoulos, K. Kronenberg, M. Kokota, V. Grigoras, M. Namolosanu

PROSPECTIVE MATHEMATICS TEACHERS' TPACK IN PLANNING LESSONS INTEGRATING TECHNOLOGY: A CONTEXT OF AN INITIAL TEACHER EDUCATION EXPERIMENT 6469
A. Henriques, R. Winícius da Silva Bueno

PRIMARY SCHOOL TEACHERS' VIEWS ON TRANSLANGUAGING IN THE ENGLISH AS A FOREIGN LANGUAGE CLASS IN VALENCIAN SCHOOLS 6474
A. Cerveró-Carrascosa, C. Baenas Roig, C. Gómez-Lobo

USING PROBLEM POSING AS A MEANS TO ASSESS STUDENTS' UNDERSTANDING OF COMBINATORIAL OPERATIONS 6480
R. Tomás Ferreira, M. Monteiro

USING SPREADSHEETS AND MONTE CARLO SIMULATION TO TEACH CRITICAL PATH ANALYSIS AND PROGRAM EVALUATION AND REVIEW TECHNIQUES IN PROJECT MANAGEMENT 6490
F. Arteaga, M. Pérez-Bermejo, A. Cloquell, C. Moret

WHAT SOFTWARE ENGINEERS NEED TO KNOW ABOUT UX DESIGN – EXPERIENCES FROM ONE DECADE OF TEACHING 6498
R. Pucher

TRANSFORMING THE HIGHER EDUCATION LANDSCAPE IN SOUTH AFRICA: THE ROLE OF PRIVATE HIGHER EDUCATION INSTITUTIONS 6499
B. Van Wyk, W. Engelbrecht

FUTURE EDUCATION DEVELOPMENT 6507
Y. Alhammadi

A CONCEPTUAL FRAMEWORK FOR DESIGNING IMAGE-BASED VIRTUAL FIELD TRIP IN GEOLOGY TEACHING 6508
D.R. Awang Rambli, S. Sulaiman, S. Basri, A.I. Zainal Abidin, S. Mahamad, A.S. Mat Saad

INTERDISCIPLINARITY FOR FUTURE-ORIENTED EDUCATION: INSIGHT FROM EDUCATIONAL RESEARCH IN ENGLAND 6509
S. Erduran, J. Chan

ENVELOPES OF SCIENCE AWESOMENESS: AN OPPORTUNITY TO SUPPORT ELEMENTARY TEACHERS AND STUDENTS DURING COVID-19 DISTANCE LEARNING 6510
P.C. Pinner, J. Ray

MAPPING THE CHALLENGES OF UNDERGRAD ARCHITECTURE STUDENTS APPLYING SHAPE GRAMMAR INTERPRETERS TO GENERATE CHINESE LATTICE DESIGNS 6519
M. Sedrez, Z. Li, J. Zhang, X. Liu, Y. Ma, J. Yao, Z. Sun, T. Shao, G. Godoi

ARCHITECTURE GRADUATES' EMPLOYABILITY: THE CASE OF A BRITISH UNIVERSITY IN CHINA 6529
M. Sedrez

LEARNING BY PLAYING: INNOVATIVE METHODS OF LEARNING AND DISSEMINATION OF CULTURAL HERITAGE 6536
A. Bertini, T. Vitolo

A BREATHING EXERCISE WITH THE HUMANOID ROBOT NAO DESIGNED TO REDUCE STUDENT STRESS DURING CLASS: RESULTS FROM A PILOT STUDY WITH STUDENTS IN HIGHER EDUCATION 6545
I. Buchem, E. Thomas

SUSTAINABLE MOBILITY ANALYSIS AND PROPOSAL FOR THE BISCAY CAMPUS 6552
I. Alvarez Gonzalez, E. Alberdi Celaya

USING RELATIVE GRADING FOR REMOTE ONLINE EXAMINATIONS DURING COVID-19 PANDEMIC 6553
C. Chiruta, M. Calin

TECHNOLOGICAL TOOLS FOR EDUCATION IN TIMES OF PANDEMIC: A STUDY OF ACCEPTANCE AND USER EXPERIENCE IN ITALIAN SCHOOLS 6559
D. Agostini, E. Murgia

BENCHMARK OF THE GENERIC SKILLS OF THE ENGINEERING DEGREES AT THE UNIVERSITY OF ALMERIA 6567
E. Salmerón-Manzano, A. Alcayde-García, A. Zapata-Sierra, F. Manzano-Agugliaro

GENERIC SKILLS ASSESSMENT IN THE MEDICINE DEGREE AT UNIVERSITY OF ALMERIA 6577
E. Salmerón-Manzano, G. Castro-Luna, B. Nievas-Soriano, A. Alcayde-García, A. Zapata-Sierra, F. Manzano-Agugliaro

THE EFFECT OF CHANGES IN THE MODE OF TEACHING AND LEARNING AT UNIVERSITY FIRST YEAR LEVEL ON STUDENTS ATTITUDE AND BELIEFS ABOUT PHYSICS 6586
P. Molefe, M.P. Rankhumise

REMOTE CARE: CURRICULUM DEVELOPMENT TO TEACH TELEHEALTH COMPETENCIES THROUGH CINEMEDUCATION 6587
G. Gonzalez-Caminal, C. Gomar-Sancho, J. Pique-Buisan, I. Cambra-Badii

DEVELOPING MATHEMATICAL MEANING THROUGH DISCOURSE IN DIFFERENT SOUTH AFRICAN MULTILINGUAL TEACHER EDUCATION CONTEXTS 6588
A. Essien

A NEW INFORMATION TECHNOLOGY EDUCATION METHOD INTRODUCING JAPANESE NATIONAL CERTIFICATE INTO UNIVERSITY CURRICULUM IN DEVELOPING COUNTRY 6589
Y. Miyamoto

SUPPORTING TEACHERS' PROFESSIONAL SELF-AWARENESS WITH BIBLIOTHERAPY METHODS 6598
N. Birta Szekely

CAREER RESOURCES IN HIGHER EDUCATION: CHARACTERIZATION AND DIAGNOSIS OF PSYCHOEDUCATIONAL NEEDS 6606
S. Monteiro, F. Seabra, S. Santos, L. Almeida

EMPOWERING STUDENTS IN THE ASSESSMENT AND FEEDBACK OF WORK-INTEGRATED LEARNING: KEY STAKEHOLDER VIEWS 6612
G. O'Neill

IMPORTANCE OF ENJOYMENT AND BEHAVIOURAL CONTROL WHEN ACQUIRING LEARNING TO LEARN COMPETENCE IN MARKETING UNDERGRADUATES 6619
E. González-Gascón

UNDERSTANDING GENDER DIFFERENCES IN THE PERCEPTION OF THE RELATION BETWEEN ALUMNI & THEIR UNIVERSITY 6626
P. Martinez Hague, A. Macarachvili, M. Lau

THE AGRICULTURAL ENGINEERING DEGREE AT UNIVERSITY OF HUELVA: TRANSVERSAL SKILLS ASSESSMENT 6636
A. Zabalo Torrejón, E. Salmerón-Manzano, F. Manzano Agugliaro

TRANSVERSAL SKILLS ASSESSMENT OF THE ENVIRONMENTAL SCIENCES DEGREE AT UNIVERSITY OF HUELVA 6644
A. Zabalo Torrejón, E. Salmerón-Manzano, F. Manzano Agugliaro

IMAGE EDUCATION BETWEEN DISTANCE AND PRESENCE: REFLECTIONS ON THE EXPERIENCE OF THE THREE-YEAR PANDEMIC 6652
F. Zuccoli, A. De Nicola

MAPS MI: FIRST RESULTS OF A PARTICIPATORY SCIENCE PROCESS TO ACTIVATE THE EDUCATING COMMUNITY OF A SUBURB AGAINST BLACK CARBON 6659
F. Zuccoli, A. De Nicola

STUDENTS' MENTAL HEALTH AND TEACHER SUPPORT DURING THE COVID-19 PANDEMIC 6667
D. Paić, J. Kudek Mirošević

FEAR OF MISSING OUT (FOMO) IN HIGHER EDUCATION: AN EXPLORATORY PERSPECTIVE FROM CENTENNIALS IN SPAIN 6672
L.M. Cerdá Suárez

REDESIGNING COLLEGE-LEVEL TEACHING AND CLASSROOM MANAGEMENT FOR POST-PANDEMIC EDUCATION 6680
M. Ben Ghalia

DEVELOPMENT OF A MOBILE APPLICATION FOR THE PERSONALITY ASSESSMENT OF STUDENTS UNDER THE MANAGEMENT OF THE KEDAH STATE ZAKAT BOARD (LZNK), MALAYSIA 6685
A. Md Hashim

SUBJECTIVELY PERCEIVED PREPAREDNESS OF PRE-SERVICE VOCATIONAL SUBJECT TEACHERS FOR PROVIDING SECOND CHANCE EDUCATION 6693
S. Barnová, L. Hasajová, L. Pasternáková, G. Gabrhelová, S. Krásna

DESIGN THINKING AS A METHOD FOR THE STUDENTS SOFT SKILLS TRAINING 6700
B. Boorova, V. Orfánusová, R. Ševčíková

VIDEOS OF MADRID BRIDGES RECORDED BY STUDENTS, EDUCATION FOR CITY AND HERITAGE 6706
J. Bernabéu-Larena, P. Hernández-Lamas, B. Cabau-Anchuelo

COLLABORATIVE CARTOGRAPHIES OF LINEAR PUBLIC WORKS, EDUCATION FOR TERRITORY AND LANDSCAPE 6716
B. Cabau-Anchuelo, P. Hernández-Lamas, J. Bernabéu-Larena

DEVELOPMENT OF STUDENTS' SOCIO-CULTURAL COMPETENCE THROUGH THE USE OF AUTHENTIC MATERIALS 6725
E. Chelpanova, E. Bystray, V. Moshkovich, F. Zakirova, A. Shabalina

THE QUALITY OF UNDERGRADUATE VOCATIONAL SUBJECT TEACHER TRAINING IN THE CONTEXT OF THE COVID-19 PANDEMIC 6732
S. Barnová, S. Krásna, L. Hasajová, G. Gabrhelová

THE EFFECTS OF ENGLISH CONVERSATION LESSONS IN VIRTUAL REALITY ON THE CONFIDENCE OF JAPANESE LEARNERS OF ENGLISH 6737
Y. Satake, S. Yamamoto, H. Obari

ACQUISITION OF DIGITAL SKILLS OF UNIVERSITY TEACHERS: A MASSIVE EXPERIENCE 6745
M. Sempere, F. Fernández

DEVELOPING EFFECTIVE ANDRAGOGY-BASED EDUCATIONAL ENVIRONMENT FOR ADULT LEARNERS OF FOREIGN LANGUAGES 6750
M. Bolina, K. Bolshakova, L. Naumenko, I. Orlova, E. Shmidt

FLIPPED CLASSROOM IN THE CONTEXT OF METHODS OF TEACHING ENGLISH STUDY 6754
M. Bolina, K. Bolshakova, L. Naumenko, I. Orlova, E. Shmidt

USING AR FEATURED COURSES COMBINED WITH ENVIRONMENTAL FILM TEACHING TO PROMOTE ENVIRONMENTAL AWARENESS AND PROTECT THE EARTH 6758
S.T. Wei

ASSESSING LEARNERS' WRITING DEVELOPMENT: THE ROLE OF FORMATIVE FEEDBACK IN THE WRITING PROCESS 6766
N. Mather

SCAFFOLDING LEARNING DURING THE STAGES OF THE WRITING CYCLE: THE IMPACT OF THE TEACHING STRATEGIES THAT TEACHERS ADOPT 6773
N. Mather

CHILDREN'S AGENCY: DIFFERENT PERSPECTIVES THROUGH A LITERATURE REVIEW 6781
L. Luini

THE PEDAGOGICAL INTERNSHIP DURING THE LOCKDOWN: NARRATIVES OF FUTURE TEACHERS 6788
I. Freire-Ribeiro, E. Mesquita, A. Sanches

ENTREPRENEURSHIP AS A FUNDAMENTAL TRANSVERSAL COMPETENCE IN FIRST-YEAR STUDENTS OF THE DEGREE IN CHEMISTRY 6796
C.J. Pelegrín Perete, M.J. Mendoza Castro, J.J. Delgado Marín, A. García Juan, C. Gómez Pertusa, D. Torregrosa Carretero, N.O. Grané Teruel, A. Jiménez Migallón, A. Juan Polo, A.C. Mellinas Ciller, I. Solaberrieta Gonnet, J.J. Villora Picó, P. Romero Navarro, M.C. Garrigós Selva

PROMOTING CULTURAL DIVERSITY(IES) WITH CHILDREN: ACCOUNTS OF LEARNING EXPERIENCES IN THE EDUCATION CONTEXT 6804
I. Freire Ribeiro, E. Mesquita, A. Sanches, C. Pimentel

BRIDGING THE GAP BETWEEN THE NEW ARTIFICIAL INTELLIGENCE CAPABILITIES AND THE SKILLS OF JOURNALISTS IN DIGITAL MEDIA 6809
I. Otero

TOWARDS THE NEW EDUCATIONAL PARADIGMS IN THE 5TH WAVE OF ARTIFICIAL INTELLIGENCE: A FOCUS ON JOURNALISM 6815
I. Otero

USE OF AN ONLINE SELF-LEARNING TOOL BEFORE AND DURING THE COVID 19 PANDEMIC IN MARKETING UNDERGRADUATES 6820
E. González-Gascón

THE WORKPLACE DISCRIMINATION OF WOMEN IN LEADERSHIP: A CASE OF WATERBERG DISTRICT IN LIMPOPO PROVINCE 6827
S.J. Madela, T. Ngobeni, I. Phage

DEVELOP COMPUTATIONAL THINKING SKILLS FROM ARTIFICIAL INTELLIGENCE CONCEPTS IN SECONDARY EDUCATION 6834
I.C. Muñoz, J.C. Giraldo, J.C. Durango, A.M. Cordero

IMPLEMENTATION OF THE "PIENSA-C" STRATEGY FOR THE DEVELOPMENT OF COMPUTATIONAL THINKING WITH ARTIFICIAL INTELLIGENCE IN SECONDARY EDUCATION 6842
J.C. Durango, A.M. Cordero, I.C. Muñoz, J.C. Soto Jimenez, J.C. Giraldo

ENHANCING STUDENTS' MOTIVATION AND ACADEMIC RESULTS THROUGH INTERNATIONAL CYBERSECURITY COMPETITIONS 6848
B. Bordel, R. Alcarria, M.A. Manso, T. Robles

INTERNAL FACTORS INFLUENCING THE INTENTION TO PARTICIPATE IN ONLINE LEARNING AMONG MALAYSIAN UNIVERSITY STUDENTS 6855
M.N. Mohd Noor, N.F.A. Mohd Nazri, W.M.A. Wan Abdul Rahaman, A. Abdul Aziz, N. Mohd Yasin

BESPOKE ARCHITECTONICS: PRIORITIZING FABRICATION OVER VISUALIZATION 6865
V. Hui, S. Agma, J. Levy, A. Halanytska, H. Deng

TOWARDS INCLUSIVE EDUCATION: ASSESSING READING SKILLS OF STUDENTS WITH SPECIAL EDUCATIONAL NEEDS 6873
I. Bilbokaitė-Skiauterienė, I. Kaffemanienė

IMPACT OF ICT ON THE SATISFACTION OF UNIVERSITY STUDENTS 6883
A. Marín García, I. Gil-Saura, M.E. Ruiz-Molina, M. Bordian, R. Gil Saura

PERCEPTION TOWARDS ICT AND SATISFACTION AS SEGMENTATION VARIABLES OF UNIVERSITY STUDENTS 6884
A. Marín García, I. Gil-Saura, M.E. Ruiz-Molina, R. Gil Saura, M. Bordian

NURTURING EMPLOYABILITY USING STRUCTURED MENTORSHIP FOR TECH STUDENTS IN KENYA 6885
C. Mbogo, R. Waiganjo, A. Wasega, M. Nyaga

ANALYSIS OF THE SUBJECT STARTING POINT AND ASPECTS FOR IMPROVEMENT BASED ON THE RESULTS OF THE STUDENT SURVEYS 6895
G. Gómez, P. Fernández, M. Martinez de Aguirre, H. González, S. Etxebarria, O. Pereira, A. Calleja, L.N. López de la Calle

APPLICATION OF ACTIVE METHODOLOGIES IN THE DESCRIPTIVE SUBJECT OF 'MECHANICAL TECHNOLOGY' 6901
M. Martinez de Aguirre, G. Gómez, P. Fernández, H. González, S. Etxebarria, A. Calleja, L.N. López de la Calle

INFORMATION AND COMMUNICATION TECHNOLOGIES SUPPORTING THE STANDARDISATION OF CREDENTIALS AMONG MOOC PROVIDERS 6910
S. Terzi, K. Zourou, I. Stamelos

THE HEAD PROGRAMME IN NORTH MACEDONIA: PRINCIPALS BOOSTING INCLUSIVE SCHOOL POLICIES 6920
M. Veldin, A. Mlekuž

INTERACTIVE DIGITAL STORYTELLING FOR A PLAYFUL AND ENGAGING SCHOOL EDUCATION: THE INTERACTED ERASMUS+ PROJECT 6926
P. Digkoglou, S. Falconi, E. Lykogianni, L. Profiri, D. Schina, D. Vlachopoulos

FOSTERING DELIBERATION AND ENVIRONMENTAL SUSTAINABILITY COMPETENCES IN VET THROUGH CITIZEN SCIENCE 6934
S. Oikonomou, K. Zourou

LET`S TALK ABOUT SEX - THE VIEWS OF TRANSYLVANIAN HUNGARIAN TEACHERS ON THE SEXUAL DEVELOPMENT AND EDUCATION OF CHILDREN 6941
N. Szállassy, N. Erős

ADAPTATION OF FOREIGN STUDENTS TO THE NEW EDUCATIONAL ENVIRONMENT IN THE CHANGING SOCIO-ECONOMIC CONDITIONS IN THE NORTH OF RUSSIA 6951
P. Bessonov, N. Bessonova, V. Bessonova, A. Syrovatsky

DEVELOPING HABITS AND SKILLS IN THE EDUCATIONAL PROCESS IN TERMS OF COMPLIANCE WITH THE WORK SAFETY PRINCIPLES 6955
M. Feszterova

CHALLENGES OF EDUCATING FOR INNOVATION AND ENTREPRENEURSHIP: THE ROLE OF THE HIGHER EDUCATION INSTITUTIONS 6963
J. Miranda, G. Gonçalves, J. Reis

CITIZEN SCIENCE AND ENVIRONMENTAL ORAL HISTORY IN CLIMATE EDUCATION: INTEGRATING THE USE OF A CITIZEN OBSERVATORY FOR BIODIVERSITY MONITORING IN A CLIMATE CHANGE EDUCATION PROJECT 6974
M. Daskolia, A. Trigatzi, J. Piera, S.M. Woods, P. Bonnet

THE SELF-EFFICACY OF TRAINEE TEACHERS RECOMMENDED FOR QUALIFIED TEACHER STATUS (QTS) IN ENGLAND DURING THE COVID-19 PANDEMIC: LOOKING FOR EXPLANATIONS 6984
R. Tynan, A. Mallaburn

GENDER-RELATED DYNAMICS OF STEM-RELATED BELIEFS, GENDER STEREOTYPES AND CAREER PREFERENCES IN ADOLESCENCE 6994
V. Ismatullina, T. Adamovich, I. Zakharov

DUAL LANGUAGE AND TRANSLANGUAGING: PRACTICES PROMOTING STUDENT BILITERACY 7001
J. Villegas, C.R. Calderon-Diaz

HOW DO RUMORS AND INFORMATION ABOUT RESULTS AND EXPERIENCES IN THE PAST AFFECT CURRENT STUDENTS' LEARNING? 7006
B. Bordel, R. Alcarria, T. Robles

FROM RESEARCH TO PRACTICE: COMING TOGETHER TO BRIDGE THE GAP 7011
R. Tamim

LEARNING A FOREIGN LANGUAGE REMOTELY DURING A PANDEMIC (EXPERIENCE FROM CROATIA) 7012
I. Mikulaco

URBAN SHRINKAGE: LEARNING FROM DESSAU 7020
R. Davids

THE SCHOOL – A SAFE ENVIRONMENT FOR CHILDREN. STUDY OF THE INTERACTION BETWEEN EDUCATIONAL AND SOCIAL INSTITUTIONS. QUALITY OF INTER-INSTITUTIONAL INTERACTION 7027
D. Angelova

THE ROLE OF TEACHERS IN THE CONTEXT OF NEW TRENDS OF DIGITIZED AND PERSONALIZED EDUCATION 7031
S. Bellomo

PROMOTION OF HEALTH LITERACY IN THE CONTEXT OF STEM CELL DONATION FOR LEUKAEMIA PATIENTS 7039
D. Elster, J. Holzer

RESEARCH BASED LEARNING IN AGRICULTURAL ENGINEERING STUDIES 7049
J. Soler-Rovira, J.M. Arroyo-Sanz, L. Galvez-Paton, D. Palmero-Llamas, J. Novillo-Carmona, S. Garcia-Marco, D. Gonzalez-Rodriguez, P. Almendros-Garcia, A.F. Obrador-Perez, A. Arce-Martinez

LEARNING STYLES AND RESEARCH BASED LEARNING IN ENGINEERING STUDIES 7054
J. Soler-Rovira, J.M. Arroyo-Sanz, L. Galvez-Paton, D. Palmero-Llamas, J. Novillo-Carmona, S. Garcia-Marco, D. Gonzalez-Rodriguez, P. Almendros-Garcia, A.F. Obrador-Perez, A. Arce-Martinez

REFLECTIONS ON ONLINE LEARNING ECOSYSTEM IN ICE INSTITUTE 7058
P. Pannen, R. Dwi Riyanti

PARTICULARITIES OF THE EDUCATIONAL PROCESS IN PENITENTIARY INSTITUTIONS (EXPERIENCE AND LEGISLATION OF THE REPUBLIC OF MOLDOVA) 7068
A. Nastas, S. Cernomoreț

THE POTENTIAL OF PSYCHOLOGICAL CAPITAL FOR PROMOTING WELL-BEING IN PRE-SERVICE AND IN-SERVICE TEACHERS: A RESEARCH-TRAINING PROJECT 7076
A. Crescentini, M. Pettignano, A. D'Amato, L. Sciaroni

PAGARAMI, A NEW TOOL FOR SET UP YOUR OWN TV QUIZ IN CLASSROOM 7084
R.M. Pagán, C. Ramírez

EDUCATIONAL INNOVATION IN INITIAL TEACHER TRAINING: AN EXPERIENCE BASED ON EXPERIENTIAL LEARNING 7091
R. Mateu Pérez, P. Escobedo Peiró, M. García Baldán, R. Flores Buils

ART IN THE PROCESS OF INDUSTRIAL DESIGN 7092
S. Nuere Menéndez-Pidal, A. Castell López, L. de Miguel Álvarez, C. Alía García, M. Ruiz Gómez

MOVING EXAM BOARD PROCESSES ONLINE - A CASE STUDY 7102
H. Neal

LEARNING SCENARIOS IN SAFETY AT WORK IN THE SCOPE OF POLYTECHNIC HIGHER EDUCATION COURSES 7111
F. Silva, J. Ribeiro, P.M. Barros

ENGAGING STUDENTS DURING THE PANDEMIC: THE UNIVERSITY OF MALAYA LIBRARY EXPERIENCE 7116
Z. Saupi Udin, R. Hisham

CREATION OF VIDEOS BY STUDENTS AS A WAY TO PROMOTE LEARNING IN THE AREA OF MECHANICS: AN EXPERIENCE IN HIGHER EDUCATION 7124
J. Ribeiro, F. Silva, P.M. Barros

FROM EASY COMMUNICATION TO DIFFICULT TEXTS: HOW TO INTEGRATE LITERATURE IN A NON-READING CLASSROOM 7130
E. Poyntner, B. Huber

ANALYSIS OF SENSORS AFFECTING HARMFUL EMISSIONS FROM ROAD TRANSPORT APPLIED IN ENGINEERING EDUCATION 7136
H. Kanevski, S. Lyubomirov

USING MOTION PICTURES TO FOSTER HISTORICAL THINKING: A PROPOSAL FOR HISTORY TEACHERS' EDUCATION 7146
Y. Mathias

THE IMPORTANCE OF EDUCATION FOR SUSTAINABILITY IN THE DEVELOPMENT OF ENTREPRENEURIAL INTENTIONS, FOCUSED ON SUSTAINABLE DEVELOPMENT 7147
C. Simut, D. Bac, R. Simut

(BIO)PRINTING IN MODERN MEDICAL EDUCATION 7157
D. Shopova, A. Mihaylova, P. Kasnakova, A. Yaneva, M. Hristozova, Y. Sbirkov, V. Sarafian, M. Semerdjieva, D. Bakova

STUDENTS' PERCEPTION ON CIVIC EDUCATION AND THE EFFICIENCY OF SCHOOLS IN SHAPING THE SOCIAL MENTALITY 7162
F. Ortan, C. Simut, J. Kiss

STUDENT ASSISTANT PERSPECTIVE ON FLEXIBLE LEARNING SPACES: CHALLENGES AND SUCCESS FACTORS 7170
A. Lazareva, C. Edelhard Tømte

INTERTWINED VOICES - A COMMUNITY PARTICIPATION PROJECT FOR YOUNG HIGHER EDUCATION STUDENTS 7178
C. Figueiredo, F. Fialho, A. Alcântara, J. Matos

A PROBLEM BASED APPROACH TO MECHATRONICS USING FORMULA SAE 7183
V. Lorenzi, B. Zappa, P. Righettini, R. Strada

PSYCHOSOCIAL CHARACTERISTICS OF TWICE-EXCEPTIONAL STUDENTS IN COMBINATION OF SPECIFIC LEARNING DISABILITIES AND INTELLECTUAL GIFTEDNESS 7191
P. Baranová, I. Márová

RESILIENT EDUCATION FOR COLLECTIVE WELL-BEING 7199
D. Chiusaroli, G. Arduini

THE TEACHER'S PROFILE IN INCLUSIVE CLASSROOM MANAGEMENT 7208
D. Chiusaroli

EVALUATION OF TEAMWORK COMPETENCE. VIEW OF TEACHERS AND EMPLOYERS 7214
D. Martínez, B. Amante, N. Salán, M.C. Romero

EMPLOYABILITY, PROFESSIONAL SKILLS, AND JOB PLACEMENT: THE VISION OF SCIENCE STUDENTS 7222
I. Solaberrieta Gonnet, A. Khalfi, A. Jiménez Migallón, M. Ramos

IT IS NOT WHAT IT SEEMS: BIOCHEMICAL BASIS OF INTERSEXUALITY (CONGENITAL ADRENAL HYPERPLASIA) AND ETHICAL CONSIDERATIONS 7230
M. Alonso-Chamorro, M.C. Turpin, S. Álvarez Montero

A PHENOMENOLOGICAL EXPLORATION OF THE HOLISTIC EXPERIENCES OF STUDENTS OF AFRICAN DESCENT AT A POST-1992 UNIVERSITY IN ENGLAND 7234
P. Seuwou, D. Sarwar, A. Pilkington

PROMOTING SCIENTIFIC RESEARCH AND COMMUNICATION IN ANIMAL PRODUCTION PREGRADUATE STUDENTS 7244
N. Formoso-Rafferty, P. García-Rebollar, M.D. Carro, N. Nicodemus, T. de Evan, B. Velasco, P. Rebollar

SUSTAINABLE DEVELOPMENT GOALS AWARENESS IS IMPROVED AFTER INTRODUCTION OF RELATED ACTIVITIES IN HIGHER EDUCATION DEGREE SUBJECTS 7252
M. Leiva-Brondo, N. Lajara-Camilleri, C. Lull

DEBATE: A USEFUL TOOL TO ENHANCE COMMUNICATION SKILLS IN AGRICULTURAL ENGINEERING STUDENTS 7258
N. Formoso-Rafferty, N. Nicodemus, P. García-Rebollar, T. de Evan, P.G. Rebollar, M.D. Carro

THE TEACHING STRATEGIES EMPLOYED IN THE TEACHING OF SCIENCE BY MULTIGRADE PRIMARY SCHOOL TEACHERS: A CASE OF TWO RURAL DISTRICTS IN LESOTHO 7264
M. Phakisi, R. Bhagwandeen, A. Rambuda

PREPARING PRESERVICE ELEMENTARY TEACHERS TO TEACH MATHEMATICS AND COMPUTER SCIENCE SKILLS THROUGH PEDAGOGICAL APPROACHES INVOLVING GAME DESIGN LEARNING 7265
C. Navarrete

TEACHING SYNTAX OF RUSSIAN AS A FOREIGN LANGUAGE AT PHILOLOGICAL STUDIES IN POLAND (PROBLEMS AND CHALLENGES) 7273
A. Romanik

WRITING FLUENCY, AN ESSENTIAL YET OVERLOOKED COMPONENT OF COMMUNICATIVE COMPETENCE 7277
I. Saad

EXPERIENTIAL LEARNING THROUGH EDUCATIONAL GAMIFICATION AND ORAL NARRATION: A PROPOSAL FROM NEUROSCIENCE 7278
E. Hernández Pérez, M. Pena Garrido

THE USE OF SIMULATORS IN THE PHYSICS TEACHING IN PRIMARY SCHOOL: DESCRIPTIVE ANALYSIS OF EDUCATIONAL INNOVATION IN A PANDEMIC CONTEXT 7282
C. Toro, S. Contreras

ANALYSIS OF TACTICS AND STRATEGIES TO INTEGRATE DIGITAL RESOURCES IN THE EDUCATIONAL MODEL IN SPAIN (SECONDARY EDUCATION AND BACCALAUREATE) 7290
J. Garcia Alonso

EMPIRICAL RESEARCH ON HOW EFFICIENTLY DIGITALIZATION IS BEING INTEGRATED IN SECONDARY, BACCALAUREATE AND VOCATIONAL EDUCATION IN SPAIN 7295
J. Garcia Alonso

A TECHNOLOGY-VALUE SYNERGY MODEL FOR LEARNING MATH THAT EVOKES EMOTIONS AND CREATES THE BEST LEARNING MOMENTS 7300
A. Cunska

ROBOT COMPETITION DESIGN FOR IMPROVING ENGINEERING STUDENTS' STEM SKILLS 7306
M. Salah, A. Alghazo, A. Abu-aisheh

ASSESSMENT OF DIGITAL LABORATORY EFFECTIVENESS IN THE BASIC ELECTRONICS SUBJECT 7312
N. Novas, F. Portillo, M. Fernández-Ros, J.A. Gazquez, C. Cano, R.M. García Salvador, M. Soler-Ortiz, F. Segura

TEACHERS' ATTITUDES ON THE APPLICATION OF INNOVATIVE MODELS IN TEACHING OF BIOLOGY IN PRIMARY SCHOOL 7320
V. Županec, T. Lazarević, T. Pribićević

COMBINATION OF PEER INSTRUCTION AND FLIPPED CLASSROOM METHODOLOGIES: A MURDER IN FORENSIC ANALYTICAL CHEMISTRY 7329
M.C. Garrigós Selva, M. Ramos, R. Belhadj, C.J. Pelegrín Perete, A.C. Mellinas Ciller

WHY AND HOW TO IMPLEMENT A FLIPPED CLASSROOM MODEL IN BIOLOGY EDUCATION IN PRIMARY SCHOOL 7336
V. Županec, Ž. Ilić, T. Lazarević, T. Pribićević

COMPREHENSIVE LEARNING OF DIGITAL ELECTRONICS THROUGH FPGAS 7343
C. Cano, M. Soler-Ortiz, R.M. García Salvador, F. Portillo, N. Novas, J.A. Gazquez, M. Fernández-Ros, F. Segura

DIFFERENCES IN THE TEXT PROBLEM SOLUTION OF PRIMARY SCHOOL STUDENTS WHO WERE TAUGHT AND NOT TAUGHT TO REASON MATHEMATICALLY 7351
N. Cibulskaitė, V. Grabauskienė, O. Moskaitytė - Rastenienė

MATHEMATICAL REASONING USING KNOWLEDGE OF NUMBER BONDS WHILE SOLVING ALGEBRAIC PROBLEM IN THE 4TH GRADE 7361
N. Cibulskaitė, V. Grabauskienė, O. Mockaitytė-Rastenienė

DESIGN THINKING: IT'S A MARATHON AND A SPRINT 7367
P. Lane, R. Lafferty

EFFICIENCY OF CONFERENCE CALLS AS AN EDUCATIONAL DELIVERY METHOD DURING COVID-19 IN ELEMENTARY SCHOOLS 7374
G. Kerekes

THE ETHICAL CODE OF HIGHER EDUCATION INSTITUTIONS AS THE BASIS FOR THE UNIVERSITY'S CORPORATE CULTURE. CASE STUDY: HOW DO ETHICAL CODES WORK? 7379
A. Nurutdinova, A. Bogdanova, A. Sayın

AN ONTOLOGY FOR EDUCATIONAL AND CAREER PROFILING BASED ON THE ROMANIAN OCCUPATION CLASSIFICATION FRAMEWORK: DESCRIPTION AND SCENARIOS OF UTILISATION 7386
M.I. Dascalu, I. Marin, I.V. Nemoianu, I.F. Puskás, A. Hang

EXTENSION OF E-LEARNING DATA VISUALIZATION SYSTEM FOR DIFFERENT KNOWLEDGE REVIEWS DATASETS 7396
B. Kovačić

MANAGER AS AN EDUCATOR: THE RISK OF BURNOUT 7404
L. Kopac, A. Klein, H. Polat, B.. Maier

MANAGER AS AN EDUCATOR: PREVENTION OF BURNOUT 7409
L. Kopac, A. Muller, T. Eidenmuller, A. Mussmann

THE FUTURE OF EDUCATION: CONSEQUENCES OF COVID-19 PANDEMIC ON THE EDUCATION SYSTEM 7413
N. Jurina Babović, I. Jemrić Ostojić, T. Tolnauer-Ackermann

HOW TO CHOOSE ONE'S CAREER? A PROPOSAL FOR A SMART CAREER PROFILER SYSTEM TO IMPROVE PRACTICES FROM ROMANIAN EDUCATIONAL INSTITUTIONS 7423
I.C. Stanica, S.M. Hainagiu, S.. Neagu, N. Litoiu, M.I. Dascalu

EDUCATION OF A PUPIL WITH MILD INTELLECTUAL DISABILITY IN STANDARD ELEMENTARY SCHOOL 7433
V. Kolková

THE STUDENT PODCAST AS A PEDAGOGICAL STRATEGY OF EDUCATION FOR PEACE IN THE EL SANTUARIO NEIGHBORHOOD OF THE CITY OF BARRANQUILLA, COLOMBIA 7440
H. Cerra

FARE: AN ONLINE APPLICATION FOR GRAPHICALLY DESIGNING FINITE AUTOMATA AND COMPUTING EQUIVALENT REGULAR EXPRESSIONS 7445
Z.S. Tramparis, E. Papaioannou, C. Kaklamanis

NATURAL LANGUAGE PROCESSING APPLIED FOR TEACHING EVALUATION 7454
S. Montalvo, M.A. Rodríguez, R. Cabido, D. Concha

RESEARCH IN VIRTUAL REALITY AND 3D PRINTERS IN EDIFICATION AND ENGINEERING 7460
M. Valiente Lopez, S.L. Diez Sanz, M.C. Sanz Contreras

USE OF NITINOL-SHAPE MEMORY ALLOY IN THE REINFORCEMENT OF 3D CONCRETE PRINTING INDUSTRY 7470
B. Ahadi, M. Valiente Lopez

THE SEARCH FOR LIFE IN THE UNIVERSE: DESIGNING AND IMPLEMENTING A COURSE FOR M.ED. SCIENCE TEACHERS 7480
O. Eldar

THE SUSTAINABLE FEEDBACK CONCEPT FROM RESEARCHERS' PERSPECTIVE: A NARRATIVE REVIEW 7481
R. Faria, D. Pedrosa, B. Lopes, F. Ribeiro Faria

CONCEPTUAL OVERVIEW ON CORL: NARRATIVE LITERATURE REVIEW 7490
F. Ribeiro Faria, D. Pedrosa, B. Lopes, R. Faria

A FRAMEWORK FOR THE DESIGN, IMPLEMENTATION AND EVALUATION OF AI BASED REAL-LIFE LEARNING SCENARIOS FOR COMPUTER SCIENCE NON-MAJORS 7499
D. Meyer, S. Fausser

A SURVEY ON GRADING FORMAT OF AUTOMATED GRADING TOOLS FOR PROGRAMMING ASSIGNMENTS 7506
A. Agrawal, B. Reed

A NEW APPROACH TO INTERDISCIPLINARITY: THE CASE OF THE MASTER'S DEGREE STUDY PROGRAMME "APPLICATIONS OF ARTIFICIAL INTELLIGENCE" 7515
Z. Rutkuniene, B. Narkeviciene

A CONTEMPORARY ADOLESCENT'S PRACTICAL MODEL OF UPBRINGING: PEDAGOGICAL POSSIBILITIES OF NETWORKING 7516
N. Medina Brakamonte, O. Zayka

SIMULATION OF ENGINE MALFUNCTIONS AND THEIR IMPACT ON EMISSIONS WITH AN EMPHASIS ON ENGINEERING EDUCATION 7525
H. Kanevski, S. Lyubomirov, S. Asenov

DIALECTICAL VERSUS VIRTUAL/REMOTE LEARNING 7533
M. Klekovska, C. Martinovska

UNIVERSITY-WIDE SKILLS FRAMEWORK 7540
F. Vansweevelt, J. Notermans

GEOGEBRA IN ONLINE GEOMETRY COURSES FOR FUTURE MATHEMATICS TEACHERS 7541
A. Schmid, L. Korenova

DEVELOPING AND SCALING EUROPEAN HEIS' INNOVATION VISION THROUGH LEARNING AND MENTORING PROGRAMS 7548
D. Facal, M. Gandoy-Crego, N. Gerbaudo-González, S. Feijoo-Quintas, J.M. Pinto, E. Costa, M. Duarte, A. Leal, P. Hatton, P. Doležel, L. Routil, J. Pospichal, E. Sevtsenko, G. Teodorescu, M. Oliveira, G. Gonçalves

USAGE OF AUGMENTED REALITY APP TO DEVELOP THE MATHEMATICAL COMPETENCES OF CHILDREN IN PRIMARY EDUCATION 7553
N. Nevrelova, L. Korenova

DIGITAL SKILLS OF STUDENTS 7561
J. Hudáková, V. Papcunová

STUDENT FEEDBACK ON ONLINE LEARNING DURING THE COVID-19 PANDEMIC 7565
J. Hudáková, V. Papcunová

LIEM: INNOVATION LABORATORY FOR ENVIRONMENTAL EDUCATION 7570
J. Holgado Garcia

CATCH THE PLATE! 7574
V. Misiti, D. Riposati, F. Di Laura, P. Battelli

DEVELOPING KNOWLEDGE, ATTITUDES AND COMPETENCES OF STUDENTS IN RUSSIAN STUDIES THROUGH AN ACTION-ORIENTED APPROACH 7580
M. Karolczuk

DEVELOPMENT OF EFFECTIVE COURSE DESIGN INTEGRATING ACTIVE LEARNING AND ANALYSIS WITH NEAR-INFRARED SPECTROSCOPY FOR JAPANESE ENGINEERING STUDENTS 7585
R. Tobita

MOVIEFICATION OF MATHEMATICAL WORD PROBLEMS: USING ENTERTAINMENT MECHANISMS TO SUPPORT LEARNER ENGAGEMENT 7590
J. Smith

BOARDGAMES PROPOSAL AS NEW PARADIGM IN EDUCATION GAMIFICATION: IDEATRIZ-X PROJECT 7597
J.D. Cano-Moreno, I. Cerdeño García de Blas, F.V. Sánchez Martínez, M.M. Recio Díaz, S. Nuere Menéndez-Pidal

DISTANCE CAREER INTERVENTION WITH PORTUGUESE HIGHER EDUCATION STUDENTS: PROGRAMME OVERVIEW 7602
F. Seabra, S. Monteiro, S. Santos, L. Almeida

DIGITAL-BASED INTERVENTIONS TARGETING SCHOOL FAILURE: A SYSTEMATIC REVIEW 7609
R. Azevedo, A. Costa, D. Moreira, A. Azevedo, I. Oliveira, A. Gonçalves, J. Casanova, P.C. Dias

HOW DEVELOPMENT ORIENTED IS THE UNIVERSITY FOR DEVELOPMENT STUDIES TAMALE-GHANA? FROM THE LENS OF SUSTAINABLE DEVELOPMENT GOALS (SDGS) 7615
A.M. Abdulai

HOW TO BUILD AN ENTREPRENEURSHIP EDUCATION SYSTEM ACROSS EDUCATIONAL LEVELS? 7623
K. Kivisild

E-WASTE EDUCATION AS A MOTIVATING FACTOR IN CHEMISTRY EDUCATION 7624
M. Feszterová, Z. Jenisová

DISCOVERING SCIENCE THROUGH COLORS 7632
S. Pisano

FULLY REMOTE CONTROLLABLE LAB SETUP FOR PRACTICAL TRAINING IN PHOTONICS HIGHER EDUCATIONS 7638
F. Lukas, J. Domke, C. Henkel, J. Kretzschmar, F. Sojka, C. Helgert, T. Pertsch

EXTRACURRICULAR ACTIVITIES FOR STUDENTS' SKILLS DEVELOPMENT 7645
Ü. Kesli, L. Ariva

THE EXTREME-ENERGY EVENTS PROJECT: INTRODUCING PEOPLE TO SCIENCE THROUGH COSMIC RAYS 7646
S. Pisano

THE MAIN ACTIVITIES AND OUTCOMES OF PROCESS PROJECT SO FAR 7651
A. Kakko

ETHICAL PRINCIPLES IN INCLUSIVE EDUCATION: A SYSTEMATIC REVIEW 7659
M. García-Parra, F. Negre Bennasar, S. Verger

THE USE OF THE MOBILE PHONE TO ACHIEVE A USEFUL AND FUN CONTINUOUS EVALUATION 7660
A. Linares-Unamunzaga, H. Gonzalo-Orden, M. Rojo Arce, M. Miguel-Borge

INTRODUCING SYSTEMS THINKING SKILLS TO IMPROVE THE LEARNING PROCESS ABOUT COMPLEXITY AND COMPLEX SYSTEMS 7670
G.L. Dugarte-Peña, E. Muñoz-García, N. Gordo-Herrera

THE VOICES OF FAMILIES AND CHILDREN IN SITUATIONS OF SOCIAL AND ECONOMIC VULNERABILITY: A REPORT OF A PROJECT 7678
P. Fortunato Vaz, E. Mesquita, I. Freire-Ribeiro, R. Reichert

ARABIC LANGUAGE EDUCATION IN THE DISTANCE EDUCATION MODEL (FOR NON-NATIVE ARABIC LANGUAGE) 7684
S. Karuko

RESHAPING THE STUDENT ADMISSION PROCESS: AN ANALYSIS OF THE CHANGES BROUGHT BY THE RECENT PANDEMIC 7691
L. Patachi

FROM THEORY TO PRACTICE: DEVELOPING SOCIAL STUDIES TEACHERS' CAPACITY FOR COMPUTER SCIENCE INTEGRATION BY RIDING THE SEMANTIC WAVE 7696
P. Shank, R. Dovi, K. Franklin

THE USE OF SOCIAL NETWORKS AS A TOOL FOR FLIPPED CLASSROOM METHODOLOGY: A PRACTICAL EXPERIENCE IN HIGHER EDUCATION FRAMEWORK 7697
M. Soler Porta, M. Rojas-de-Gracia, A. Lopes, A. Esteban, F. Soares, M.J. Bentabol, M.D. Rodríguez-Ruiz, M. Muñoz, A. Bentabol, R. Caña-Palma

QUANTUM COMPUTING KNOWLEDGE PROVIDES AN EXPONENTIAL SPEEDUP TO HARD COMPUTATIONAL PROBLEMS: AN EXPERIENCE WITH ENGINEERING STUDENTS 7701
E. Muñoz-García, G.L. Dugarte-Peña

MEASURING THE EFFECTS OF AN EMERGENT DISTANCE EDUCATIONAL PROGRAM ON THE APPROVAL RATINGS DURING THE COVID-19 PANDEMIC 7705
J. Figueroa-González, S.B. González-Brambila, B.A. González-Beltrán, L. Sánchez-Guerrero

COMPARING THE PROGRESS OF NEW INCOMING STUDENTS IN THEIR FIRST YEAR BEFORE AND DURING THE COVID-19 PANDEMIC 7713
S.B. González-Brambila, B.A. González-Beltrán, L. Sánchez-Guerrero, J. Figueroa-González

CONNECTING THE DOTS: A REALITY-BASED LEARNING APPROACH IN A MASTER IN MANAGEMENT DEGREE 7720
P. Ferreira, I. Maldonado, C. Miguens, S. Jayantilal

OPEN-SOURCE AR/VR LEARNING APPLICATIONS FOR PHOTONIC QUANTUM EXPERIMENTS 7726
J. Kretzschmar, S. Ritter, F. Eilenberger, C. Helgert, T. Pertsch

A SYSTEMATIC REVIEW ON IMPLEMENTING ACTIVE LEARNING AS A DESIGN LEARNING METHOD IN THE ARCHITECTURE STUDIO 7732
M. Pirdavari, Z. Akbari

REMOTE LAB SYSTEM FOR TEACHING ENGINEERING TOPICS RELATED TO MECHATRONICS 7740
G. Soprano Machado, W. de Souza Picanço, M. Melo de Carvalho, F.A. de Carvalho Ayres Junior, R.L. Paiva de Medeiros, V. Ferreira de Lucena Junior

ACADEMIC ENGLISH: CURRENT AND FUTURE DIRECTIONS IN TEACHING ENGLISH TO UNIVERSITY STUDENTS 7741
N. Solovyeva

INDIGENOUS PERSPECTIVES: IS EQUITY UNFAIR TO THE MAYANGNA OF NICARAGUA? 7748
P. Lane, B. Mills

RESULTS OF THE ACTIVITIES PERFORMED WITH VET STUDENTS/LEARNERS AND AIMED AT TESTING THE PRODUCTS OF THE ERASMUS+ TRANSNATIONAL EDUCATION PROJECT "CHERISH - CULTURAL AND NATURAL HERITAGE: A SUSTAINABLE TOURISM VET INTEGRATED APPROACH" 7753
P. Ciccioli, R. Coratella, F. D'Esposito, P. Ragni

IMPLEMENTATION OF A VIRTUAL LIGHT LABORATORY 7764
M. Ibryamov, O. Petrov

COVID-19 TEACHING AND LEARNING EXPERIENCES PROJECT: USING THE GREX DASHBOARD TO INVESTIGATE ONLINE SKILL DEVELOPMENT DURING THE PANDEMIC 7772
M. McGravey, R. van Oostveen

FORMAL AND NON-FORMAL MUSICAL EDUCATION: THE SEARCH FOR WELL-BEING 7782
A. Lapinska, R. Bakutytė

THE SUMMER COMPUTER SCHOOL FOR STUDENTS WITH VISUAL IMPAIRMENT IN PREPARATION FOR UNIVERSITY 7789
M. Cujdikova, M. Stankovicova

AI EDUCATION AND INCLUSION IN K-12 7798
QI. Xia, THOMAS, K.F. Chiu

DISTANCE LEARNING IN TIMES OF CRISIS: PREDICTING GRADUATE STUDENTS' SELF-EFFICACY THROUGH PERSONAL, OCCUPATIONAL AND ACADEMIC FACTORS 7799
S. Tsemach, A. Barth

CREATING THE NEW NORM EDUCATIONAL "MINDSET" THROUGH KNOWLEDGE MANAGEMENT CREATED DURING THE COVID-19 PANDEMIC 7800
B. Barrett

STRATEGIES EMPLOYED IN THE TEACHING OF SCIENCE BY MULTIGRADE PRIMARY SCHOOL TEACHERS IN LESOTHO 7808
M. Phakisi, R. Bhagwandeen, A. Rambuda

INTRODUCTION TO UNIVERSITY TEACHING – A TRAINING PROCESS FOR EARLY-CAREER ACADEMICS AT THE UNIVERSITY OF PORTO 7809
C. Sousa, M. Pinto, R. Sinde

THE IMPACT OF NEW TECHNOLOGIES ON THE SCAFFOLDING OF SIGNIFICANT LEARNING ABOUT SAFETY AND RISK MANAGEMENT IN THE CONSTRUCTION SECTOR IN COLOMBIA 7815
F. Lopez-Perez, S. Cubillos-Vanegas, M.E. Bulla-Ruiz, E. Cortés-Paez

FORMATION OF STUDENTS' INTERCULTURAL COMMUNICATIVE COMPETENCE IN THE PROCESS OF TEACHING CHINESE LANGUAGE 7824
L. Makogon, L. Makogon

A COMPARISON OF TWO (NOT WELL KNOWN) EDUCATIONAL ROBOTIC KITS FOR TEACHING COMPUTATIONAL THINKING 7830
K. Miková, V. Fejková

THE DIFFICULTIES IN LEARNING CHINESE WRITTEN SPEECH AND THE WAYS TO OVERCOME 7838
L. Makogon, L. Makogon

DIGITAL CITIZENSHIP EDUCATION IN EUROPE 7843
E. Mesquita, M.R. Patrício, I. Freire-Ribeiro, A. Pereira

IMPACT OF DIGITAL COLLABORATIVE TOOLS ON THE DEVELOPMENT OF COMMUNICATION IN ENGLISH 7849
M. Martins, I. Araújo

AN ACTIVE LEARNING METHODOLOGY TO IMPROVE ENGLISH ORALITY DEVELOPMENT SUPPORTED BY AN ONLINE DIGITAL TOOL 7857
C. Cunha, P. Faria, I. Araújo

CATEGORIZING AND ANALYZING LEARNER BEHAVIOUR IN DIGITAL CONSTRUCTION TASKS 7864
A. de Koning, R. van Oostveen

HEALTH SCIENCES LIBRARIANS' TRAINING ON EVIDENCE-BASED MEDICINE AMID THE RECENT PANDEMIC 7873
R. Hisham Shunmugam, Z. Saupi Udin, M.F. Hamzah, A. Michael, M.S. Abu Kassim

PROMOTING INTERAGENCY COLLABORATIONS FOR ENHANCING TRANSITION TO EMPLOYMENT FOR INDIVIDUALS WITH SPECIAL NEEDS 7874
D. Zhang, E. Roberts, M. Orsag, R. Maddalozzo, Y.F. Li

SPATIAL SKILLS ENHANCEMENT AND 3D DIGITAL MODELLING TOOLS IN ARCHITECTURE AND CONSTRUCTION ENGINEERING: A LITERATURE REVIEW 7884
P. Piumatti

T@SK PROJECT: BUILDING BRIDGES BETWEEN UNIVERSITY AND SOCIETY THROUGH SOCIAL WORK 7888
G. Bulli, G. Mascagni, S. Moroni

THE BENEFITS OF PERSONAL DEVELOPMENT MODULES FOR HEALTH AND SOCIAL CARE LEARNERS WITHIN HIGHER EDUCATION 7897
G. Maughan

HACKATHONS THRILLS NOT ONLY NERDS: BEST PRACTICES FOR A MULTICULTURAL AND MULTIDISCIPLINARY APPROACH 7902
D. Meyer, R. Wyngaard, J. Njenga, J. Grinninger, J. Vogt, A. Bagula

PROVIDING TODAY'S STUDENTS WITH THE SKILLS THEY WILL NEED FOR TOMORROW'S TECHNOLOGY 7913
D. Joseph

EMBODIED PEDAGOGY FOR A DEMOCRATIC SPACE 7914
N. Ferri

PATRIOTIC UPBRINGING IN VOCATIONAL EDUCATION: DOCUMENT ANALYSIS IN LATVIAN CONTEXTS 7918
J. Ozols, R. Bakutyte

THE ROLE OF ICT IN MULTICULTURAL EDUCATION POLICIES 7927
K. Papaioannou, E. Papaioannou

THE EFFECT OF PRESCHOOL EDUCATION ON CHILDREN'S SCHOOL DROPOUT RATES IN MOROCCO - SPATIAL ANALYSIS 7931
A. Ibourk, S. Raoui

SPECIFICS IN THE EDUCATION OF CHILDREN WITH HEARING IMPAIRMENT IN AN INCLUSIVE SETTING OF MAINSTREAM PRIMARY SCHOOL 7936
M. Štibrányiová

GLOBAL CLASSROOM AND THE DEVELOPMENT OF COMMUNICATION SKILLS 7940
J. Cortés Vásquez, S. García Ángeles

INTEGRATING RESEARCH AND EDUCATION: "HYBRID AND FUSION PREDICTION OF THE FUNCTIONALITY OF ENERGY CONVERTING ELEMENTS" PROJECT 7945
S. Stoyanova-Petrova, D. Stoyanova, N. Kafadarova, S. Sotirov

ACTIVE METHODOLOGIES AT UNIVERSITY: THE IMPORTANCE OF MAINTAINING MOTIVATION 7949
A. Batlles de la Fuente, M.J. López Serrano, F.J. Castillo Díaz, E. Abad Segura

QUALITY ANALYSIS IN SHORT-TERM COURSES ON A PERSPECTIVE OF RAPID ENTERING THE LABOR MARKET 7953
B. Wilges, A. Schwaab, D. Longo, V. Martins, G. Mateus, R. Cislaghi

SUPPORTING HIGHER EDUCATION STUDENTS DURING THEIR ERASMUS INCOMING/OUTGOING MOBILITIES: AN EXPERIENCE FROM A PSYCHOLOGY COURSE IN PORTUGAL 7963
A. Gonçalves, I. Oliveira

GAMIFICATION IN TEACHING NATURAL AND TECHNICAL SCIENCES 7970
Y. Daineko, M. Ipalakova, D. Tsoy

TEAMWORK AND EFFICIENCY IN CHEMISTRY PRACTICAL SESSIONS 7979
J.J. Lull, C. Lull

PRACTICAL TRAINING OF STUDENTS - A MOTIVATING FACTOR FOR PSYCHOSOCIAL MUTUAL AID IN A DIGITAL ENVIRONMENT 7983
D. Bakova, P. Kasnakova, A. Mihaylova, R. Stoyanova, D. Davcheva, T. Deneva, E. Toseva, D. Rajcinovska, G. Burov, S. Harizanova

EFFICIENCY OF THE EDUCATION COST IN LOCAL GOVERNMENT: AN APPLICATION TO THE SPANISH CASE 7988
J.L. Zafra-Gómez, P. Povedano-Fernández, L. Marquez-Arenas, G. Pérez-López, G. López-Pérez

PROFESSIONAL COMPETENCE OF AN ONLINE LATVIAN LANGUAGE TEACHER FOR PUPILS FROM THE DIASPORA 7992
L. Krastiņa, S. Zariņa, R. Bakutytė, E. Bogdāne

DIGITAL ART CREATION EDUCATION FOR THE ELDERLY WITH MILD COGNITIVE IMPAIRMENT THROUGH EXPRESSIVE ART THERAPY 7999
P.F. Wu, R. Lee

SALVADOR: HOW NETFLIX AND INSTAGRAM CAN INCREASE STUDENT MOTIVATION FOR AN ACTIVE LEARNING METHODOLOGY 8008
C. Ramirez, R. Frías, E. Martinez-Miguel

CURRICULUM DESIGN STRATEGIES FOR K-12 COMPUTER SCIENCE INTEGRATION 8016
P. Shank, K. Franklin, V. Fawley

PARENTAL UNDERSTANDING OF CAREER DEVELOPMENT SUPPORT FOR YOUTH IN LATVIA 8017
R. Burceva

TEACHING AND LEARNING UNITS OF INQUIRY THROUGH ART 8023
C. Osorio Alvarez

LACK OF NORMALCY PLANNING IN HIGHER EDUCATION IN MEXICO 8024
N. Dominguez-Vergara

INDIVIDUAL CAREER COUNSELLING IN GENERAL AND PROFESSIONAL EDUCATION INSTITUTIONS: CASE OF LATVIA 8033
R. Burceva

PROBLEMS OF UNEMPLOYED YOUTH AND GRADUATES 8038
L. Madlenakova, R. Madlenak

"FROM OCCUPATION TO PARTICIPATION": STUDENT VOICE AND REFLECTIONS ON HOW TO RETHINK HIGH SCHOOL EXPERIENCE, CENTERED ON RELATIONSHIP, STUDENT'S ENGAGEMENT AND SCHOOL'S EDUCATIONAL DIMENSION 8046
M. Brognoli, V. Pagani, G. Pastori

THE IMPACT OF EDUCATION ON ECONOMIC DEVELOPMENT 8053
C. Feniser, A. Sadeh, O.P. Stan, C.F. Radu, A. Constantinescu-Dobra, V. Maier, I.D. Popa

BUILDING PRACTICAL SKILLS TO FORMING RESILIENCE AMONG STUDENTS IN PANDEMIC 8060
R. Stoyanova, A. Mihaylova, P. Kasnakova, D. Bakova, D. Davcheva, T. Deneva, E. Toseva, G. Burov, G. Ristevska-Dimitrovska, S. Harizanova

INTEGRATING MULTI-DISCIPLINARY PAEDIATRIC PALLIATIVE CARE WITHIN THE UNDERGRADUATE TRAINING OF SOCIAL SERVICE PROFESSIONALS 8066
R. Swanzen

PROJECT-BASED LEARNING IN HIGHER EDUCATION: NEEDS AND EXPECTATIONS FROM ROMANIAN, PORTUGUESE, AND TURKISH TEACHERS 8074
I.M. Oliveira, P.C. Dias, A.S. Azevedo, E. Kara, H.M. Dönmez, O. Ergunay, M. Girtu, D. Caprioara

VIRTUAL PATIENT: ARCHITECTURE OF AN EDUCATIONAL WEB PLATFORM FOR THE ASSESSMENT OF CONSULTATION AND DIAGNOSING SKILLS OF MEDICAL STUDENTS 8080
I.A. Awada, A. Sorici, M. Drăgoi, A.M. Florea, A. Scafa-Udriște

EFFECT OF COVID-19 PANDEMIC ON THE PUBLIC ACCEPTANCE OF PARENT-LED HOME-BASED EDUCATION – THE CASE OF CZECHIA 8085
Y. Kostelecká, T. Kostelecký

DEVELOPMENT OF A PLATFORM TO PROMOTE PROJECT-BASED LEARNING IN HIGHER EDUCATION: CONTRIBUTES OF THE RESTART4EDU PROJECT 8086
P.C. Dias, I.M. Oliveira, A.S. Azevedo, E. Kara, H.M. Dönmez, O. Ergunay, M. Girtu, D. Caprioara

IMPLEMENTING PROJECT-BASED APPROACH IN TEACHING ESL STUDENTS AT KAZAN FEDERAL UNIVERSITY 8092
D. Khakimzyanova, E.S. Khovanskaya

EFFECTS OF AN AUTOMATIC ASSESSMENT TOOL ON THE MOTIVATION TO LEARN OF COMPUTER PROGRAMMING STUDENTS 8097
H.D. Lozano Rojas, F. Restrepo Calle, J.J. Ramírez Echeverry

RAPID PANDEMIC RESPONSE: SIMPLE TECHNIQUES FOR CREATING VIRTUAL LABS 8107
R. Drlička, M. Kotus, J. Macho

ESP TEACHERS' PERCEPTION OF HOW THEY COMPLY WITH THE REQUIREMENTS OF DIGITAL FORMATIVE ASSESSMENT 8112
K. Inozemtseva, E. Morozova

EMOTIONAL REGULATION IN THE COOPERATIVE WORK OF STUDENTS OF SCIENCE OF PHYSICAL ACTIVITY AND SPORT 8113
L. Vega, A. Reyno, C. Hederich, M.A. Ávalos

DESIGN BASED RESEARCH OF A SENSOR BASED MOBILE LEARNING COMPANION 8117
H.S. Yun, A. Sardogan

DESIGNING A WEB-QUEST FOR STUDYING LANGUAGE AND CULTURE OF AUSTRALIA 8125
K. Inozemtseva, N. Nurieva

ELEMENTS OF INFORMAL LEARNING IN TEACHING PROCESS IN GENERAL ENGLISH CLASSES AT KAZAN FEDERAL UNIVERSITY 8132
D. Khakimzyanova, E.S. Khovanskaya

REDEFINING ASSESSMENT AND EVALUATION POLICIES AND PRACTICES: A CANADIAN PERSPECTIVE 8137
M. Marchione, W. Barber, R. van Oostveen, J. Stokes

DIGITAL TRANSFORMATION AND LEAN THINKING: PERCEIVED INTERCONNECTIONS IN THE MANAGEMENT OF EDUCATIONAL SERVICES AT CAMPUS III OF THE FEDERAL UNIVERSITY OF PARAÍBA DURING AND AFTER THE COVID-19 PANDEMIC 8144
K. Ferreira Santos, A. Garcez, R. Moreira da Silva, F. Charrua-Santos

LINGUISTIC AUTOBIOGRAPHY AS AN EXAMPLE OF DEVELOPING DISCIPLINARY LITERACY AND ACADEMIC WRITING 8149
I. Tragel, N.K. Teiva, L.M. Komissarov

SOCIAL AND EMOTIONAL SKILLS DEVELOPMENT IN PRESCHOOL CHILDREN IN THE FAMILY ENVIRONMENT 8153
D. Apostolova

CHALLENGES OF EMPLOYING E-LEARNING FOR LEARNING ESTONIAN SPEAKING INTERACTION 8162
M. Teral

THE INNOVATIVE EDUCATIONAL METHODS TO ENHANCE ENTREPRENEURIAL ABILITIES 8166
V. Maier, A. Constantinescu-Dobra, M.A. Cotiu, O.P. Stan, C. Feniser

ASSESSMENT OF THE IMPACT OF EXTERNAL FACTORS ON LEARNING OUTCOMES 8176
E. Benks, B. Ilyukhin, N. Serbina, E. Lepustina

MAJOR CHALLENGES OF VOCATIONAL EDUCATION IN GEORGIA - VOCATIONAL EDUCATION PROVIDERS' PERSPECTIVE 8177
I. Grdzelidze, R. Sanadze, S. Idadze, M. Boehner, H. Tegelbeckers, T. Hennige

TEACHERS' APPROACH TO THE TOPIC OF DEATH IN THE TEACHING OF LITERATURE IN THE CZECH SCHOOLS 8183
P. Bubeníčková

EXTRINSIC VERSUS INTRINSIC MOTIVATIONAL FACTORS IN THE CHOICE OF BACHELOR DEGREE IN CASE OF STUDENTS FROM DISADVANTAGED SOCIO-ECONOMIC GROUPS 8189
D.M. Cismaru, R.S. Ciochina

FAIRY TALES AS AN EDUCATIONAL TOOL FOR TEACHING FOREIGN LANGUAGES 8193
H. Li, L. Wang

E-LEARNING AT THE UNIVERSITY COLLEGE OF TEACHER EDUCATION VIENNA: A COMPARISON ON THE EVALUATION OF SUPPORTING E-LEARNING COURSES IN DIFFERENT SUBJECTS IN PHYSICAL EDUCATION 8197
C. Rudloff

ADOLESCENT OFFENDERS WITH A MIGRANT BACKGROUND: EDUCATIONAL PATHS IN ITALIAN RESIDENTIAL CARE 8207
A. Monniello

IDENTIFICATION OF THE INFLUENCE OF UNFORESEEN EXTERNAL INFLUENCES (COVID-19 PANDEMIC) ON EDUCATIONAL OUTCOMES IN THE GENERAL EDUCATION SYSTEM 8214
E. Benks, B. Ilyukhin, N. Serbina

LESSONS LEARNED FROM INITIATIVES TO ROLL OUT DIGITAL CREDENTIALS IN EUROPE 8215
M.L. Bruno, L. Morgado

ENHANCING STUDENTS' SOFTWARE DEVELOPMENT SKILLS IN INTRODUCTORY JAVA-BASED PROGRAMMING COURSES WITH PROFESSIONAL COMMUNITY ACTIVITIES AND EXTERNAL RESOURCES 8225
B. Mihaljević, A. Radovan, M. Žagar, D. Jureković

THE EFFECT OF THE COVID-19 PANDEMIC ON MEDICAL STUDENT ELECTIVES AT THE UNIVERSITY OF MANCHESTER, UK 8235
I. Ioannou, A. Davis, A. Ahmed, S. Gupta, E. Ashton, M. Saint, T. Wasty

BENEFITS OF NEURODEVELOPMENTAL STIMULATION FOR CHILDREN WITH DEVELOPMENTAL LANGUAGE DISORDER 8236
J. Mironova Tabachová, K. Vitásková

E-LEADERSHIP: AN EXPLORATORY ANALYSIS OF THE SCIENTIFIC PRODUCTION 8245
M. Amorim, B. Lins, M. Ferreira Dias, R. Madureira, C. Silva, M. Rodrigues, M. Sampaio

ONLINE LEARNING FOR WORKING ADULTS DURING COVID-19 PANDEMIC: ADVANTAGES AND CHALLENGES 8253
P. Enciso

MONEY MAKES THE WORLD GO AROUND: THE ROLE OF PROBLEM SOLVING IN FINANCIAL LITERACY 8254
H. Campos, D. Almeida

LEARNING FROM TEXT OR VIDEO: COMPARATIVE ANALYSIS ON LEARNING ACROSS MODALITIES 8260
E. Dikbas Torun

AN INSIGHT ON THE TRANSFORMATION OF THE TRADITIONAL EDUCATIONAL EXPERIENCE TO A COMBINATION OF SYNCHRONOUS, ASYNCHRONOUS, AND TRADITIONAL LEARNING ENVIRONMENT 8265
S. Shaw, O.A. Tapia

THE "CUBIST" DWELLINGS OF OLHÃO (PORTUGAL): A CASE STUDY ON DEVELOPING SKILLS IN ARCHITECTURAL REHABILITATION DESIGN THROUGH THE HISTORY OF ARCHITECTURE AND TRADITIONAL CONSTRUCTION TECHNOLOGIES 8273
M. C. S. Nepomuceno, A. M. T. Martins Nepomuceno, Y. Gomez, V. Afonso

STEM PEDAGOGICAL INNOVATIONS FOR THE INCORPORATION OF SOCIAL JUSTICE IN UNIVERSITY EDUCATION: THE CASE OF THE UNIVERSIDAD DEL ROSARIO 8280
R. Méndez-Romero, S. Carrerá-Martínez, M.A. Suavita-Ramírez

TOWARDS AN ADAPTIVE USE OF CONCEPT MAPPING CONSIDERING LEARNING STYLES 8287
J. Bechara

STEM TRAINING AND ITS RELATIONSHIP WITH THE NEW MEXICAN SCHOOL EDUCATIONAL MODEL 8292
C.P. Suarez Rodriguez, C. Zamora Pedraza

USING FLIPPED LEARNING IN ONLINE COURSES 8293
M. Fazal, C. Navarrete

HISTORICAL ANALYSIS OF THE FORMATION OF ENGINEERING STUDENTS THROUGH THE DEVELOPMENT OF TECHNOLOGICAL PRODUCTS IN THE OPEN ROBOTICS WORKSHOP 8294
L. Miranda-Cordero, R. García-García, Y. Minami, U. Peñuelas-Rivas

STRATEGY FOR TEACHING CLASSICAL GENETICS BASED ON AUGMENTED REALITY 8302
D.M. Rivera Pinzón, S. Cuervo Guzman, Y.M. Gamboa Forero

ADDRESSING A LABOR MARKET NEED FOR HEALTH MANAGERS AND POLICY PROFESSIONALS: DEVELOPMENT OF A NON-CLINICAL HEALTH SCIENCE DEGREE PROGRAM FOR HEALTH POLICY AND MANAGEMENT 8311
N. Rodriguez

DESIGN OF REMOTE REALIZATION PRACTICE TO IMPROVE STUDENT LEARNING IN EMERGENT SITUATIONS 8318
A. Hernández, A.Y. Jiménez Rodríguez, Y. Minami

TECHNOLOGICAL CHARTS OF FOREIGN LANGUAGE CLASSES: TEACHING HOW TO MODEL AND IMPLEMENT 8325
E. Chelpanova, E. Bystray, V. Moshkovich, F. Zakirova, A. Shabalina

KAGAN'S COOPERATIVE LEARNING STRATEGIES IN A HIGHER EDUCATION ESL CONTEXT: FOSTERING WILLINGNESS TO COMMUNICATE (WTC) IN A POST-PANDEMIC ENVIRONMENT 8332
J. Fonseca-Chacana

COMMONLY MISPRONOUNCED WORDS IN ENGLISH FOR ACADEMIC PURPOSES 8333
H. Vancova

THE ROLE OF PEERS IN IMPROVING ENGLISH PRONUNCIATION 8334
H. Vancova

RECORDING AND EDITING EDUCATIONAL VIDEOS: COMPARATIVE EVALUATION OF AVAILABLE FREE SOFTWARE AND AN EXAMPLE OF USE 8340
E. Romero, J. Remón

TRANSITIONING FROM THE PAPER TO THE TABLET: DO STUDENTS AT THE HIGHER EDUCATION LEVEL USE TABLETS FOR NOTE TAKING? ARE THEY AWARE OF THE DIFFERENT FEATURES AND POTENTIAL OF NOTE-TAKING APPLICATIONS? 8346
J. Remón, E. Romero

DESIGN THINKING IN DEVELOPING INTEGRATED HOLISTIC EDUCATION THROUGH PROJECT WORK (PW) 8350
H.F. Lee, T. Divenaran

REFORMING BUAYA DI BAWAH JAMBATAN ADAB AND MORAL VALUES BOARD GAME BASED ON TEACHERS' FEEDBACK 8355
F.A. Mohd Radzi, N.A. Dahlan, K. Said Hashim, F. Wan Yunus, S. Silah, R. Abdul Wahab

DESIGNING OF LEARNING ASSISTANCE ENVIRONMENT WITH MULTI EDGE DEVICES FOR THE ERA OF COMPLEX MASSIVE NATURAL DISASTERS 8361
S. Togawa, A. Kondo, K. Kanenishi

IMPACTS OF THE COVID-19 PANDEMIC ON THE AREA OF COMMUNICATION AND RESPIRATION IN PRE-SCHOOL AND YOUNGER SCHOOL-AGED CHILDREN OBSERVED BY TEACHERS IN THE CZECH REPUBLIC 8367
E. Šlesingrová, K. Vitásková

THE IMPACT OF TEXT AND VIDEO-BASED CONTENT DELIVERY IN ONLINE FLIPPED LEARNING ENVIRONMENT ON STUDENTS' ENGAGEMENT 8372
M. Abuhmaid

THE CONCEPTUAL REPERTOIRE (CORE) IN THE CHEMISTRY TEACHING IN SECONDARY EDUCATION: ANALYSIS OF THE AMPLITUDE, DIVERSITY AND LEVELS OF REPRESENTATION IN ORGANIC CHEMISTRY CLASSES 8373
S. Contreras

BETWEEN TEACHER TRAINING AND EDUCATIONAL INNOVATION. WHAT HAPPENED DURING DISTANCE EDUCATION BY COVID19? 8380
N.P. Maldonado Reynoso, A.J. Rodriguez Aguirre

THE EFFECTIVENESS OF LEARNING MODEL GAWI MANUNTUNG BASED ON MULTIPLE INTELLIGENCES IN TERMS OF STATISTICAL LITERACY ABILITY AND SCIENTIFIC SKILLS OF ELEMENTARY SCHOOL STUDENTS 8388
A. Suriansyah, A.R. Agusta, R. Purwanti, S. Hussin, R.P. Hayati, D.A. Pratiwi

EVALUATION OF THE STATE OF EDUCATIONAL SCIENCES IN UNIVERSITIES AND HIGHER EDUCATION INSTITUTIONS OF IRAN 8389
S. Khalijian, G. Shams

AN ACCESSIBLE AND INCLUSIVE FUTURE FOR TABLETOP GAMES AND LEARNING: PARADIGMS AND APPROACHES 8397
C. Sousa, F. Luz, M.M. Fonseca, P. Neves, P. Lopes, V. Maratou, R. Chaliampalias, A. Kameas, Y. Abdullahi, S. Rye

CHALLENGES AND SCENARIOS FOR HIGHER EDUCATION IN THE POST PANDEMIC WORLD 8407
N. Dominguez-Vergara

DRAWING ON ARTS-BASED METHODS FOR STUDENTS' COLLECTIVE SENSE-MAKING OF THEIR GROUP-WORK LEARNING EXPERIENCES: A CASE STUDY FROM A UNIVERSITY-BASED HEALTH SCIENCE PROGRAM 8416
S. Walsh, A. Morgan, C. Kutay

EFFECTIVENESS EVALUATION INDICATORS OF ORGANIZATIONAL E-LEARNING COURSES 8417
G. Shams, M. Zareisaroukolaei

ACTION RESEARCH WITHIN ERASMUS+ 8421
M.E. Cîmpean, V.A. Găzdac, M.D. Bocoș

DEVELOPING DIGITAL AND SUSTAINABILITY COMPETENCES THROUGH ETWINNING PROJECTS AND ERASMUS+ ACCREDITATION 8431
M.E. Cîmpean, V.A. Găzdac, M.D. Bocoș

DIGITAL SKILLS IN UNIVERSITY EDUCATION: AN ANALYSIS OF ITS IMPLEMENTATION AMONG STUDENTS 8437
M.S. Valero-Gracia, J.S. Artal-Sevil

FIT FOR PURPOSE: POSTGRADUATE CERTIFICATE IN EDUCATION STUDENTS' TEACHING PRACTICE 8444
N.P. Caga, N. Majiba

EVALUATION OF THE IMPACT AND NECESSITY OF EDUCATIONAL (COMPUTER) PROGRAMS USED IN THE EDUCATIONAL PROCESS OF PRE-SCHOOL CHILDREN 8449
I. Bilbokaitė-Skiauterienė, R. Bilbokaitė

ACADEMIC ADJUSTMENT, PSYCHOLOGICAL WELL-BEING, AND FEAR OF COVID-19 AMONGST UNDERGRADUATE UNIVERSITY STUDENTS DURING THE COVID-19 PANDEMIC, IN SOUTH AFRICA 8450
M. Tau, C. Mapaling, W. Tsabedze

FOSTERING STUDENTS' AWARENESS IN CHOOSING UNDERGRADUATE STUDIES IN ARCHITECTURE @POLITO 8457
M. Pavignano, U. Zich

URBAN SURVEY BETWEEN ON-SITE AND ON-LINE APPROACH IN THE BACHELOR'S OF ARCHITECTURE 8467
M. Pavignano

EXPLORING THE EXPERIENCE OF PEOPLE WITH DEMENTIA IN VIRTUAL REALITY DRAWING CREATION BASED ON THE ARCS MODEL 8477
P. F. Wu, K.Y. Fan, F.C. Wu, S.W. Yen

INVESTIGATING THE RELATIONSHIP AMONG SCHOOL CONNECTEDNESS, INTENSITY OF FACEBOOK USE AND SCHOOL ADAPTATION IN UKRAINIAN REFUGEE JUNIOR HIGH SCHOOL STUDENTS 8482
T. Touloupis

ACADEMIC CHEATING BEHAVIORS AMONG ADOLESCENTS: THE ROLE OF MACHIAVELLIANISM AND MORAL DISENGAGEMENT 8483
T. Touloupis

THE INFLUENCE OF COOPERATIVE LEARNING TO FOSTER THE DEVELOPMENT OF EFL STUDENTS` ENGLISH SKILLS 8484
S. Anaguano, M. Zurita

COOPERATIVE LEARNING STRATEGY TO IMPROVE THE ATTITUDE OF STUDENTS TOWARDS EFL LEARNING AND OBTAIN BETTER RELATIONS AMONG PEERS 8490
S. Anaguano, M. Zurita

INTEGRATION OF UKRAINIAN REFUGEE ATHLETES INTO THE OLYMPIC CHANEL OF THEIR NEIGHBORING COUNTRIES 8497
G. Braniste

TEACHING BEYOND WORDS: NON-VERBAL CUES IN FOREIGN LANGUAGE LEARNING 8498
A.M. Toma

TEACHERS PROFESSIONAL DEVELOPMENT USING NARRATIVE METHODOLOGY: IDEAS FOR LEADERSHIP CAPABILITY ISSUE 8503
E. Seghedin

DISTANCE LEARNING OF FOREIGN LANGUAGES BY IMMIGRANTS AND REFUGEES THROUGH 'LANGUAGE ON THE GO' MOBILE APP 8504
P. Psomos

STUDENTS' VIEWS ON A MOBILE SERIOUS GAME THAT FOSTERS MATHEMATICAL SKILLS THROUGH MAGIC (SPELLS): A SURVEY STUDY 8505
P. Psomos

INTELLIGENT TUTORS DESIGNED TO IMPROVE STUDENT LEARNING IN PHYSICS 8506
V. Aravind, A. Kumar

PROFESSIONAL COMPETENCIES: AN ASSESSMENT OF LECTURERS AT A PRIVATE HIGHER EDUCATION INSTITUTE IN SOUTH AFRICA 8507
C. Engelbrecht, W. Engelbrecht

AGILE, HYBRID TEACHING METHODS OF DISTRIBUTED PROJECT MANAGEMENT AND INTERCULTURAL SKILLS FOR GLOBAL SOFTWARE ENGINEERING DURING THE PANDEMIC 8513
D.M. Marutschke, V. Kryssanov, P. Brockmann

DESIGN AND TESTING OF A MOBILE EXPERIMENTAL DEVICE IN THERMAL SCIENCES 8521
E. Glakpe, S. Franco, C. Badiane

21ST CENTURY SKILLS: WHAT ELSE? 8529
A.M. Lara-Palma, R. Brotóns-Cano, M.M. Delgado-Hurtado, A. Jiménez, O. Valencia-García, M.M. Jimeno-Bulnes

ALCOHOL ABUSE AS A NON-STANDARD SITUATION IN THE CARE OF WOMEN IN THE PRECONCEPTION PERIOD, DURING PREGNANCY, DURING CHILDBIRTH, AND IN THE PUERPERIUM FROM THE MOTHER POINT OF VIEW: A CHALLENGE FOR HEALTH LITERACY EDUCATION 8537
I. Olecká, A. Lemrová

REVIEW OF PEDAGOGICAL STRATEGIES EMPLOYED IN TEACHING TOURISM AND HOSPITALITY PROGRAMMES AT POLYTECHNIC COLLEGES IN ZIMBABWE 8542
K. Ngwenya, S. Luggya, X. Khalo

EXPERIENTIAL DESIGN THINKING FOR ENTREPRENEURS AND INNOVATIVE MANAGERS IN THE DIGITAL AGE 8551
S. Shcholokova, G. Laptev

BUILDING ACTIVE CITIZENS - STRATEGIES AND PRACTICES OF EDUCATION FOR CITIZENSHIP: TRAINING EXPERIENCES OF PRE-SCHOOL AND PRIMARY TEACHERS 8560
C. Araújo, A. Osório

RELATIONSHIPS BETWEEN ROBOTICS, PROGRAMMING AND NARRATIVES IN PRE-SCHOOL AND PRIMARY EDUCATION 8567
C. Araújo, A. J. Osório, A. P. Martins

QUALITATIVE EQUITABLE EARLY CHILDHOOD CARE AND EDUCATION FOR SUSTAINABLE DEVELOPMENT IN SELECTED EARLY CHILDHOOD DEVELOPMENT CENTRES IN SOUTH AFRICA 8568
N. Tyilo, T. Matshoba

SELF-REGULATION AS A CONDUIT FOR PLAY-BASED LEARNING APPROACH FOR YOUNG CHILDREN BETWEEN 0-5 YEARS. 8575
N. Tyilo

ENHANCING L2 WRITERS' ARGUMENTATIVE SKILLS WITH THE "THINK, PAIR, AND SHARE" ONLINE TOOL 8583
J. Qin

THE OPINION OF TEACHERS ON EVALUATING AND MARKING PUPILS' ACHIEVEMENTS IN LOWER PRIMARY SCHOOL GRADES IN CROATIA 8588
V. Valjan Vukić, S. Zrilić, M. Vunić

IMPACT OF ONLINE TEACHING AND LEARNING ON AT-RISK STUDENTS AT AN INSTITUTION OF HIGHER LEARNING IN SOUTH AFRICA: SMU CASE STUDY 8594
NS. Mathiba, TA. Dandadzi, EL. Sesale, SM. Seeletse

THE CHALLENGE OF PEER ASSESSMENT IN HIGHER EDUCATION 8603
P. Vossen, S. Ajit

CREATING BIOPLASTICS: A CO-DESIGNED EDUCATIONAL PRACTICE? 8613
P. Enciso, C. Vignoli, S. Horjales, I. Marsicano, R. Mantaras, F. Palma

ITEACH: A SERVICE-LEARNING PROJECT FOR ONLINE SCHOOL-BASED SUPPORT 8614
C. Fernandez-Jimenez, D. Tomás Cámara, L. Hernando Guadaño

COMPETENCE MANAGEMENT AND EMPLOYEE TRAINING: CONTRIBUTION TO MOTIVATION AND PROFESSIONAL PERFORMANCE 8615
R. Silva, M. Preza

THE LITERARY TEXT AS AN EDUCATIONAL SUPPORT OF POLITICAL AUTHORITY – A CASE STUDY 8616
C. Alexandrache

CHALLENGE-BASED LEARNING FOR THE DEVELOPMENT OF ENTREPRENEURSHIP COMPETENCIES 8623
S. Sousa, F. Cortellese, M.F. Casado Claro, S. Marcos Alsina

INFLUENCE OF INTERACTIVE EDUCATIONAL VIDEOS ON BLENDED LEARNING: A CRITICAL REVIEW IN HIGHER EDUCATION 8628
J.S. Artal-Sevil, M.S. Valero-Gracia

ROBOTICS IN LANGUAGE LEARNING: A SYSTEMATIC REVIEW 8641
E. Psara, A. Parmaxi, A. Athanasiou

DEVELOPING A VIRTUAL REALITY TRAINING SYSTEM FOR AGRICULTURAL MACHINERY 8650
R. Stephens, A. Awasthi, K. Crowley, F. Boyle, J. Walsh

FORMATION OF INTERCULTURAL COMMUNICATIVE COMPETENCE OF STUDENTS ON THE BASIS OF TBLT TECHNOLOGY 8656
E. Nazmieva, R. Gubaidullina, G. Chumarina

EFFECTIVENESS OF THE EDUCATIONAL PROGRAM 'GOLDEN5' FOR IMPROVING STUDENTS' PSYCHOLOGICAL WELL-BEING AND ACADEMIC ACHIEVEMENT IN PRIMARY EDUCATION 8662
MJ. Lera, JM. Leon-Perez, P. Ruiz-Zorilla

THE CHALLENGE OF ACHIEVING GENDER EQUALITY IN NIGERIAN EDUCATION: HINDRANCES FACED BY GIRLS IN SCHOOL 8663
L. Audu, A. Lawani

STUDENT-CENTERED CURRICULUM IN THE CONTEXT OF QUALITY INCLUSIVE THEORY AND PRACTICE – SOME KEY DETERMINANTS 8669
M. Karamatić Brčić

MENTORING CHAIN IN A COIL EXPERIENCE 8677
A. Ayunts, E.. Dias, E.. Fernandes, T. Guarino, A. L. Prestes

DIGITAL SKILLS, CULTURAL MANAGEMENT AND ONLINE EDUCATION: A DYNAMIC MODEL TO ADDRESS THE DIGITAL GAP 8686
G. Gantzias

EXPLORING FACTORS CONTRIBUTED TO INSTRUCTIONAL COACHES' PSYCHOLOGICAL CAPITAL 8687
N. Burhanuddin, N. Ahmad, R. Said, S. Asimiran

EXAMINING 9TH GRADE STUDENTS' AWARENESS OF THEIR CAREER OPTION 8700
S. Alsuwaidi

CARE IN EARLY CHILDHOOD EDUCATION AND CARE: A REVIEW OF THE INTERNATIONAL LITERATURE 8701
I. Mussini

USE OF ICT IN THE CLASSROOM: A CASE STUDY WITH STUDENTS OF VOCATIONAL COURSES FROM FOUR PORTUGUESE SCHOOLS 8708
A.E. Sousa, S. Pais

GAMIFICATION IN EDUCATION: THE USE OF THE ESCAPE ROOM AS A LEARNING STRATEGY 8713
A.E. Sousa, S. Pais

3D PRINTED MODELS FROM CT SCANS: PARAMETERS AFFECTING QUALITY OF ANATOMICAL MEDICAL MODELS 8718
D. Moeller, K. Budisalich, C. Gunter, T. Kelsey, G. Maddux, B. Schroer

THE IMPACT OF DISTANCE LEARNING ON THE PROGCONT SYSTEM AFTER PANDEMIC 8729
P. Biró, T. Kádek

ANALYSIS OF INNOVATIVE AND ENTREPRENEURIAL POTENTIAL OF FIVE WESTERN BALKAN UNIVERSITIES SUPPORTED BY THE HEINNOVATE INITIATIVE 8736
T. Velkovski, R. Polenakovikj, B. Jovanovski, M. Velkovska, L. Polenakovikj, N. Shterjova Uzunovska, J. Kostikj

INNOVATIVE DIGITAL INCLUSION STRATEGY FOR MUNICIPALITIES 8745
S. Muñoz Hernández, C. Urbano Molina

BUILDING THE CAPACITY OF RESEARCH-INFORMED TEACHING AND LEARNING IN THE BUSINESS, COMMUNICATION, AND SOCIAL SCIENCE DISCIPLINES: THE HONG KONG EXPERIENCE 8753
K. Chan, N.Y.M. Siu, G. Lai

FINANCIAL WISDOM IN GENERAL EDUCATION 8757
L. Kirch

ENTREPRENEURIAL SCHOOL PROGRAM 8758
P. Torm-Mirontšik

THE ENTREPRENEURSHIP AND CAREER EDUCATION PROGRAMME OVERVIEW 8759
E. Veide

HOW TO INTEGRATE ENTREPRENEURSHIP EDUCATION INTO SCHOOL LESSONS? 8760
P. Granovski

A CASE STUDY OF ETHICAL LEADERSHIP AND TRANSPARENCY IN SELECTED SECONDARY SCHOOLS 8761
R. Mestry, D. Edwards

THE ROLE OF SCHOOL LEADERS IN MANAGING PUBLIC SCHOOLS DURING THE COVID-19 PANDEMIC 8762
R. Mestry, P. Du Plessis

EXPERIMENTATION WITH MODELS IN THE TEACHING OF BUILDING STRUCTURES IN A SCHOOL OF ARCHITECTURE. FIRST RESULTS 8763
C. Olmedo, B. Orta, J. Antuña, M. A. Benito, D. Mencías-Carrizosa, V. Pascual

DESIGN & DEVELOP A SMART LEARNING CITY ENVIRONMENT FOR SUSTAINABILITY

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Abstract

To progress towards the goals of the 2030 Agenda, citizens must have opportunities to develop key competences in sustainability. Mobile devices, augmented reality and outdoor games can be mobilized to promote education for Sustainable Development for diverse target publics. Thus, there is a need of research changes in sustainable development competences in citizens brought about by the exploration of a smart learning city environment, sustained by mobile Augmented Reality (AR) game-based resources. This is a work-in-progress report on a design-based research approach for development of the technological facet of a smart learning city environment for education for sustainable development, under the EduCITY project. It is expected that the EduCITY will produce a technology-enhanced intervention, using a mobile app with AR challenging games, co-created by citizens through an open and easy to use access platform, supporting participatory dynamics. Once the games are created, the citizens can also explore AR games in strategic paths in the city. The games are grounded in city-based aggregating topics, promoting education in context and lifelong learning. It is a challenging and ambitious endeavour, where citizens commit to transformation and engage in it for the benefit of cities' quality of life and sustainability. Nevertheless, several difficulties are foreseen that need to be addressed, such as issues regarding AR triggering and interactivity, and connectivity with environmental sensors. Future work involves several cycles of testing the prototype and, after a functional version, the organization of sessions for game co-creation and, afterwards, the preparation of activities for the community to play the games in the city. These experiences enlarge the creative, multi/interdisciplinary response that seeks to provide situated learning opportunities for all, throughout the creation of participatory dynamics involving the academy and the community. The EduCITY contribution for the knowledge progress is its innovative framework based on a grounded, participatory, and user centred approach for the development of key competences for sustainable development, by using a smart technology and moving Education to a Smart City. This is anchored on a community-based participatory project integrating AR location games based on challenges, to be explored in the city, in formal, non-formal and informal educational contexts, in a socio constructivism approach.

Keywords: Mobile learning, augmented reality, game-based learning, Education for Sustainable Development, design-based research.

1 INTRODUCTION

Education for Sustainable Development must empower learners to take informed decisions and responsible actions. To achieve sustainability an action-oriented transformative pedagogy must be developed, integrating self-directed learning, participation and collaboration under a social constructivism approach, problem-orientation, inter and multidisciplinary approach, linking formal and informal learning [1].

Mobile devices are the most frequent digital technology used for Education for Sustainable Development in outdoor settings with different target groups [2]. The devices can: 1) increase student motivation [3]; 2) be used by students to document learning in situ [4], 3) sustain time management and the adequation of the pace of learning [2], among other benefits. Yet, mobile learning approaches can be expensive, due to devices and internet costs, and require technical skills from teachers; thus, these need guidance or professional development initiatives [4]. When combined with augmented reality (AR) contents, the educative effect of mobile devices may be exponential [5]. In education, AR has been used to: 1) support the development of high-risk skills, such as piloting [6], 2) allow the visualization of difficult concepts [7], 3) promote personalized learning [8], to name a few. However, in education, AR is usually linked to textbooks and printed material [7], not taking advantage of the potential of mobile devices supported AR to provide contextual and situated learning [5]. The integration of game-based learning approaches may enhance engagement in challenging situations and improve student overall sense of enjoyment, whilst

promoting effective learning [9]. Future developments involve creating better learning experiences, supported by the users' experience *in situ* [10].

From the above and from the need of analysing potential changes in sustainable development competences in citizens brought about by the exploration of mobile AR game-based resources, emerged the EduCITY (https://educity.web.ua.pt/), a project developed by a multidisciplinary team of University of Aveiro, in Aveiro, Portugal. The project aims to promote sustainability learning through a disruptive smart learning environment, sustained by a mobile app with active location games with diverse educational resources (AR, data from environmental sensors, etc.). For that, EduCITY will produce a technology-enhanced intervention, using a mobile app with AR challenging games, co-created by citizens through an open and easy to use access platform, supporting participatory dynamics. Once the games are created, the citizens can also explore AR games in strategic paths in the city. The games are grounded in city-based aggregating topics, promoting education in context and lifelong learning.

The main purpose of this contribution is to present an approach to develop the technological facet of a smart learning environment towards sustainability learning in a specific city. Hence, the remaining of this work presents the methodological options, where it is shown that EduCITY involves the adoption of a pragmatic paradigm with a design-based research approach [11] towards a technological based solution, through successive cycles of improvement. The following section presents the preliminary results, regarding the smart learning city environment technology, which is under development, and final, some conclusions are put forward. The technology enhanced city learning environment is being developed, but, when ready, it can be replicated in other cities, challenging conventional thinking about how people can learn about their city and change their habits towards sustainable and resilient cities.

2 METHODOLOGICAL OPTIONS

Under a pragmatic paradigm, mixed methods are being used in a design-based research approach, which is a useful framework for developing technology-enhanced learning environments, such as mobile learning delivered by mobile handheld devices [11]–[14]. The design-based research methodology comprises several cycles of improvement of a solution prototype.

In this technology focused study, the aimed solution is a smart learning city environment towards sustainability that is currently under development. Initial work includes an analysis and exploration stage [14], to shape a better understanding of the problem. It was conducted through literature review and brainstorming of ideas for the app, AR contents and web platform. This work supported the progress to the second stage, of design and construction [14], with the definition of specifications for a subcontracted programmer, who is producing the first prototype.

Under the evaluation and reflection stage [14], the first prototype will be analyzed by the research team and by the project's expert consultant through heuristics analysis to identify issues regarding usability, AR triggering, connectivity with environmental sensors using Internet of Things technology [15], among others, for improvement. New mature versions of the technological solution are field tested in four improvement cycles involving activities with small groups of students, teachers, and public. Data collection instruments (observation grid and focus group interview guide) are validated by experts and consider ethical aspects and procedures. The resulting data are analyzed through content analysis. The findings are reflected upon to refine the understanding about it, how and why the technology-enhanced solution work. Additionally, after successive evaluative cycles for improvement, it is expected to achieve a functional solution comprising a mobile app, a web-based platform for game creation by non-programmers, and a set of challenging games in the city, integrating AR contents and environmental sensors, ready to be implemented and evaluated with different target publics.

Finally, throughout the entire research process, special attention is given to implementation and spread, in articulation with practitioners, particularly school teachers, in order to study changes in knowledge, skills, values, and attitudes towards sustainability through inquiry (before and after activities), in situ observations and game data.

3 PRELIMINARY RESULTS

As mentioned, the EduCITY design-based research started with the analysis and exploration stage [14], where literature recommendations were considered, such as the promotion of personalized learning [8] and the support of the users' experience in situ [10]. It also involved several work meetings, of the whole

team and in small groups, to brainstorm and compile ideas for the smart learning city environment. The main features intended for the smart learning city environment are:

1 An easy-to-use and freely accessible mobile app towards education for sustainability, comprising AR multimedia resources to be integrated in outdoor games developed in different paths and places within the city, such as the university campus, schools and non-formal educational spaces (natural parks, museums, culture houses, and science centres);

2 An easy-to-use open access web platform, to allow citizens (educational stakeholders, academy and the wider community) to co-create activities and challenges to be integrated as games in the app;

3 A set of activities to create AR educational games with teachers, students, and the wider community. These activities can be accredited training advanced courses for teachers, learning sessions for students, and informal workshops for the wider community. Masters and PhD students are also involved in the creation of location-based games. The games include AR contents, 3D animations, and data from environmental sensors, which are used to create interactive challenges to stimulate participants to detect environmental changes in the city and to identify hidden clues for best game performance and knowledge improvement. Motivation game elements include competition among teams, collaboration within teams, score keeping, and immediate feedback provided by a friendly mascot, who also guides players through learning paths. The games are grounded on aggregating curriculum topics, namely Clean Energy, Food Waste, or Pollution, and city-based topics, as Infrastructures, Services, or Urban Culture;

4 A set of activities to explore the created games by students and teachers from Primary up to Higher Education, teacher educators and trainees (articulating the educational offer of the involved departments of the University of Aveiro), and the wider community (inhabitants, tourists and public).

These experiences enlarge the creative, multi/interdisciplinary response that seeks to provide situated learning opportunities for all through the creation of participatory dynamics involving the academy, local government, teachers, children, inhabitants, and city visitors.

Based on the initial literature review and brainstorming, the ideas were co-constructed and negotiated among several project team members, to achieve a solution integrating all the required features. From the work resulted the wireframes of the app and platform.

3.1 The mobile app

The mobile app sustains location-based games with challenging activities. The initial screen supports starting a new game, access to the free mode, seeing the score previously achieved, and learning the game rules (how to play), as shown in Figure 1, a).

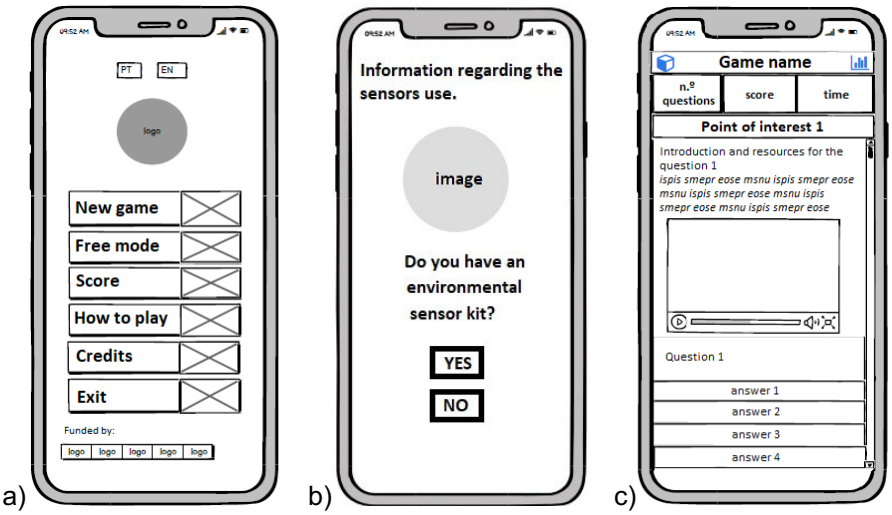

Figure 1. EduCITY mobile app wireframe examples: a) initial screen; b) screen with information regarding the use of environmental sensors; and c) screen with a multiple-choice question.

For each game, the user can see information, such as the school level or school subject the game was developed for, number of points of interest or if it includes AR. After selecting a new game, the user must indicate if he/she will be using an environmental sensor provided by the EduCITY team (Figure 1, b). In case of "yes" option selection, the user is prompted to connect the kit and will collect sensor data regarding: i) particulate and others, ii) NO2 and others, or iii) noise. That data is collected and aggregated in graphs in ThingSpeak (https://thingspeak.com/), and made available in the EduCITY website (https://educity.web.ua.pt/), for the community to have access.

The AR experiences are possible through 2D markers, such as architectonical tiles or trees identification plaques. Other types of AR triggering will be studied under EduCITY as well.

Following, the user starts playing. He/she will be "accompanied" by a friendly Flamingo mascot to find points of interest in the city, where he/she will be prompt to observe, to have access to information in multimedia format, including AR, and to answer multiple choice questions (Figure 1, c). After selecting an answer option, differentiated feedback is shown. At the end, the user will have access to the achieved score, number of questions answered correctly, time of play, etc.

3.2 The web platform

The games are created by non-programmers, in a web platform (Figure 2). Each user must create an account to be able to use it. With this tool the user can define written information, such as the initial message of the game, and multimedia resources, such as specific digital content used to create AR experiences, to include in phase of the game. For each point of interest in the city, defined by the user, he/she: i) introduces information regarding how to find its location and why it is interesting, and ii) creates multiple choice question(s), including the answer options and feedback to provide to the players accordingly to game performance. The number of answer options can vary from two to four, and the correct options can also vary in this range.

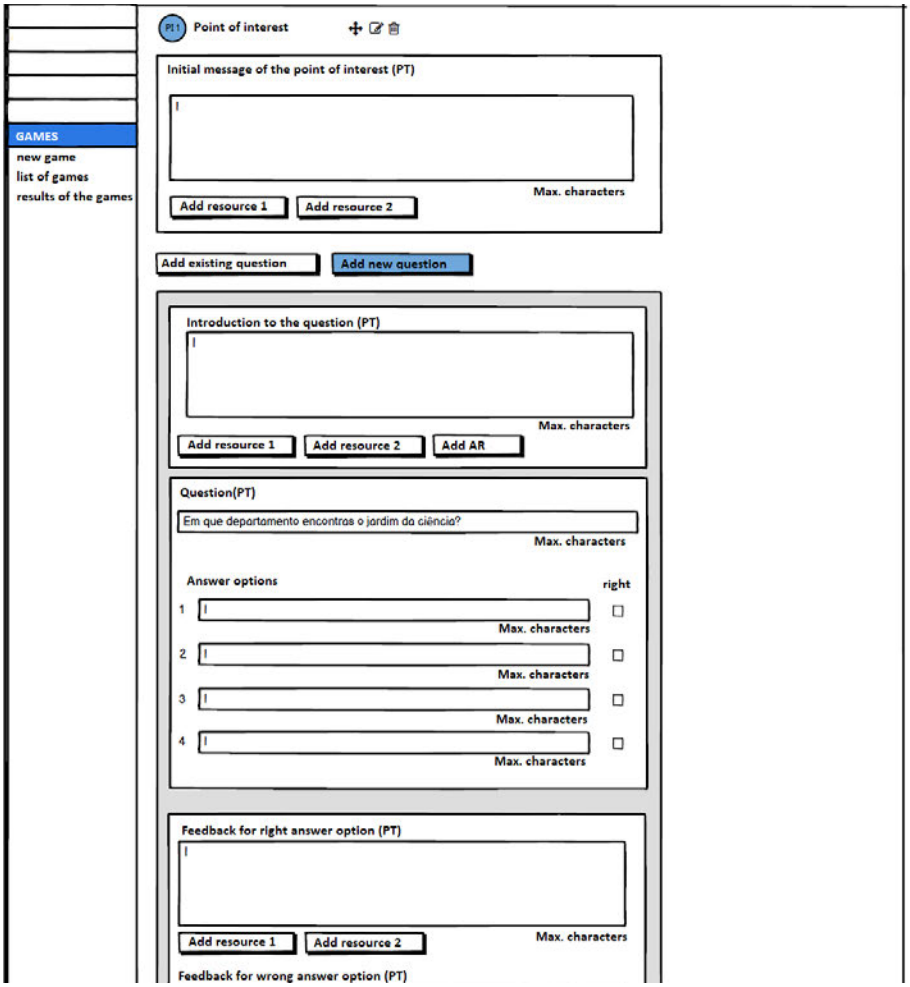

Figure 2. EduCITY web platform wireframe example: question creation.

Multimedia resources can be included to contextualize the players, to give information, to support the visualization of difficult concepts, among other aims. For that, a content repository (video, audio, 3D models,) is integrated in the platform, which is fed by the research team and by the platform users.

Both the AR markers and the digital content for AR experiences are created by the EduCITY team. They can, however, be also created by users (Figure 3), for greater flexibility and project sustainability after the funding period. The users can create three types of AR experiences, such as associating a 3D object to a marker, subtitling an image or creating a button screen with information.

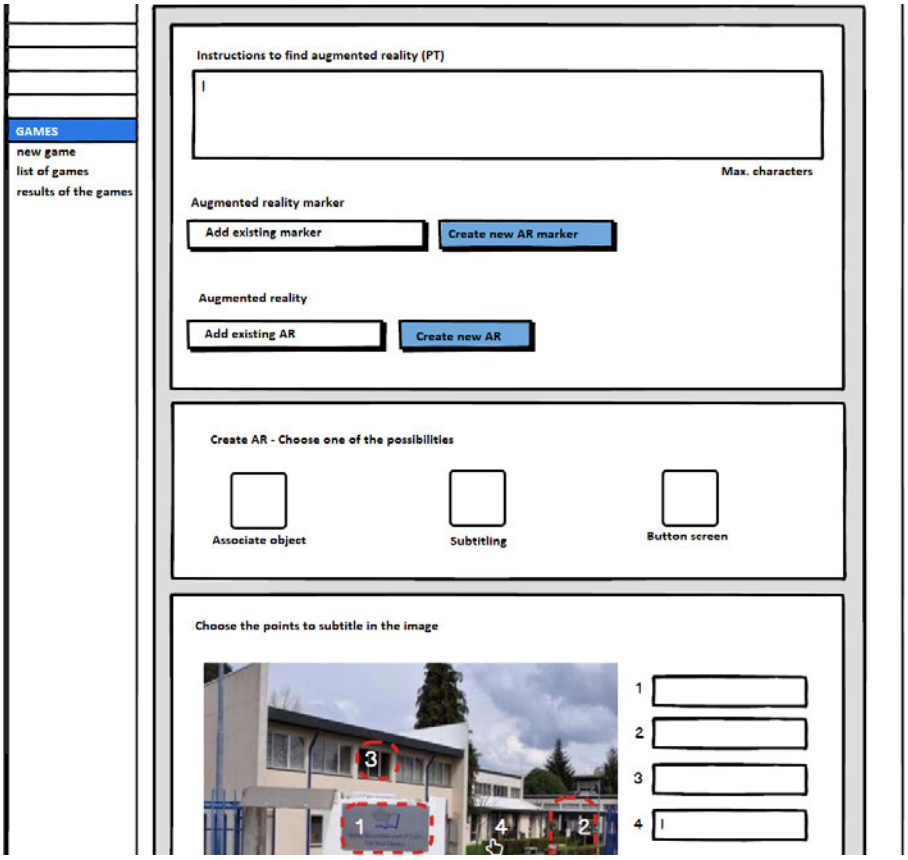

Figure 3. EduCITY web platform wireframe example: AR creation.

Participatory dynamics are supported by the platform. Each user can invite other authors to co-create content and games, by introducing one or more email addresses in the platform. The invitees receive an email with information and direct link to the platform. They must create an account or login into the platform to accept the invitation.

Games are always available for their creators to use in the app, through the use of a code. To be publicly available, games can be submitted to validation by members of the research team. The platform collects anonymous game logs for the game creators to be able to analyse and decide on eventual improvements to conduct.

4 CONCLUSIONS

This work-in-progress study present an approach to develop a smart learning city environment towards changes in citizens' sustainable development competences. It is expected that the EduCITY will produce a technology-enhanced intervention, using a mobile app with AR challenging games, co-created by citizens through an open and easy to use access platform supporting participatory dynamics. With this tool, citizens will also be able to explore AR games in strategic paths in the city. The games will be grounded in city-based aggregating topics, promoting education in context and lifelong learning.

The EduCITY innovation lies in: a) the use of the territory as a living experimental laboratory, moving Education to a real-life context; b) the use of widely-used smart technology with AR mobile games; c) community participation, giving opportunities for all to actively contribute, in a social constructivism

approach; d) wide knowledge sharing between the university and the community; e) the applicability of this approach to any city to build a digital, green and healthy future for everyone. The development of a

technology that can support such innovative smart learning city environment is a challenging and ambitious endeavour. Here, citizens are asked to commit and engage in the transformation of their city towards sustainability, for the benefit of cities' increased quality of life. In such a challenging proposal, several difficulties are foreseen, as issues regarding AR triggering and interactivity, and connectivity with environmental sensors. These must be addressed during the design-based research, in order to achieve a mature, easy-to-use and fully functional solution.

Considering the characteristics of the adopted methodological option, future work involves several cycles of analysing and testing the prototype and, after a functional and mature technological version, the organization of activities for game co-creation by the community, particularly educational stakeholders, as students and teachers. Afterwards, the games created through participatory dynamics need to be tested and explored in situ, so the project also organizes activities for the community to play them in the city. These experiences enlarge the creative, multi/interdisciplinary response that seeks to provide situated learning opportunities for all through the creation of participatory dynamics involving the academy and the community.

The design-based research does not only provide the design, implementation and evaluation of an intervention in practice [14]. This methodology is characterized by its dual outputs: one is the intervention and the other is a deepened theoretical understanding of phenomena associated with it, such as success factors and constraints. More specifically, the EduCITY contribution for the knowledge progress is, precisely, its innovative framework. As mentioned above, the framework is based on a grounded, participatory, and user-centred approach aiming the development of key competencies for sustainable development, by diverse citizen stakeholders. These sustainability competences development is supported by smart technology accessible to everyone in modern societies, such as mobile devices and AR, which allows moving Education from the classroom to a Smart City. This is anchored on a community-based participatory project integrating AR location games based on challenges, to be explored in the city, in formal, non-formal and informal educational contexts, in a social constructivism approach.

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