Advances in Intelligent Systems and Computing

Volume 1192

Series Editor
Janusz Kacprzyk, Systems Research Institute, Polish Academy of Sciences, Warsaw, Poland

Advisory Editors
Nikhil R. Pal, Indian Statistical Institute, Kolkata, India
Rafael Bello Perez, Faculty of Mathematics, Physics and Computing, Universidad Central de Las Villas, Santa Clara, Cuba
Emilio S. Corchado, University of Salamanca, Salamanca, Spain
Hani Hagras, School of Computer Science and Electronic Engineering, University of Essex, Colchester, UK
László T. Kóczy, Department of Automation, Széchenyi István University, Gyor, Hungary
Vladik Kreinovich, Department of Computer Science, University of Texas at El Paso, El Paso, TX, USA
Chin-Teng Lin, Department of Electrical Engineering, National Chiao Tung University, Hsinchu, Taiwan
Jie Lu, Faculty of Engineering and Information Technology, University of Technology Sydney, Sydney, NSW, Australia
Patricia Melin, Graduate Program of Computer Science, Tijuana Institute of Technology, Tijuana, Mexico
Nadia Nedjah, Department of Electronics Engineering, University of Rio de Janeiro, Rio de Janeiro, Brazil
Ngoc Thanh Nguyen, Faculty of Computer Science and Management, Wroclaw University of Technology, Wroclaw, Poland
Jun Wang, Department of Mechanical and Automation Engineering, The Chinese University of Hong Kong, Shatin, Hong Kong
The series “Advances in Intelligent Systems and Computing” contains publications on theory, applications, and design methods of Intelligent Systems and Intelligent Computing. Virtually all disciplines such as engineering, natural sciences, computer and information science, ICT, economics, business, e-commerce, environment, healthcare, life science are covered. The list of topics spans all the areas of modern intelligent systems and computing such as: computational intelligence, soft computing including neural networks, fuzzy systems, evolutionary computing and the fusion of these paradigms, social intelligence, ambient intelligence, computational neuroscience, artificial life, virtual worlds and society, cognitive science and systems, Perception and Vision, DNA and immune based systems, self-organizing and adaptive systems, e-Learning and teaching, human-centered and human-centric computing, recommender systems, intelligent control, robotics and mechatronics including human-machine teaming, knowledge-based paradigms, learning paradigms, machine ethics, intelligent data analysis, knowledge management, intelligent agents, intelligent decision making and support, intelligent network security, trust management, interactive entertainment, Web intelligence and multimedia.

The publications within “Advances in Intelligent Systems and Computing” are primarily proceedings of important conferences, symposia and congresses. They cover significant recent developments in the field, both of a foundational and applicable character. An important characteristic feature of the series is the short publication time and world-wide distribution. This permits a rapid and broad dissemination of research results.

**Indexing: The books of this series are submitted to ISI Proceedings, EI-Compendex, DBLP, SCOPUS, Google Scholar and Springerlink**

More information about this series at [http://www.springer.com/series/11156](http://www.springer.com/series/11156)
Michael E. Auer · Thrasyvoulos Tsiatsos
Editors

Internet of Things, Infrastructures and Mobile Applications
Proceedings of the 13th IMCL Conference
IMCL2019 was the 13th edition of the International Conference on Interactive Mobile Communication, Technologies and Learning.

This interdisciplinary conference is part of an international initiative to promote technology-enhanced learning and online engineering worldwide. The IMCL2019 covered all aspects of mobile learning as well as the emergence of mobile communication technologies, infrastructures and services and their implications for education, business, governments and society.

The IMCL conference series actually aims to promote the development of mobile learning to provide a forum for education and knowledge transfer, to expose students to latest ICT technologies and encourage the study and implementation of mobile applications in teaching and learning. The conference was also the platform for critical debates on theories, approaches, principles and applications of mobile learning among educators, developers, researchers, practitioners and policy-makers.

IMCL2019 has been organized by Aristotle University of Thessaloniki, Greece, from 31 October to 01 November 2019.

This year’s theme of the conference was “Internet of Things, Infrastructures and Mobile Applications”.

Again, outstanding scientists from around the world accepted the invitation for keynote speeches:

- Olga Viberg, KTH Royal Institute of Technology, Sweden: Supporting Self-Regulated Learning with Mobile Learning Analytics.
- Ralf Klamma, RWTH Aachen University, Germany: The Future of Learning and Teaching Augmented Reality – A European Perspective.
- Petros Nicopolitidis, Aristotle University of Thessaloniki, Thessaloniki, Greece: Security issues in Mobile Communications.
Furthermore, one very interesting workshop and one tutorial have been organized:

- Tutorial titled “A Gameful Approach Towards Tutors’ Professional Development on Mobile Learning and Interactive Blended Learning” by Anna Mavroudi (Norwegian University of Science and Technology, Norway) & Olga Viberg (KTH Royal Institute of Technology, Sweden).
- Workshop titled “5G Networks: Technologies, Challenges, Deployments and Demo” by Thrasyvoulos Spyropoulos (EURECOM, France), Kostas Tsagkaris (Inelligent/Wings ICT Solutions, Greece), Markos Anastasopoulos (University of Bristol, UK) & Evangelos Pikasis (Eulambia Advanced Technologies Ltd, Greece).

Since its the beginning, this conference is devoted to new approaches in learning with a focus to mobile learning, mobile communication, mobile technologies and engineering education.

We are currently witnessing a significant transformation in the development of working and learning environments with a focus on mobile online communication. Therefore, the following main topics have been discussed during the conference in detail:

- Mobile Learning Issues:
  - Dynamic learning experiences
  - Large-scale adoption of mobile learning
  - Performance support in the workplace
  - Ethical and legal issues
  - Assessment, evaluation and research methods in mobile learning
  - Mobile learning models, theory and pedagogy
  - Lifelong and informal learning using mobile devices
  - Open and distance mobile learning
  - Social implications of mobile learning
  - Design of adaptive mobile learning environments
  - Cost-effective management of mobile learning processes
  - Quality in mobile learning
  - Case studies in mobile learning
  - Interactive Communication Technologies and Infrastructures:
    - Wearables & Internet of Things (IoT)
    - Tangible, embedded and embodied interaction
    - Location-based integration
    - Cloud computing and future Internet research and experimentation (fire) environments
    - Emerging mobile technologies and standards
Interactive and collaborative mobile learning environments
Crowd sensing
5G network Infrastructure

Mobile Applications:
Smart cities
Online laboratories
Game-based learning
Mobile health care and training
Learning analytics
Mobile learning in cultural institutions and open spaces
Mobile systems and services for opening up education
Social networking applications
Mobile Learning Management Systems (mLMS)

The following special sessions have been organized:

Designing and Developing Mobile Serious Games for Augmenting Arts and STEM Competencies, Capabilities and Skills (DG-STEAM)
University–Industry–Cooperation in Mobile Technologies (UIC-MT)
Mixed Reality Applications for Industry and Education (MIRINDE)
Digital Technology in Sports Program Committee (DiTeS)
5G Wireless and Optical Technologies for Mobile Communication Systems (5G Fi-Wi for MC)
Social Networks and Mobile Applications for Health (SNMAH)
Interactive Learning Interfaces for Music Education (iLIME’2019)

Also, the "3rd IMCL International Student Competition for Mobile Apps” has been organized in the context of IMCL2019. The winning team of the competition presented “Magic-Matt, An Interface To Transform Video Games To A Sports Experience” and were composed by Nikolaos Politopoulos, Agisilaos Chaldogeridis, Hippokratis Apostolidis, Panagiotis Stylianidis, Angeliki Mavropoulou by Aristotle University of Thessaloniki, Greece, presenting the

As submission types have been accepted:
Full paper, short paper, distant/pre-recorded presentation
Work in progress, poster
Special sessions
Round-table discussions, workshops, tutorials and students’ competition

All contributions were subject to a double-blind review. The review process was very competitive. We had to review about 250 submissions. A team of about 160 reviewers did this terrific job. Our special thanks go to all of them.
Due to the time and conference schedule restrictions, we could finally accept only the best 105 submissions for presentation.
Our conference had again more than 175 participants from 31 countries. IMCL2021 will be held again at Aristotle University of Thessaloniki, Greece.

Michael E. Auer
IMCL Steering Committee Chair

Thrasyvoulos Tsiatsos
IMCL General Chair
Organization

Committees

Steering Committee Chair
Michael E. Auer CTI, Villach, Austria

General Conference Chair
Thrasyvoulos Tsiatsos Aristotle University of Thessaloniki, Greece

International Chairs
Samir A. El-Seoud The British University in Egypt, Africa
Neelakshi C. Premawardhena University of Kelaniya, Sri Lanka, Asia
Alexander Kist University of Southern Queensland, Australia, Australia/Oceania
Alaa Ashmawy American University Dubai, Middle East
David Guralnick Kaleidoscope Learning, New York, USA, North America

Technical Program Chairs
Ioannis Stamelos Aristotle University of Thessaloniki, Greece
Stavros Demetriades Aristotle University of Thessaloniki, Greece
Sebastian Schreiter IAOE, France

IEEE Liaison
Russ Meier IEEE Education Society Meetings Chair
Workshop, Tutorial and Special Sessions Chair
Andreas Pester  Carinthia University of Applied Sciences, Villach, Austria

Publication Chair
Sebastian Schreiter  IAOE, France

Local Organization Chair
Stella Douka  Aristotle University of Thessaloniki, Greece

Local Organization Committee Members
Christos Temertzoglou  Aristotle University of Thessaloniki, Greece
Vasiliki Peana  Aristotle University of Thessaloniki, Greece

Program Committee Members
Abul Azad  Northern Illinois University, USA
Achilles Kameas  Hellenic Open University, Greece
Agisilaos Konidaris  Technological Educational Institute of Ionian Islands, Greece
Alexander Chatzigeorgiou  University of Macedonia, Greece
Anastasios Economides  University of Macedonia, Greece
Anastasios Karakostas  Information Technologies Institute, Greece
Anastasios Mikropoulos  University of Ioannina, Greece
Andreas Veglis  Aristotle University of Thessaloniki, Greece
Apostolos Gkamas  University Ecclesiastical Academy of Vella of Ioannina, Greece
Barbara Kerr  Ottawa University, Canada
Carlos Travieso-Gonzalez  Universidad de Las Palmas de Gran. Canaria, Spain
Charalampos Karagiannidis  University of Thessaly, Greece
Christos Bouras  University of Patras, Greece
Christos Katsanos  Aristotle University of Thessaloniki, Greece
Christos Douligeris  University of Piraeus, Greece
Christos Georgiadis  University of Macedonia, Greece
Christos Panagiototakopoulos  University of Patras, Greece
Christos Pierrakeas  Technological Educational Institute (TEI) of Western Greece and Hellenic Open University, Greece
Cleo Sgouropoulou  Technological Educational Institute of Athens, Greece
Costas Mourlas  National and Kapodistrian University of Athens, Greece
Daphne Economou University of Westminster, UK
Demetrios Sampson University of Pireaus, Greece
Despo Ktoridou University of Nicosia, Cyprus
Dieter Wuttke Technical University Ilmenau, Germany
Dimitrios Kalles Hellenic Open University, Greece
Dimitris Alimisis Edumotiva, Greece
Dimitris Gouscos National and Kapodistrian University of Athens, Greece
Dionysios Politis Aristotle University of Thessaloniki, Greece
Doru Ursutiu University Transylvania Brasov, Romania
George Ioannidis Patras University, Greece
George Magoulas Birkbeck College, UK
George Palaigeorgiou University of Western Macedonia, Greece
Giasemi Vavoula University of Leicester, UK
Golberi S. Ferreira CEFET/SC, Brazil
Helen Karatza Aristotle University of Thessaloniki, Greece
Ioannis Vogiatzis Technological Educational Institute of Athens, Greece
Khitam Shraim Palestine Technical University, Palestine
Kostas Apostolou McMaster University, Canada
Maiga Chang Athabasca University, Canada
Manuel Castro Universidad Nacional de Educación a Distancia, Spain
Maya Satratzemi University of Macedonia, Greece
Maria Meletiou-Mavrotheris European University Cyprus, Cyprus
Michail Giannakos Norwegian University of Science and Technology, Norway
Michalis Xenos University of Patras, Greece
Minjuan Wang Shanghai International Studies University (Oriental Scholar); San Diego State University, USA
Monica Divitini Norwegian University of Science and Technology, Norway
Nektarios Moumoutzis Technical University of Crete, Greece
Nikolaos Avouris University of Patras, Greece
Nikolaos Samaras University of Macedonia, Greece
Nikolaos Tselios University of Patras, Greece
Panagiotis Bamidis Aristotle University of Thessaloniki, Greece
Panagiotis Petridis Aston University, UK
Panagiotis Politis University of Thessaly, Greece
Petros Lameras The Serious Games Institute, UK
Petros Nicopolitidis Aristotle University of Thessaloniki, Greece
Rhena Delport University of Pretoria, South Africa
Santi Caballé Open University of Catalonia, Spain
Stelios Xinogalos University of Macedonia, Greece
Stavros Demetriadis  Aristotle University of Thessaloniki, Greece
Stavros Nikou  University of Strathclyde, UK
Symeon Retalis  University of Piraeus, Greece
Tharenos Bratitsis  University of Western Macedonia, Greece
Ting-Ting Wu  National Yunlin University of Science and Technology, Taiwan
Vassilis Komis  University of Patras, Greece

3rd IMCL Student International Competition for Mobile Apps

**Chairs**

Andreas Pester  Carinthia University of Applied Sciences, Austria
Ioannis Stamelos  Aristotle University of Thessaloniki, Greece

**Judges**

Petros Nikopolitidis  Aristotle University of Thessaloniki, Greece
Teresa Restivo  University of Porto, Portugal
Ilias Trohidis  Tero Consulting, Greece
Athena Vakali  Aristotle University of Thessaloniki, Greece
George Palaigeorgiou  University of Western Macedonia, Greece
## Contents

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interactive and Collaborative Mobile Learning Environments</td>
<td></td>
</tr>
<tr>
<td><strong>Autism Serious Game Framework (ASGF) for Developing Games</strong> for Children with Autism</td>
<td>3</td>
</tr>
<tr>
<td>Geoffrey Gaudi, Bill Kapralos, Alvaro Uribe-Quevedo, Geoffrey Hall, and Diana Parvinchi</td>
<td></td>
</tr>
<tr>
<td><strong>LinkLearn: Blockchain Technology as a Learning Tool</strong></td>
<td>13</td>
</tr>
<tr>
<td>Dawid Benjamin Jordaan</td>
<td></td>
</tr>
<tr>
<td><strong>New Era of the Nano-Electronic Devices – One of the Most Adaptive Learning Areas for the Next Period</strong></td>
<td>25</td>
</tr>
<tr>
<td>Cristian Ravariu, Doru Ursutiu, Dan Mihaiescu, Alina Morosan, Mihai Tanase, and Thrasyvoulos Tsiatsos</td>
<td></td>
</tr>
<tr>
<td><strong>Open Source Online Conference System for Industry Experts Participation in Education</strong></td>
<td>36</td>
</tr>
<tr>
<td>Dan Robu, Radu Curpen, Daniel Ilie, and Titus Balan</td>
<td></td>
</tr>
<tr>
<td><strong>Interactive TV and Music Education</strong></td>
<td>45</td>
</tr>
<tr>
<td>Rafail Tzimas, Dimitrios Margounakis, Dionysios Politis, and Nektarios-Kyriakos Paris</td>
<td></td>
</tr>
<tr>
<td><strong>Assessment, Evaluation and Research Methods in Mobile Learning</strong></td>
<td></td>
</tr>
<tr>
<td><strong>An Analysis for the Identification of Use and Development of Game Design Strategies as Problem Posing Activities for Early Childhood Learners</strong></td>
<td>57</td>
</tr>
<tr>
<td>George Kalmpourtzis, Margarida Romero, Cindy De Smet, and Andreas Veglis</td>
<td></td>
</tr>
</tbody>
</table>
Measuring Knowledge Gains in an SMS m-Learning Intervention: The Case of ChildConnect South Africa
Nicky Roberts, Ingrid Mostert, and Lydia-Ann Plaatjies

Measuring Uptake and Engagement in an m-Learning Intervention: The Case of ChildConnect South Africa
Ingrid Mostert, Nicky Roberts, and Lydia-Anne Plaatjies

Development of a Classroom Response System: A Web-Based Approach Used in SEPT
Dan Centea, Konstantinos Apostolou, and Moein Mehrtash

Analysis of the Perception of Students of the Autonomous University of Baja California Sur for the Use of m-Learning
Jesús Andrés Sandoval Bringas, Mónica Adriana Carreño León, and Francisco Javier Alvarez Rodriguez

Work-in-Progress: Development of a Framework for Incorporating Usability Aspects with Digital Didactical Design for Mobile/Tablet Based Learning in Pre-primary Education
Uthpala Samarakoon and Hakim Usoof

Promoting Authentic Student Assessment for STEM Project-Based Learning Activities
Andri Vrioni, Anna Mavroudi, and Ioannis Ioannou

Predictive Modeling Concerning Mobile Learning Advance
Malinka Ivanova

Assessing Early Grade Mathematics Learner Outcomes Using m-Learning
Nicky Roberts

Users’ and Experts’ Evaluation of TARGET: A Serious Game for Mitigating Performance Enhancement Culture in Youth
Panagiotis Stylianidis, Agisilaos Chaldogeridis, Nikolaos Politopoulos, Vassilis Barkoukis, and Thrasyvoulos Tsiasatos

Poster: Exploring the Educational Affordances of an Academic ePortfolio for Engineer Students Through a Self-regulated Learning Framework
Foteini Paraskeva, Eleni Neofotistou, Angeliki Alafouzou, and Aikaterini Alexiou

Mobile Learning Models, Theory and Pedagogy

M-Health as a Tool in the Cognitive Flexibility of the Elderly
Cristina Páez-Quinde, Sonia Armas-Arias, Dorys Cumbe-Coraizaca, and Santiago Velastegui-Hernández
<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical Categorization of Android and IOS Applications Available</td>
<td></td>
</tr>
<tr>
<td>for STEAM Education in Early Childhood</td>
<td>178</td>
</tr>
<tr>
<td>Tharrenos Bratitsis, Michalis Ioannou, and George Palaigeorgiou</td>
<td></td>
</tr>
<tr>
<td>Museum Exhibits that Interact with Pupils’ Mobile Devices.</td>
<td></td>
</tr>
<tr>
<td>The Case of Hellenic Maritime Museum</td>
<td>189</td>
</tr>
<tr>
<td>Dimitris Rammos and Tharrenos Bratitsis</td>
<td></td>
</tr>
<tr>
<td>Can Elementary Students Co-design the Learning Content of</td>
<td></td>
</tr>
<tr>
<td>Educational Apps: The We!Design!Fractions Participatory Design</td>
<td>202</td>
</tr>
<tr>
<td>Approach</td>
<td></td>
</tr>
<tr>
<td>George Palaigeorgiou and Vasiliki Sidiropoulou</td>
<td></td>
</tr>
<tr>
<td>Pedagogical Considerations for Mobile-Based Augmented Reality Learning Environments</td>
<td>215</td>
</tr>
<tr>
<td>Betul Czerkawski and Margherita Berti</td>
<td></td>
</tr>
<tr>
<td>Machine Learning and Deep Learning: Recent Overview in Medical Care</td>
<td>223</td>
</tr>
<tr>
<td>Nour Elhouda Chalabi, Abdelouahab Attia, and Samir Akrouf</td>
<td></td>
</tr>
<tr>
<td>Learn to Code, an Interactive Application to Promote Mobile Student-Centred Learning</td>
<td>232</td>
</tr>
<tr>
<td>Anne-Gaelle Colom and Wendy Purdy</td>
<td></td>
</tr>
<tr>
<td>Emerging Technologies and Augmented Reality in the Development of</td>
<td></td>
</tr>
<tr>
<td>Learning and Human Potential</td>
<td>242</td>
</tr>
<tr>
<td>Barba Téllez María Nela, Pullas Tapia Paúl Santiago,</td>
<td></td>
</tr>
<tr>
<td>Mocha-Bonilla Julio Alfonso, and Morales Jaramillo María Belén</td>
<td></td>
</tr>
<tr>
<td>Open and Distance Mobile Learning</td>
<td></td>
</tr>
<tr>
<td>Level of Digital Literacies Among Austrian College Students Assessed</td>
<td></td>
</tr>
<tr>
<td>with an Online Survey</td>
<td>255</td>
</tr>
<tr>
<td>Anita Kloss-Brandstätter, Andreas Pester, and Gila Kurtz</td>
<td></td>
</tr>
<tr>
<td>A Gamified Educational Network for Collaborative Learning</td>
<td>266</td>
</tr>
<tr>
<td>Andrei B. B. Torres, Bill Kapralos, Alvaro Uribe-Quevedo, Enilda Zea Quero, and Adam Dubrowski</td>
<td></td>
</tr>
<tr>
<td>Dynamic Mobile Student Response System</td>
<td>276</td>
</tr>
<tr>
<td>Evangelos Sakkopoulos, Pantelis Krasadakis, Rozita Tsoni, and Vassilios S. Verykios</td>
<td></td>
</tr>
<tr>
<td>Poster: The Use of a Virtual Personal Assistant (FENNChat) as a</td>
<td></td>
</tr>
<tr>
<td>Platform for Providing Automated Responses to ODL Students’ Queries</td>
<td>289</td>
</tr>
<tr>
<td>at UNISA</td>
<td></td>
</tr>
<tr>
<td>Chaka Chaka and Tlatso Nkhobo</td>
<td></td>
</tr>
</tbody>
</table>
Poster: Proposal of an Intelligent Remote Tutoring Model .......... 297
Bounama Gueye, Amadou Dahirou Gueye, Assane Gueye, Omar Kasse, and Claude Lishou

A Comparative Study of Augmented Reality Platforms for Building Educational Mobile Applications ......................... 307
George Terzopoulos, Ioannis Kazanidis, Maya Satratzemi, and Avgoustos Tsinakos

M-Learning: Are We Ready to Go Mobile? ...................... 317
Ana M. B. Pavani and Guilherme P. Temporão

Framework for Automatic VPN Access to Remotely Discovered Resources .................................................. 327
Baboucar Diatta, Cherif Bachir Deme, Adrien Basse, and Samuel Ouya

Life-Long and Informal Learning Using Mobile Devices
Poster: Learn to Love My Grandchild Design-with-the-User ........ 339
Lydia-Anne Plaatjies

Enhancing Second Language Listening Skills Through Smartphones: A Case Study ............................................. 347
Mallikarjuna Sastry Mallampalli, V. Surya Seshagiri Anumula, and Sherine Akkara

Exposing Rural Indian Students to Mobile Assisted Language Learning: A Case Study ........................................ 357
Sherine Akkara, Mallikarjuna Sastry Mallampalli, and V. Surya Seshagiri Anumula

How Can Facebook Use in Education Be Realized as Crowdsourcing of Learning? an Exploration of Junior, Senior and Graduates Working Together .................................................. 367
Christiana Varda and Andri Ioannou

Concept of Digital Competences in Service Training Systems .... 379
Sergiy Bronin, Alexander Kuchansky, Andrii Biloshchytskyi, Olga Zinyuk, and Volodymyr Kyselov

Means of Cyber Security Aspects Studying in Maritime Specialists Education ..................................................... 389
Vladlen Shapo and Maksym Levinskyi

Evaluating a Coaching MOOC Course to Support Dual Career of Athletes ...................................................... 401
Thrasyvoulos Tsiatsos, Nikolaos Politopoulos, Panagiotis Stylianidis, Vasiliki Zilidou, Efthymios Ziaigkas, and Stella Douka
Wearables and Internet of Things (IoT)

LoRa Technology Benefits in Educational Institutes .......... 413
Apostolos Gkamas

Three IoT Wearables in Six European Cities! Reality and Perception ........................................ 425
Rasha Ibrahim, Holly Towndrow, and Dorothy Monekosso

Work-in-Progress: Designing an e-Coaching System for Chronic Heart Failure Patients .................................. 437
Evdokimos Konstantinidis, Niki Pandria, Antonis Billis,
Sophia-Anastasia Mouratoglou, and Panagiotis D. Bamidis

A Comparative Examination of AR and Video in Delivering Assembly Instructions .................................. 445
Kaija Petrone, Richard Hanna, and G. Shankaranarayanan

Wearable E-Textile as a Narrative Mediator for Enhancing Empathy in Moral Development ......................... 457
George Palaigeorgiou, Grigoria Vroikou, Charoumenou Nikoleta,
and Tharrenos Bratitsis

RSSI Fingerprinting Techniques for Indoor Localization Datasets .... 468
Angelos Chatzimichail, Athina Tsanousa, Georgios Meditskos,
Stefanos Vrochidis, and Ioannis Kompatsiaris

Multimedia Data Representation Based on Multi-image Concept .... 480
Yevgeniya Sulema, Abhishek Bhattacharya, and Niall Murray

Cryptographic Systems and Threats in e-Commerce ................ 492
Javier Sánchez Guerrero, Sandra Carrillo Ríos, Darwin García Herrera,
and Julio Mocha-Bonilla

Work in Progress. SportSWARES, Towards an Intelligent Way of Physical Training .................................. 507
Thrasyvoulos Tsiatos, Ippokratis Apostolidis, Nikolaos Politopoulos,
Agisilaos Chaldogeridis, and Ioannis Stamatos

Greek Traditional Dances Capturing and a Kinematic Analysis Approach of the Greek Traditional Dance “Syrtos” (Terpsichore Project) ........................................ 514
Efthymios Ziagkas, Vasiliki Zilidou, Andreas Loukouvitis, Styliani Douka,
and Thrasyvoulos Tsiasatos

Game Based Learning

Educational Mobile Applications on Computational Thinking and Programming for Children Under 8 Years Old .......... 527
George Terzopoulos, Maya Satratzemi, and Despina Tsompanoudi
Work-in-Progress: GameLet: Readers’ Theater in Media-Based Gamification for Reading Skills
Chrystalla Neofytou, Thanasis Hadzilacos, and Ute Massler

Students’ Experiences of Learning Mathematics Through Games Design
Wayne Gallear, Petros Lameras, and Craig Stewart

A Serious Game for Amplifying Awareness on Multimodal Teaching: Game Design and Usability Study
Petros Lameras, Stephanie Philippe, and Lars Oertel

Smart Citizens for Smart Cities –
Benjamin Stelzle, Anja Jannack, Torsten Holmer, Fabrice Naumann, Andreas Wilde, and Jörg Rainer Noennig

ADDventurous Rhythmical Planet: A 3D Rhythm-Based Serious Game for Social Skills Development of Children with ADHD
Marina Giannaraki, Nektarios Moumoutzis, Elias Kourkoutas, and Katerina Mania

The Design and Development of a Game-Based Approach to Entrepreneurship Education
Ian Dunwell and Petros Lameras

Interactive Serious Games for Cultural Heritage
Dimitrios Margounakis, Themistoklis Karalis, and Theodoros Iliou

Mobile Technologies Serious Games for the Development of Social Skills in Children with Autism Spectrum Disorders, in Enhanced with Socially Assistive Robots Interventions
Sofia Pliasa and Nikolaos Fachantidis

Creating Magic-Matt, An Interface to Transform Video Games to a Sports Experience
Nikolaos Politopoulos, Panagiotis Stylianidis, Ippokratis Apostolidis, Agisilaos Chaldogeridis, Angeliki Mavropoulou, and Thrasyvoulos Tsiatsos

Dynamic Learning Experiences

“The Greek Steelbook (TGS)” The Home of Steelbook Presentations
Nikolaos Giannoulopoulos, Dimitrios Kotsifakos, and Christos Douligeris

Poster: Determining a Network and Pedagogical Efficient Approach to Learning in Disruptive Environments
Collins Nnalue Udanor, Agozie H. Eneh, and Ogbonna U. Oparaku
<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>An Escape Room Game for Learning Digital Electronics in Vocational</td>
<td>664</td>
</tr>
<tr>
<td>Education and Training (VET)</td>
<td></td>
</tr>
<tr>
<td>Romanos Dochtsis, Dimitrios Kotsifakos, and Christos Douligeris</td>
<td></td>
</tr>
<tr>
<td>The e-Facilitator as a Key Player for Interactive Dissemination</td>
<td>675</td>
</tr>
<tr>
<td>of STEAM Resources for e-Learning via Webinar</td>
<td></td>
</tr>
<tr>
<td>Radoslav Yoshinov, Toni Chehlarova, and Monka Kotseva</td>
<td></td>
</tr>
<tr>
<td>Work-In-Progress: Interactive Lab Manuals and Videos for a Unit</td>
<td>687</td>
</tr>
<tr>
<td>Operations Course</td>
<td></td>
</tr>
<tr>
<td>Konstantinos Apostolou and Dan Centea</td>
<td></td>
</tr>
<tr>
<td>Towards a Learning Analytics Dashboard for Collaborative</td>
<td>693</td>
</tr>
<tr>
<td>Conversational Agent Activities in MOOCs</td>
<td></td>
</tr>
<tr>
<td>Stergios Tegos, Thrasyvoulos Tsiatsos, Georgios Psathas,</td>
<td></td>
</tr>
<tr>
<td>and Stavros Demetriadis</td>
<td></td>
</tr>
<tr>
<td>Interactive Educational Practices and Distance Learning: A Small</td>
<td>705</td>
</tr>
<tr>
<td>Connection with Mobile Learning and the Challenges of Deregulation</td>
<td></td>
</tr>
<tr>
<td>in Connectivity</td>
<td></td>
</tr>
<tr>
<td>Anastasios Nikiforos, Dimos Charidimou, and Ioannis Inglezakis</td>
<td></td>
</tr>
<tr>
<td>Mobile Systems and Services for Opening Up Education</td>
<td>717</td>
</tr>
<tr>
<td>Automatic Source Code Generation from Owl Pseudocode</td>
<td></td>
</tr>
<tr>
<td>Baboucar Diatta, Adrien Basse, Chérif Bachir Deme, and Samuel Ouya</td>
<td></td>
</tr>
<tr>
<td>Gamifying Early Foreign Language Learning</td>
<td>726</td>
</tr>
<tr>
<td>Eleni Korosidou and Tharrenos Bratitsis</td>
<td></td>
</tr>
<tr>
<td>Ontology-Based System for Automatic SQL Exercises Generation</td>
<td>738</td>
</tr>
<tr>
<td>Adrien Basse, Baboucar Diatta, and Samuel Ouya</td>
<td></td>
</tr>
<tr>
<td>Augmented Reality Application Based on Information Barcoding</td>
<td>750</td>
</tr>
<tr>
<td>Ivan Dychka, Olga Sulema, Anton Salenko, and Yevgeniya Sulema</td>
<td></td>
</tr>
<tr>
<td>Mobile Health Care and Training</td>
<td>765</td>
</tr>
<tr>
<td>Work in Progress: The Impact of the Project OnBoardMed</td>
<td></td>
</tr>
<tr>
<td>on Development of Study Courses in Maritime</td>
<td></td>
</tr>
<tr>
<td>Emergency Management</td>
<td></td>
</tr>
<tr>
<td>Inese Barbare</td>
<td></td>
</tr>
<tr>
<td>An Approach for Supporting Space Orientation of the Blind Using</td>
<td>773</td>
</tr>
<tr>
<td>Ontologically-Based Object Map</td>
<td></td>
</tr>
<tr>
<td>Dariusz Mikulowski and Marek Pilski</td>
<td></td>
</tr>
<tr>
<td>Soupa and Integration of Ontologies Verl for Conceptualizing</td>
<td>785</td>
</tr>
<tr>
<td>Contexts in Video Surveillance and Ubiquitous Computing</td>
<td></td>
</tr>
<tr>
<td>Susana Arias T, Xavier Arias, Claudia Cartuche, and Lozada J. Francisco</td>
<td></td>
</tr>
<tr>
<td>Title</td>
<td>Page</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>A Small Robotic Step for the Therapeutic Treatment of Mental Illnesses</td>
<td>800</td>
</tr>
<tr>
<td>Hector F. Gomez A, Diego Freire, Elena Malo, and Francisco Naranjo Cobo</td>
<td></td>
</tr>
<tr>
<td>The Use of Gamification in Evaluating Children’s Emotional Intelligence</td>
<td>806</td>
</tr>
<tr>
<td>Abbas Narimani, Ali Khaleghi, Hadi Haedar, and Farzad Semnani</td>
<td></td>
</tr>
<tr>
<td>Using Gamification Based on Mobile Platform in Therapeutic Interventions for Children with Dyslexia</td>
<td>814</td>
</tr>
<tr>
<td>Mahsa Behnamghader, Ali Khaleghi, Pegah Izadpanah, and Farzaneh Rahmani</td>
<td></td>
</tr>
<tr>
<td>Combined Approach to Diagnose ADHD: Gamifying Conners Rating Scale</td>
<td>825</td>
</tr>
<tr>
<td>Ali Khaleghi, Fatemeh Heydari, Maedeh Takhttavani, Hadi Haedar, and Alireza Soltaninezhad</td>
<td></td>
</tr>
<tr>
<td>Using Gamification Based on Virtual Reality Mobile Platform for Treatment of Adults with Amblyopia</td>
<td>836</td>
</tr>
<tr>
<td>Fateme Hosseinnia, Ali Khaleghi, and Kamran Mahmoudi</td>
<td></td>
</tr>
<tr>
<td>Linear Programming Model Applied to the Optimization of Nutritional Diets for Athletes</td>
<td>844</td>
</tr>
<tr>
<td>Julio A. Mocha-Bonilla, Victor Hugo Guachimbosa, Carolina Guachimbosa Santiago, and Javier Sánchez Guerrero</td>
<td></td>
</tr>
<tr>
<td>White Blood Cells Detection and Classification Using Convolutional Neural Network</td>
<td>867</td>
</tr>
<tr>
<td>Muaad Hammuda Siala, M. Samir Abou El-Seoud, and Gerard McKee</td>
<td></td>
</tr>
<tr>
<td>Work-in-Progress: The Use of Big Data and Data Analytics in the Prevention, the Diagnosis and the Monitoring of Long-Term Diseases</td>
<td>879</td>
</tr>
<tr>
<td>Oualid Mecili, Barkat Hadj, Farid Nouioua, Samir Akhrouf, and Rachid Malek</td>
<td></td>
</tr>
<tr>
<td>An Interactive Augmented Reality Volume Rendering Mobile Application</td>
<td>888</td>
</tr>
<tr>
<td>Amr S. Mady and Samir Abou El-Seoud</td>
<td></td>
</tr>
<tr>
<td>Design of an Accessible Web Portal for the Labor Insertion of People with Blindness</td>
<td>897</td>
</tr>
<tr>
<td>Javier Sánchez Guerrero, Julio Alfonso Mocha-Bonilla, Esmeralda Zapata-Mocha, and Sandra Carrillo Rios</td>
<td></td>
</tr>
</tbody>
</table>
Case Studies in Mobile Learning

MassiveLearning: Online Masterclass Course .......................... 911
Ndeye Massata Ndiaye and Cheikh Ahmadou Lamine Yakhine Diop

Touch Gesture Performance of Kindergarten Children in E-learning Applications: A Case Study in Sri Lanka .......................... 919
Uthpala Samarakoon and Hakim Usoof

Learning Diaries—A Valuable Companion of Mobile Learning for Higher Education in Software Engineering .......................... 930
Sigrid Schefer-Wenzl and Igor Miladinovic

A ‘Small and Thick’ Portrait of Kabelo’s Digital Play .................. 938
Shafika Isaacs

Use of the Fractal Analysis of Non-stationary Time Series in Mobile Foreign Exchange Trading for M-Learning .......................... 950
A. Kuchansky, A. Biloshchytksyi, S. Bronin, S. Biloshchytkska, and Yu. Andrashko

Work-in-Progress: SMART-WATER, a Novel Telemetry and Remote Control System Infrastructure for the Management of Water Consumption in Thessaloniki .......................... 962

Stefanos Xefteris, George Palaigeorgiou, and Helen Zoumpourtikoudi

TimeTracker App: Facilitating Migrants’ Engagement in Their Second Language Learning .......................... 983
Olga Viberg, Mohammad Khalil, and Gustav Bergman

“School – University – Industry” Cooperation .......................... 995
Doru Ursutiu, Cornel Samoila, Patrick Kane, Magdalena Ciurea, Mircea Stremtan, and Cristian Ravariu

PerFECt: A Performative Framework to Establish and Sustain Onlife Communities and Its Use to Design a Mobile App to Extend a Digital Storytelling Platform with New Capabilities .......................... 1002
Nektarios Moumoutzis, Alexandros Koukis, Marios Christoulakis, Ioannis Maragioudakis, Stavros Christodoulakis, and Desislava Paneva-Marinova
Exploring Impact of Olfactory Stimuli on User Performance on Mobile Platforms .................................................. 1015

Building a Virtualized Cybersecurity Lab ........................................... 1024
Titus Bălan, Dan Robu, Florin Sandu, and Alexandra Bălan

Work-in-Progress: Developing a Master Programme for Specialists in Industry 4.0 ............................................. 1033
Tom Savu and Andrei Dumitrescu

Teachers’ Perceptions Towards the Use of Mobile Augmented Reality .................................................. 1039
Christina Pasalidou and Nikolaos Fachantidis

NavMusApp: Exploring the Instrumental Continuum ......................... 1051
Dionysios Politis, Veljko Aleksić, Gregory-Telemachos Stamkopoulos, and Georgios Kyriaфинис

Developing Communities of Practice to Maximize the Usability and Impact of Clean Sport Education in Europe: IMPACT Project ... 1058
Lambros Lazuras, Antonia Ypsilanti, Vassilis Barkoukis, Panagiotis Stylianidis, Nikolaos Politopoulos, and Thrasyvoulos Tsiatsos

5G Network Infrastructure

A Fiber Wireless A-RoF/IFoF Uplink Transmission of up to 0.6 Gb/s User Data Rate Over a 32-Element 60 GHz Beam-Steering Antenna for 5G Fronthaul Networks .................................................. 1067
Eugenio Ruggeri, Apostolos Tsakyridis, Christos Vagionas, George Kalfas, Amalia Miliou, Nikos Pleros, and Yigal Leiba

An eHealth-Care Driven Perspective on 5G Networks and Infrastructure .................................................. 1076
Dimitrios Konstantinou, Simon Rommel, Alvaro Morales, Thiago R. Raddo, Ulf Johannsen, and Idelfonso Tafur Monroy

25 Gb/s Colorless Transmitter Based on Reflective Electroabsorption Modulator for Ultra-Dense WDM-PON Application ............... 1089
Kebede Atra, Giancarlo Cerulo, Jean-Guy Provost, Karim Mekhazni, Cosimo Calo, Frederic Pommereau, Carmen Gomez, Catherine Fortin, Jean Decobert, Florence Martin, Estelle Derouin, Christophe Caillaud, Didier Erasme, Cédric Ware, Franck Mallecot, and Mohand Achouche

Challenges of Using Phased Array Antennas in Commercial Backhaul Equipment at 26 GHz ............................................. 1101
Steven Caicedo, Matteo Oldoni, and Stefano Moscato
Predictive Modeling Concerning Mobile Learning Advance

Malinka Ivanova

College of Energy and Electronics, Technical University of Sofia, Sofia, Bulgaria
m_ivanova@tu-sofia.bg

Abstract. The paper treats an application of predictive modeling in the field of mobile learning. A methodology to facilitate the realization of a model predicting the most utilized research topics that are close to the term mobile learning is developed. The constructed model is based on machine learning technique and fuzzy logic method and it predicts the implementation of mobile learning in different educational context. The results point out the found dependency and tendency for future advance of mobile learning.

Keywords: Mobile learning · eLearning informatics · Machine learning · Linear regression · Fuzzy logic

1 Introduction

One brunch of eLearning Informatics as a scientific field explores the possibility of Informatics statements and theories how to be applied in the context of eLearning. Informatics attainments propose a huge pool of knowledge in different topics, including in modeling of concepts, events and processes in eLearning. Modeling algorithms and techniques contribute to better understanding the static and dynamic features of a system, preparing views from different perspectives. For the purposes of modeling a wide variety of machine learning approaches are utilized to automate identification of patterns and trends in the domain of teaching and learning [1]. Predictive modeling with machine learning algorithms allows complex systems to be explored and studied with opportunity of algorithms for self-learning and self-evolving. Predictive analysis facilitates understanding the challenging issues, assumptions permission and decision making based on precise data processing and training.

Mobile learning (mLearning) is seen as the future of eLearning proposing new virtual learning environment that stimulates students to learn from any geographical location and at suitable for them time [2, 3]. Mobile technology is also a driving force for open teaching achieving extreme flexibility and efficacy. eLearning imperceptibly converts to mLearning uncovering multiple advantages of mobile technologies like: devices portability and integration of smart functions, wearability and networking as well as its applications in different learning context. The state of mobile learning in Europe is summarized in [4], giving its main characteristics related to: bridging formal and informal learning, improving collaborative and conversational learning, stimulating self-directed and personalized learning.

© Springer Nature Switzerland AG 2021
https://doi.org/10.1007/978-3-030-49932-7_13
Predictive modeling based on machine learning techniques in mobile learning is well accepted approach for predicting the students’ performance and effectiveness, for identifying the students’ at-risk and their drop-out rate, to improve retention and engagement.

This work presents a methodology for forecasting the directions for evolvement of mobile learning and its relationships with contextual learning, based on extracted terms from abstract and citation database Scopus and construction and visualization the bibliographic networks as well as applying linear regression and fuzzy logic techniques. A model based on the proposed methodology is created to predict the future state of mLearning and its further implementation in a wide variety of scenarios and situations.

2 Methodology

This methodology is developed to facilitate the implementation of a predictive model concerning the mLearning evolvement in order to point out the well explored topics and topics that need more attention by researchers. The methodology consists of the following procedures: I. Data extraction from abstract and citation database Scopus and construction of bibliometric networks through usage of VOSviewer software for scientific visualizations.; II. Creation of preparatory matrixes with extracted terms containing information about terms’ occurrences in the used set of documents and the terms’ total link strengths as well as the dependences between occurrences and year of publication.; III. Applying linear regression algorithm to forecast the effect of changes in the term’s occurrences and the term’s total link strengths during eleven consecutive years – from 2008 year to 2018 year as well as to predict the trends trough utilization of Octave software for numerical computations.; IV. Constructing a fuzzy inference system (FIS) through usage of software VisPro for predicting the connection of the term mobile technology to the terms teaching and learning.

I Procedure: Data extraction and bibliometric networks construction.

1. Gathering data about the term mLearning. The starting point is query construction in Scopus search engine regarding the keyword mobile learning (and its equivalents keywords mLearning and m-learning) and performance of results limitation according to documents relevance, year of publication – consecutive eleven years – from 2008 to 2018 year, document type – conference paper, article and review, source type - conference papers and journals, language – English. The query is applied to search in Article title, Abstract and Keywords of documents. The obtained bibliographic results (citation information, bibliographical information and abstract and keywords) separately for each year are exported in csv format.

2. Construction of bibliometric networks. To find the connections among the term mLearning and other extracted terms the bibliometric networks over the selected years separately are constructed. For this purpose the exported .csv file from Scopus is imported in VOSviewer [5]. Several settings are adjusted like: type of analysis is chosen to co-occurrence and unit of analysis is selected to all keywords. The applied method is full counting and minimal numbers of occurrences of a keyword.
is limited to 5. A co-occurrence link between two terms shows the number of documents that at the same time include these both terms. Just one link connects two terms. Each link characterizes with a strength that is defined with a positive number. The strength is greater when the number of co-occurrences is higher. Full counting method takes into account the assigned number of occurrences of a keyword in documents. Then the software calculated the total strength of the co-occurrence links from one term to other terms through text-mining method and linguistic filtering. The result is a list with terms and assigned weights related to frequency of occurrences and total links strength. The final set with terms is used for creation of bibliometric network that presents the terms, links and distance among them.

II Procedure: Creation of preparatory matrixes.
The preparatory matrices for each year and for every extracted term with values of occurrences and total links strength are prepared for machine learning analysis in Octave software. Two types of data files are created. The first type of data files contains measurements of occurrences and total links strength. The y-values are occurrences of a keyword in documents and x-values are total links strength corresponding to the occurrences. The second type of data files points out the x-values which are the years and y-values show the corresponding occurrences.

III Procedure: Building a predictive model forecasting the effect of changes in the terms regarding the values of occurrences and total link strengths and dependences between years and occurrences.

Applying Supervised Learning. The sets with the preparatory matrices are used for input data to Octave software. The linear regression algorithm with gradient descent is applied to the training sets according to the equations [6]:

\[ y = \beta_0 + \beta_1 x + \epsilon, \]  
\[ \hat{y} = \hat{\beta}_0 + \hat{\beta}_1 x, \]

where \( \beta_0 \) is a coefficient that represent the intercept and \( \beta_1 \) is the coefficient showing the slope, \( \epsilon \) is the error.

The prediction of the future \( y \) value is based on \( x \) value:

\[ \hat{y} = \hat{\beta}_0 + \hat{\beta}_1 x, \]

where \( \hat{\beta}_0 \) and \( \hat{\beta}_1 \) are estimated coefficients for the model.

The residual sum of squares RSS is:

\[ RSS = e_1^2 + e_2^2 + \cdots + e_n^2 = (y_1 - \hat{\beta}_0 + \hat{\beta}_1 x_1)^2 + (y_2 - \hat{\beta}_0 + \hat{\beta}_1 x_2)^2 + \cdots + (y_n - \hat{\beta}_0 + \hat{\beta}_1 x_n)^2, \]
To minimize the residual sum of squares $RSS$, the coefficients $\hat{\beta}_0$ and $\hat{\beta}_1$ are chosen to be: 

$$\hat{\beta}_1 = \frac{\sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^{n} (x_i - \bar{x})^2}$$

and

$$\hat{\beta}_0 = \bar{y} - \hat{\beta}_1 \bar{x},$$

where $\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i$ and $\bar{y} = \frac{1}{n} \sum_{i=1}^{n} y_i$ are samples.

**IV Procedure:** Construction of a fuzzy inference system for predicting the context of mobile learning usage.

The FIS is created for predicting the context of mobile technology usage: for teaching, learning or both. It is an important issue describing the most common exploitation of mobile technology – whether mobile technology mainly supports teachers or mainly facilitates learners or the applied scenarios are balanced, assisting at equal level the teachers and learners. The numerical data of the extracted terms during the whole examined period with VOSviewer software are used as input for FisPro software. The last one is utilized for FIS construction with three input values: mobile technology, teaching and learning and one output value: context. All values (input and output) are defined using standardized fuzzy partitioning approach that is described through the following equation:

$$\mu_{A_j}(x) = \frac{x}{x},$$

where $x$ is a point from a fuzzy set $A$ with a membership degree $0 \leq \mu_A(x) \leq 1$, $A_j$ are fuzzy sets formed after partitioning, $\mu_A$ is the membership function [7]. The created fuzzy standardized partitions are characterized with linguistic variables that are chosen to be: very low, low, average, high and very high. The Mamdani conjunctive fuzzy rules are applied in the following form:

$$\text{IF } x_1 \text{ is } A^i_1 \text{ AND } x_2 \text{ is } A^i_2 \text{ AND ... AND } x_n \text{ is } A^i_n \text{ THEN } y_1 \text{ is } B^i_1,$$

where $A^i_1, A^i_2, \ldots A^i_n$ and $B^i_1$ are fuzzy sets that present the input and output space partitioning.

The utilized rule aggregation concerns disjunction of defined conjunctive rules and it is described through the $\max$ operation:

$$W^j = \{\max(w_r(x)) | C^r = j\}$$

for $\forall j = 1, 2, \ldots, m$ and where $r$ is the number of rules, $m$ is the number of labels of the partitioned space.

3 Creating a Predictive Model

For identification of the key terms connected to the main explored term $mLearning$ (mobile learning, m-learning) the software for scientific visualizations VOSviewer is exploited. The extracted terms with their corresponding values of occurrences and total link strengths are classified in tables for each year. Table 1 is just one example showing the selected terms with non-zero values of occurrences ($O$) and total link strengths.
for 2018 year. The Table 2 includes the values of occurrences and total link strengths of the term mLearning during the explored years – from 2008 to 2018 year. Similar tables to Table 2 containing data for the extracted terms are used as data sources for performance of linear regression algorithm. The constructed bibliometric network for the term mLearning, pointing out its connection to the other terms and the strength of each connective link, is presented on Fig. 1.

Table 1. Connected terms to the term mLearning in 2018 year

<table>
<thead>
<tr>
<th>mLearning in context</th>
<th>O</th>
<th>TLS</th>
<th>mLearning in context</th>
<th>O</th>
<th>TLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>mLearning</td>
<td>506</td>
<td>1886</td>
<td>Collaborative/Cooperative learning</td>
<td>12</td>
<td>49</td>
</tr>
<tr>
<td>eLearning</td>
<td>252</td>
<td>1394</td>
<td>Experimental learning</td>
<td>5</td>
<td>34</td>
</tr>
<tr>
<td>Engineering education</td>
<td>43</td>
<td>290</td>
<td>Adaptive learning</td>
<td>7</td>
<td>33</td>
</tr>
<tr>
<td>Higher education</td>
<td>34</td>
<td>165</td>
<td>Online learning</td>
<td>7</td>
<td>35</td>
</tr>
<tr>
<td>Learning through augmented reality</td>
<td>34</td>
<td>164</td>
<td>Ubiquitous learning</td>
<td>21</td>
<td>92</td>
</tr>
<tr>
<td>Game-based learning</td>
<td>28</td>
<td>154</td>
<td>Interactive learning</td>
<td>7</td>
<td>43</td>
</tr>
<tr>
<td>Personalized learning</td>
<td>7</td>
<td>39</td>
<td>Secondary schools</td>
<td>5</td>
<td>32</td>
</tr>
<tr>
<td>Learning in virtual reality</td>
<td>18</td>
<td>112</td>
<td>Distance education</td>
<td>5</td>
<td>23</td>
</tr>
<tr>
<td>Language learning</td>
<td>15</td>
<td>63</td>
<td>Informal learning</td>
<td>9</td>
<td>38</td>
</tr>
<tr>
<td>Technology enhanced learning</td>
<td>14</td>
<td>84</td>
<td>Flipped classroom</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Problem-based learning</td>
<td>5</td>
<td>25</td>
<td>MOOC</td>
<td>13</td>
<td>77</td>
</tr>
<tr>
<td>Blended learning</td>
<td>12</td>
<td>66</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Occurrences and total link strengths for the term mLearning during the examined period

<table>
<thead>
<tr>
<th></th>
<th>2018</th>
<th>2017</th>
<th>2016</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>O</td>
<td>TLS</td>
<td>O</td>
<td>TLS</td>
</tr>
<tr>
<td>2018</td>
<td>506</td>
<td>1886</td>
<td>433</td>
<td>1985</td>
</tr>
<tr>
<td>2014</td>
<td>442</td>
<td>1902</td>
<td>383</td>
<td>1580</td>
</tr>
<tr>
<td>2010</td>
<td>463</td>
<td>2423</td>
<td>326</td>
<td>1779</td>
</tr>
</tbody>
</table>

The results after applying the algorithm for linear regression for selected terms are summarized through graphics on Fig. 2. The created patterns with trained data express the usage of the terms and show the future trends. The constructed approximate lines are characterized with intersect and slope which parameters talk about the usage state of a given term at the examined period and about the frequency of the term usage during the years. For example, if a comparison related to the usage of mobile learning in context of learning through augmented reality and learning through games is
performed, then the analysis shows very close *intersect* and *slope* coefficients that reflect on the similar line steepness. It leads to the conclusion that the topics related to mobile learning through augmented reality and games take the similar attention of researchers, including these terms in their publications. Also, the lines steepness is positive that outlines an increasing tendency for utilization of these terms in the scientific production.

The summarized results after applying linear regression method to the extracted terms indicate one positive tendency of the research topics concerning mobile learning.

The detailed analysis of the gathered data for 2018 year outlines that the mobile learning is explored in different context and multiple learning scenarios. The highest interest addresses the connection between mLearning and eLearning. Then the explorations are focused on applications of mLearning in engineering education, Higher education, learning through augmented reality, game-based learning, ubiquitous learning, learning in virtual reality, language learning, technology enhanced learning, MOOC, blended learning, collaborative/cooperative learning, informal learning, adaptive learning, online learning, personalized learning, interactive learning. The small number of research papers connects mLearning to problem-based learning, flipped classroom, experimental learning, distance education and learning in secondary schools. With zero values of *occurrences* for 2018 year are the terms: elementary schools, learning through web 2.0 technologies, seamless learning, life-long learning, inquiry-based learning, situated learning, authentic learning, outdoor learning, workplace learning, self-regulated learning/self-directed, pervasive learning, intelligent tutoring, micro-learning.

**Fig. 1.** Bibliometric network for the term *mLearning* for 2018 year
Fig. 2. Results from linear regression
In order to understand the future utilization of mobile technology for teaching and learning, a FIS is constructed with 125 rules and the part of the inference is shown on Fig. 3. The terms mobile technology, learning, and teaching are examined for the period of eleven years – from 2008 to 2018 year. The final result shows different usage of the terms teaching and learning in the context of mobile learning during the examined years. The extracted tendency is that the term mobile technology will be closer to the term learning than to the term teaching. Also, according to the selected values of the terms teaching and learning in the constructed FIS, could be found a solution that is closer to teaching or to learning as well as an approach for balanced utilization of mobile technology in teaching and learning.

The surface view regarding the FIS response at two input variables mobile technology and learning is presented on Fig. 4. The red color indicates the minimum of the output value corresponding to the input values.

![Fig. 3. The constructed fuzzy inference system](image)

![Fig. 4. The FIS response with surface view](image)

4 Conclusion

The current research uses extracted terms from Scopus bibliographic data to describe the current state regarding the connection between the term mobile learning and other examined terms as well as to find the tendency concerning the future of mobile learning.
implementation. For these purposes the machine learning algorithm of linear regression and fuzzy logic method are utilized. Also, a research methodology and a predictive model are developed. The finding point out that the term mobile learning is closer to the terms eLearning, engineering education, higher education, learning through augmented reality, game-based learning, ubiquitous learning and with big distance from the term mobile learning are the terms: cooperative learning, environmental education, elementary education, secondary education, experimental learning, location-based learning. The found tendency about the usage of the term mLearning in scientific publications is characterized with an increasing line. Also, the term mobile learning is better connected to the term learning that to the term teaching.

The proposed methodology and created predictive model are useful for: (1) gathering results about challenging issues and its further understanding, (2) for hypothesis construction and its acceptance/rejection and (3) for decision making taking account the found tendency. In the context of this work, the reached findings outline the more explored topics by researchers and the tendency of their examination during the years. Such findings can give orientation to teachers and researchers about the current state and can indicate the future directions for research.

Acknowledgements. The author would like to thank the Research and Development Sector at the Technical University of Sofia for the financial support.

References

7. FisPro : An open source portable software for fuzzy inference systems (2013). https://pdfs.semanticscholar.org/7b90/9ffe94ed60af8a76a1b09d603ef007d0facb.pdf