

Learning and Analytics in Intelligent Systems

Volume 29

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Handbook on Intelligent Techniques in the Educational Process

Vol 1 Recent Advances and Case Studies

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Preface

As one of the crucial sectors of society, education has a substantial impact on almost all other sectors. Different computer-supported educational systems have been developing for many decades with the intention to make the process of teaching and learning easier and more convenient in modern, dynamic society. Influences of rapid development of ICT and other related technologies on developing more and more quality, sophisticated educational systems are unavoidable and evident. Societal challenges to further development of educational systems for different domains, purposes, and levels of education are manifold and are not limited only to specific situations like the recent one connected to the COVID-19 pandemic.

Over the years, the use of e-learning and tutoring systems brought numerous advantages and benefits over the traditional teaching methods. Research efforts are focused on improving the overall performances and functionalities of these systems further employing emergent technologies. Attention is especially paid to the design of e-learning architectures that support adaptability to students' personal needs and learning habits. In the last decade, the architectures that offer a high level of personalization and intelligent services and provide support to improve the motivation of learners, and better learning outcomes are dominant.

Nowadays, intensive development and wide applications of AI techniques and approaches significantly influence the educational sector and the development of a range of sophisticated intelligent educational systems. We are witnessing that the future of education is coupled with technologies and their advancements. The applications of AI in educational processes are numerous starting from intelligent tutoring systems (ITS), smart learning environments, towards the use of virtual and augmented reality and robots.

Artificial Intelligence has the potential to address some of the biggest challenges in education today, but also in the future in order to establish innovative teaching and learning practices, and ultimately accelerate the progress and performance of learning.

This book presents a collection of 17 chapters that bring interesting aspects of the state-of-the-art of application of intelligent techniques in different educational processes and settings. Chapters are focused on describing the variety of approaches in diverse educational domains and levels of education; discuss their capabilities, benefits, and possible limitations in practical use.

We hope that the works presented in the book will be of interest to readers, will motivate our colleagues and researchers to apply presented and similar approaches, try to enhance them, and propose better and more advanced solutions.

Chapter 1 “Current Trends in AI-based Educational Processes—An Overview” by Mirjana Ivanović, Aleksandra Klačnja-Milićević, Marcin Paprzycki, Maria Ganzha, Costin Bădică, Amelia Bădică, and Lakhmi C. Jain is an introductory one and considers the influence of modern artificial intelligence techniques on educational processes. The authors focus on providing an overview of the current state-of-the-art of developing intelligent educational systems that have significant effects on learning and teaching processes. Recent works that put light on different roles of AI in developing educational systems are discussed: Adaptive personalization systems and intelligent tutoring systems, assessment and evaluation of students’ outcomes, and the benefits and the challenges of educational data mining and learning analytics.

Chapter 2 “Digitalization of Education”, by Đorđe Nadrljanski, Mila Nadrljanski, and Mira Pavlinović is focused on diversity and features of concepts and initiatives for digitalization in education. The advantages and challenges related to the development of digitalized environments in education, as well as the greater need for professional development of people working in digitalization, are discussed. In addition, they encourage and promote innovation in many different spheres of life. They stated that there is a very strong link between education and skills needed to utilize digital technologies in different sectors of society. The very important conclusion is that digitalization is an important tool for making fundamental changes in the processes, content, and various forms of work in educational settings to increase the quality and relevance of education for all.

Chapter 3 “Remote Teaching and Learning Math in English Through CLIL” by Maria Guida and Letizia Cinganotto focuses on teaching Mathematics by using umbrella methodology CLIL (Content and Language Integrated Learning). Authors investigate the opportunities and challenges of CLIL in Mathematics in remote and hybrid settings due to the pandemic. Examples of repositories, web tools, digital boards used by teachers for remote CLIL teaching are presented as a way to foster students’ engagement, interaction, and interactivity. Despite the problems due to the pandemic, the teachers in Italy were able to deliver adequate content in a meaningful way, using problem-based or project-based learning. Communication and interaction among the students and with the teachers through the discussion, explanation, and negotiation of the different CLIL activities are discussed.

Chapter 4 “The Potential of Artificial Intelligence for Assistive Technology in Education” by Katerina Zdravkova discusses the important aspects of the incorporation of assistive technology in education. It is evident that persons with various disabilities should have an equal access to quality education, and chapters show

how assistive technologies support such persons to keep and improve their functioning, which reinforces inclusive education. Further, the chapter presents a plethora of AI-supported educational tools intended to help people with special needs and elderly people, encompassing the tools for visual, hearing, communication, intellectual, cognitive, and motor impairment. Additionally, some ethical challenges of AI-supported educational tools are raised.

In Chap. 5 “Adaptive and Intelligent Web-Based Learning and Control Technologies”, Valery M. Kaziev, and Lyudmila V. Glukhova considered the current problem of evolution of adaptive and intelligent technologies of modern education and their influence on the digital infrastructure of educational environments. The purpose of their study is an evolutionary system analysis of the digital opportunities for the effective development of the information and educational space of universities from the Russian model of competence-oriented education. They proposed the formal, mathematical model of adaptive learning decision-making. Key methods, approaches, and technologies of adapting and intellectualizing web learning are considered including didactic aspects. The authors also investigated the issues of self-organization, web education, their adaptation to digital transformations in society, the environment of the educational system and proposed a list of basic intelligent web learning technologies.

The next, Chap. 6 “Exemplar Use-cases for Training Teachers on Learning Analytics” by Arvind W. Kiwelekar, Manjushree D. Laddha, and Laxman D. Netak provide ready-to-use examples for conducting teachers training programs on Learning Analytics. More precisely, the chapter documents a set of exemplars used to demonstrate LA applications in daily classroom activities. These exemplars have been designed and used mainly to train newly recruited teachers on data analysis methods (such as hypothesis testing, analysis of variance (ANOVA), correlation analysis, and regression analysis) during faculty induction programs.

Chapter 7 “Impact of Lesson Planning on Students’ Achievement using Learner Profile System” by Munazza A. Mirza, Khawar Khurshid, Zawar Shah, Faryal Shah, Andrew Levula, and Aleksandra Klačnja-Milićević proposed and evaluated a Learner Profile System, which is a web-based solution to generate multiple types of learner profiles. The profiles include the basic information about the learners, preference and interest profile, learning styles, and motivational goal orientation. The pilot study included 60 middle school students to measure the construct validity and reliability. Afterward, an experimental study was done on 307 middle school students to examine the impact of LPS on learners’ achievement. Teachers’ perception and their perspective regarding the feasibility and use of the LPS is also considered. The authors concluded that the group that learned using the LPS demonstrated significant improvement in their assessment scores in comparison to the controlled group.

Peter Ilic in the Chap. 8 “Towards an Understanding of Student Digital Ecosystems for Education” put attention to the use of ICT for educational purposes. The chapter sheds light on this issue and takes an initial step towards mapping students’ digital ecosystems to enable course design that better fits student learning expectations. Further, different methods were employed to obtain a better understanding of the

participants' degree of technological adoption and practice in relation to collaborative educational activities. Insight into the structure of Japanese university students' digital ecosystems was developed by capturing and analyzing participant activity in log data. The author presented several key findings that may help curriculum designers in improving their courses. Also, he considered the effects of students shifting between device types (mobile and non-mobile) depending on the context and purpose. The overall results, as well as implications for education, were discussed, along with suggestions for possible future research.

Different applications and challenges of computational argumentation for modeling distinct aspects of learning processes are presented in Chap. 9 "Computational Argumentation for Supporting Learning Processes: Applications and Challenges" by Carlos Chesñevar, César A. Collazos and Ana Maguitman. The chapter is devoted to argument-based recommender systems for educational purposes; argument-based shared knowledge for computer-supported collaborative learning and argument-based opinion mining for eliciting students' knowledge based on information items corresponding to different topics of study. The current state-of-the-art in the domain is also briefly presented. It also gives a good starting point for researchers working on intelligent techniques for educational processes who are interested in incorporating argumentation as a metaphor for modelling intelligent decision making in Intelligent Tutoring Systems and Computer-Supported Collaborative Learning systems.

Chapter 10 "Revealing Latent Student Traits in Distance Learning through SNA and PCA" by Rozita Tsoni, Evangelos Sakkopoulos, and Vassilios S. Verykios considers significant issues in a distance learning postgraduate course. The authors proposed a novel approach based on learning analytics. The approach is based on a rich spectrum of metrics of Social Network Analysis that can capture complicated interaction of social students' behavior, along with academic performance indicators, in a process that aims to reveal the latent characteristics of students participating in the discussion fora.

Chapter 11 "Smart Technology in the Classroom: Systematic Review and Prospects for Algorithmic Accountability" by Maria Ovchinnikova, Daniel Ostnes, Arian Garshi, Malin Wist Jakobsen, Jørgen Nyborg-Christensen, and Marija Slavkovik brings a comprehensive review of the use of smart technologies in the classroom. The authors explored the state-of-the-art literature in several emergent subdisciplines: wearables, AI and education, school surveillance, accountability, and so on. Both positive and negative effects of using smart technologies are pointed out, and a framework to effectively identify accountability for smart technology in education is proposed.

Automated grading is the central topic of the Chap. 12 "Objective Tests in Automated Grading of Computer Science Courses: An Overview" by Marin Lujak, Marija Slavkovik, Alexis Lebis, Mathieu Vermeulen, and Arnaud Donie. Authors analyzed and mutually compared the most used objective tests in computer science courses in Moodle and MOOCs and outlined the advantages, technical limitations, and ethical challenges. Test feedback mechanisms that facilitate continuous learning for students as well as the identification and recognition of possible evaluation mistakes of the

system of AI-supported methods for automating objective tests in programming are considered. Special attention is paid to the identification and mitigation of the context-specific ethical challenges and essential characteristics of tests.

Chapter 13 “Correlating Universal Design of Learning and the Performance in Science at Elementary School Level” by Munazza A. Mirza, Khawar Khurshid, Asma Hasan, Zawar Shah, and Faryal Shah is devoted to the essence of universal design of learning. The authors’ study aims to investigate the impact on a learner’s academic performance when a teacher uses the Universal Design of learning framework for planning science lessons. A framework based on the constructivist theory, built on cognitive neuroscience emphasizes engaging multiple brain networks by providing guidelines organized into three essential principles is presented. The experiments are conducted to discover the effectiveness of the UDL-based lesson implementation in science and a quasi-experimental pre-test and post-test design was used in the study. Authors found that elementary school pupils achieve better grades in science when taught using a universal design of learning approach in contrast to those who have been taught using traditional teaching method.

Next, the Chap. 14 “Facilitating Collaborative Learning with Virtual Reality Simulations, Gaming and Pair Programming” by Piia Näykki, Janne Fagerlund, Minna Silvennoinen, Mari Manu, Tuula Nousiainen, Merja Juntunen, and Mikko Vesisenaho brings to readers an interesting and emerging trend in educational settings. Authors presented socio-interactional functions that support collaborative learning through three case examples. The examples are based on the use of technology-enhanced simulation-based learning environments, Vive/Minecraft applying virtual and mixed reality and pair programming in a creative media project design with Scratch. These powerful experiential learning contexts provide engaging opportunities for collaborative learning.

“Gamification and the Internet of Things in Education” is the title of Chap. 15 authored by Georgios Pappas, Joshua Siegel, Ioannis N. Vogiatzakis, and Konstantinos Politopoulos. As gamification and the Internet of Things can impact education in a manner previously impossible, gamified tools built upon game engines can offer opportunities in the development of innovative virtual labs and other interactive experiences for students. The authors designed and developed a training gamified tool applied in the field of environmental studies. They showed how this is integrated with the Internet of Things to enable triggers in a virtual 3D space. Additionally, they also provided information on how this innovation has been used in a real distance-learning class for Master’s degree students.

Chapter 16 “Communication-Driven Digital Learning Environments: 10 Years of Research and Development of the Campus Platform” by Luís Pedro and Carlos Santos underlines the Campus platform and the importance of communication concepts and affordances in the research and development of a digital learning environment. They argued the approach that values the social construction of knowledge, the importance of networks, collaboration, and sharing in educational processes. Apart from that, the evaluation study of the platform is presented, which allowed to characterize it as an open communication ecosystem for effective dialogue, participation, and engagement.

The last Chap. 17 “Educational Computer Games and Social Skills Training” by Margarita Stankova, Daniela Tuparova, Polina Mihova, Tsveta Kamenski, Georgi Tuparov, and Krista Mehandzhiyska considers the aspects of Autism spectrum disorders (ASD) in the context of technology-enhanced learning. The application of educational computer games aiming to improve the emotional understanding of children with ASD is presented. A specific game is modeled based on emotional intelligence and four focus areas: perceived emotions, use of emotions to facilitate thought, understanding emotions, and managing emotions. Additionally, the chapter discusses the principles of game development and presents data collected from the pilot testing with two groups of children: typically developing and children with ASD. The proposed approach would widen the opportunities for the children to establish and build relationships with peers, be better accepted in society, and reach an improved functional level.

This book would not have existed without the tremendous contribution of the authors and the reviewers. We remain grateful.

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