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Digital Twin Integration in Engineering Pedagogy: Navigating the Challenges and Opportunities of Education 4.0 through Process Simulate

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Abstract

The rapid evolution towards Industry 4.0 has created a significant pedagogical gap in engineering education, requiring students to master complex cyber-physical systems before accessing physical laboratory infrastructure. This paper addresses the "new changes and challenges" in higher education by evaluating the integration of Digital Twin technology as a primary instructional tool. Using a Project-Based Learning (PBL) framework, this study analyzes the implementation of Siemens Process Simulate within a Digital Manufacturing curriculum. The research monitors a

cohort of engineering students as they transition from theoretical layouts to high-fidelity virtual commissioning. The methodology focuses on how virtual environments can overcome physical laboratory constraints, such as high equipment costs and safety risks. Quantitative analysis reveals a 22% increase in academic performance and a significant improvement in spatial visualization and systemic thinking compared to traditional CAD-based methods. However, the study also identifies critical "new challenges," including cognitive overload due to software complexity and the necessity for continuous faculty upskilling to maintain technological relevance. The findings demonstrate that Digital Twins offer "endless opportunities" for experiential learning, allowing students to experiment, fail, and optimize in a risk-free virtual space. This approach effectively aligns academic outcomes with industrial requirements, proposing a scalable model for modernizing engineering education in the digital era.

Keywords: Education 4.0, Digital Twin, Process Simulate, Engineering Pedagogy, Virtual Commissioning, Educational Challenges.

Building Bridges between Researchers and Pupils: Finding Future Chemists through the "Science for Future Researchers: Experiments and Knowledge" Project

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Abstract

Currently, pupils have access to a variety of sources and resources from which they can obtain the necessary information for completing homework, carrying out school projects, or enhancing their knowledge. However, conducting demonstrative or individual experiments, especially in subjects where they are indispensable - such as chemistry – is essential in order to arouse their curiosity, help them better understand processes that take place at the molecular level, and to encourage them to pursue a career in research in the future. To achieve this, chemistry classes must be held in laboratories, accompanied by practical examples. Unfortunately, the laboratories in Romanian middle and high educational institutions have often been converted into classrooms, or the necessary infrastructure is deficient or completely absent. On the other hand, research in Romania

is deficient in attracting young talents, with an acute shortage of funding and modern equipment, even though research is a key pillar of a country. The project *Science for Future Researchers: Experiments and Knowledge*, which received funding from the Romanian Ministry of Education through UEFISCDI, aims to create a bridge between scientists (researchers in the field of chemistry) and students from educational units in the Bucharest-Ilfov area by offering them the opportunity to visit the specialized research laboratories of the project consortium and to participate in workshops, demonstrative experiments, debates or lectures organized right in their classrooms. Although the project is still ongoing, the feedback received so far from pupils and their teachers is positive, highlighting the importance of the practical application of theoretical knowledge acquired in class.

Keywords: chemistry, researcher, pupil, scientific experiments, research laboratory visits

Exploring the Role of Virtual Reality in Physical Education for Stress Adaptation Among Adolescents in Socio-Political Crisis Settings

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Abstract

Physical education can serve as more than a motor domain. In unstable social environments, it can also function as a structured context for emotional regulation, controlled challenge, and resilience-oriented learning. The present quantitative experimental study examined cardiovascular stress reactivity during a single-session virtual reality protocol embedded in a secondary-school physical education setting. Fifty high school students aged 15-19 years participated (25 males, 25 females). After a resting baseline assessment, each participant completed a time-pressured virtual fire emergency task followed by a standardized 5-minute AimXr combat-survival challenge. Heart rate was monitored continuously with a Mi Band 6 wearable, and the primary physiological outcomes were resting heart rate, minimum heart rate, average heart rate, maximum heart rate. In addition, a composite performance score was derived from cardiovascular and task-performance indicators. The findings indicated clear cardiovascular activation during virtual exposure, with average heart rate increasing substantially from pre-exposure baseline to task performance. The primary physiological outcomes were resting heart rate, minimum heart rate, average heart rate, and

maximum heart rate. Average heart rate showed a weak-to-moderate positive association with performance score. This finding suggests that greater cardiovascular engagement was modestly related to better task performance, but it should be interpreted cautiously because the study did not formally test a curvilinear model. The result may be discussed conceptually in relation to the Yerkes-Dodson framework, but it does not provide direct evidence of an inverted-U relationship. The results support the educational use of supervised virtual reality in physical education as a safe means of rehearsing decision-making, self-regulation, and stress adaptation in adolescents living under conditions of heightened uncertainty.

Keywords: virtual reality, physical education, cardiovascular response, adolescent resilience, socio-political crisis.

JEL Classification: I.

Bullying Awareness and Prevention in a Multicultural University Context: Student Adaptation in Cluj-Napoca

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Abstract

This paper examines bullying awareness and prevention in a multicultural university context, focusing on students' adaptation to a new cultural environment in Cluj-Napoca, Romania. Although bullying has been widely documented in schools, less attention has been paid to how it is perceived and addressed in higher education, where mobility and diversity are strongly present. Babeș-Bolyai University (UBB), as a large academic centre attracting students from different regions of Romania and from abroad, provides a relevant context for exploring how everyday interactions, communication practices and institutional messages shape students' understanding of bullying.

The study aims to investigate how students define and recognize bullying, how they experience or witness it in academic and social settings, and how they evaluate existing prevention and awareness efforts. Particular attention is paid to differences between local students and those who relocate to Cluj-Napoca, often encountering a new cultural, linguistic and social environment. The research also explores how factors such as perceived belonging, openness to diversity and trust in university structures relate to students' willingness to seek help or report bullying situations.

Methodologically, the paper is based on a questionnaire survey conducted among undergraduate and postgraduate students enrolled in several faculties at UBB in Cluj-Napoca. The instrument includes items on perceptions of bullying prevalence, personal or observed experiences, bystander reactions, attitudes towards diversity and inclusion, and perceived accessibility of support services

and reporting mechanisms. Descriptive and comparative analyses are used to identify patterns and differences among student groups.

Preliminary insights highlight the role of communication in facilitating or hindering adaptation and in shaping bullying awareness. Students who report a lower sense of belonging and limited social networks appear more vulnerable to subtle forms of exclusion and more hesitant to report negative experiences. At the same time, many respondents indicate a preference for clear, student-centred communication strategies, peer-led initiatives and online campaigns that address bullying and discrimination in relatable language. The paper discusses implications for designing more inclusive, culturally sensitive prevention and awareness programmes in higher education, with a focus on strengthening institutional communication, student engagement and support structures at UBB.

Keywords: Bullying prevention, Student adaptation, Multicultural university context, Communication strategies, Higher education.

Education as a Tool for Civic Participation in the Danube Region

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Abstract

Education has always played multiple roles for both individuals and society. In today's world, education is no longer limited to the transmission of knowledge, but has also become a fundamental tool for promoting civic participation and engagement, especially in regions marked by cultural diversity and shared challenges, such as the Danube Region.

This paper explores the capacity of educational systems to encourage civic engagement among students, highlighting how universities in the Danube Region actively integrate civic engagement into their curricula or provide platforms and facilitate student involvement in community-based initiatives. The analysis is complemented by a survey conducted among students in the Danube region exploring their perceptions and experiences related to education and civic engagement.

The findings emphasize the potential of civic participation to promote pathways to unity and mutual understanding across multicultural communities in the Danube Region, while also offering strategic recommendations for improving civic engagement through education.

The topic is particularly relevant, given the importance of civic participation for sustainable development in the region, but also at the EU level, as well as the need to involve citizens as much as possible in decision-making processes and to promote intercultural dialogue.

This study is limited by the availability and accessibility of data from the various key stakeholders, particularly universities within Danube region.

Keywords: education, students, civic participation, Danube Region, universities

JEL Classification: I21, D72, P16, R58

Supporting School Readiness through Intensive Summer Programs: Evidence from an Emergent Literacy Intervention

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Abstract

This study examines the effectiveness of an intensive summer program designed to support school readiness through the development of emergent literacy in preschool children. Using a pre-experimental pre-test/post-test design, 16 preschoolers participated in a two-week intervention including structured daily activities such as guided reading, phonological awareness tasks, and graphomotor exercises.

Emergent literacy was assessed through a multidimensional instrument covering vocabulary, print knowledge, letter recognition, phonemic awareness, early writing, and story comprehension, alongside measures of visual attention and instruction comprehension.

Results indicate significant improvements in emergent literacy and visual attention following the intervention. However, substantial individual variability was observed. Gains in literacy were not consistently associated with improvements in visual attention, suggesting that executive functions – operationalized through instruction comprehension – may play a more important role in mediating learning outcomes.

These findings support a multidimensional perspective on emergent literacy and highlight the importance of integrating cognitive factors into intensive summer programs aimed at enhancing school readiness. The study provides preliminary empirical evidence for the effectiveness of short, structured interventions in early childhood education.

Keywords: school readiness, emergent literacy, intensive summer programs, executive functions, early childhood education

JEL Classification: I21, I24

Feedback in Technical Higher Education

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Abstract

Feedback is an important tool in all activities, used to improve communication, relationships, and performance. In educational environments, its role is to facilitate interaction between students and teachers, helping clarify expectations, correct misunderstandings, and guide learning processes. Its effectiveness depends not only on its presence but also on how it is perceived by students in terms of clarity, relevance, and usefulness. This paper investigates student perspective of feedback based on a custom-designed questionnaire applied among 125 students from different domains of a technical faculty, focusing on the aforementioned aspects. The results indicate that feedback is relatively clear, but less effective in supporting learning, and it is not provided frequently. Despite this, students express a relatively strong desire for more feedback. We also made a cluster analysis, which reveals three distinct student profiles. The largest group consists of engaged students who receive frequent, clear, and effective feedback. A second group includes students who receive limited and low-quality feedback but express a strong desire for improvement. The third group is characterized by disengaged students who perceive feedback as ineffective and show little interest in receiving more.

Keywords: cluster analyses, feedback, higher education, student perspective, technical faculty

Open-Source Technologies for Industrial Robotics Education in Industry 4.0

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Abstract

This paper addresses a gap in the current literature, namely the absence of a systematic, educationally oriented comparative framework for open-source robotics simulation platforms in the context of Industry 4.0 curricula. While platforms including Gazebo, Webots, and CoppeliaSim are widely used in academic settings, no consolidated study has evaluated them simultaneously against criteria specific to educational environments, such as ease of use, hardware accessibility, pedagogical resource availability, and alignment with ROS 2. Using a multi-criteria evaluation framework applied across four dimensions, specifically ROS 2 integration, ease of use, hardware accessibility, and availability of pedagogical resources, this paper systematically compares Gazebo, Webots, and CoppeliaSim as primary simulation platforms, with contextual references to emerging tools including NVIDIA Isaac Sim and MuJoCo (Multi-Joint dynamics with Contact). The evaluation is grounded in the specific requirements of engineering education programmes targeting Industry 4.0 competencies, where students must acquire practical robotics skills without direct access to industrial hardware. The results indicate that no single platform is optimal across all educational contexts. Webots offers the lowest barrier to entry and is most suitable for introductory courses, while Gazebo, being tightly coupled with ROS 2, is recommended for advanced undergraduate and graduate-level instruction. CoppeliaSim, through its educational license and modular scripting architecture, provides unique advantages for teaching control

systems concepts. The paper concludes with a proposed learning pathway for progressive integration of open-source tools across an academic robotics curriculum, along with practical recommendations for laboratory setup and course design.

Keywords: engineering education, simulation-based learning, active learning, competency-based education, virtual laboratory, curriculum design, open-source tools, robotics pedagogy, Industry 4.0 education.

Interdisciplinary Curriculum Reform: Integrating Sustainability and Employability in Higher Education

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Abstract

Universities worldwide face the twin challenges of preparing students for an increasingly uncertain employment landscape and enabling them to be agents of change in the world's sustainability transition. This paradigm of disciplinary silos has led to graduates with narrow but deep expertise, unsuited to the "wicked" problems of the 21st century. The paper proposes a conceptual model and design guidelines for interdisciplinary higher education curriculum reform that holistically incorporates sustainability literacy and postgraduate employability. The research, drawing on constructivist pedagogies, competency-based learning, and empirical data from higher education reform experiments, contends that integrating social-scientific inquiry, digital literacy, and sustainability ethics into the curriculum increases student motivation and employability. The new Sustainability-Employability Nexus (SEN) Model structures curriculum along three interlinked dimensions: systems thinking and ecological literacy; digital and data skills for sustainable development goals; and ethical leadership and multicultural collaboration. The case-study data show that graduates from SEN reforms are more likely to gain employment in mission-driven organizations and score higher on problems of interdisciplinary character. The paper also addresses the institutional challenges of reform, such as rigid accreditation standards, faculty pushback, and budget shortfalls, and offers governance principles for adapting the model to a variety of higher-education settings.

Keywords: Interdisciplinary curriculum, sustainability education, employability, higher education reform, digital literacy.

Unpacking Class Unevenness in University Teaching: Deconstructing Hidden Curricula

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Abstract

Universities are usually identified as meritocratic institutions that reward efforts of talent regardless of their social origin. Yet underneath formal curricula and defined learning outcomes, a hidden curriculum operates, transmitting social norms, cultural codes, and behavioural expectations that systematically benefit students from middle and upper-class socio-economic backgrounds. Therefore, this research attempts to examine how implicit pedagogical practices, linguistic conventions, assessment cultures, and socio-politico-spatial norms in higher education institutions perpetuate socio-economic divides. By employing Pierre Bourdieu's concepts of habitus and cultural capital and Paulo Freire's framework of critical pedagogy, the paper analyses three key sites of class unevenness: the unspoken expectations of educational discourse, the deficit of low-income rural-class experience in prescribed curricula, and the performative norms embedded in classroom participation culture. The present research proposes selected critical pedagogical interventions, including dialogical teaching, reflexive curriculum design, and culturally responsive assessment mechanisms that educators could adopt to dismantle mechanisms of hidden curricula. The deficit of rural-peri-urban background students' experiences result in "objectification" that refers to the experiences of rural/peri-urban students perceiving their own communities as merely objects of study rather than sources of knowledge.

The argument is not merely emphasizing universities to acknowledge socio-economic diversity, but there should be an active reconstruction of their pedagogical architectures that recognise, validate, and build upon the diverse knowledge that all students bring with them.

Keywords: hidden curriculum, class unevenness, critical pedagogy, cultural capital, higher education, Bourdieu, Freire, socio-economic equity, habitus.

Bilingual Teaching in Geography: Effects on Students' Motivation and Academic Performance in Secondary Education

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Abstract

The growing interest in multilingual education has encouraged schools to explore new ways of combining subject teaching with foreign language learning. In this context, the present paper discusses the possible impact of bilingual teaching on students' motivation and academic achievement in secondary Geography classes. Particular attention is given to the CLIL (Content and Language Integrated Learning) approach, which allows learners to study school subjects while using a foreign language as a means of communication. The paper combines theoretical perspectives with a proposed methodological framework designed for future classroom implementation. The research focuses on how the integration of English into Geography lessons may influence students' participation, classroom interaction, motivation, and understanding of geographical concepts. The proposed methodology includes classroom observation, interactive learning activities, assessment tasks, and the use of bilingual instructional materials adapted to secondary education. In addition, digital resources such as interactive maps, visual presentations, and multimedia materials may support both language learning and geographical understanding. The anticipated findings suggest that bilingual Geography instruction may contribute to increased learner motivation, more active participation during lessons, and improved communication skills in English. At the same time, CLIL-based activities may support the development of transferable competences such as collaboration, critical thinking, and intercultural awareness. The paper also discusses possible challenges related to language proficiency, instructional planning, and classroom implementation while emphasizing the educational value of bilingual teaching approaches in Geography education.

Keywords: CLIL, bilingual education, Geography education, student motivation, academic performance

From Cheating to Competence: A Pedagogical Framework for Reimagining Machine Translation in Higher Education

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Abstract

The rapid advancement of Neural Machine Translation (NMT) and Large Language Models (LLMs) has sparked a crisis of academic integrity in Higher Education, particularly in Foreign Language departments. Traditional pedagogical models often categorize the use of tools like DeepL or ChatGPT as "cheating," a view that increasingly conflicts with the demands of the global professional market. This paper proposes a paradigm shift from prohibition to Machine Translation Literacy (MTL).

Using a "Human-in-the-Loop" (HITL) instructional design within English Linguistics and Practical Language courses, this study explores how the student's role evolves from a passive learner to a critical evaluator. The proposed framework replaces traditional rote translation with a three-tiered educational process: collaborative drafting, diagnostic post-editing (error taxonomy), and sociolinguistic critique. Preliminary observations indicate that this approach promotes high-level metacognitive skills, as students must justify linguistic choices that the AI fails to make.

Rather than diminishing rigor, the integration of AI into the curriculum fosters "translingual competence," transforming the classroom into a laboratory for critical thinking. The paper concludes that by embracing AI, educators can move beyond the "cheating" narrative to cultivate the sophisticated analytical skills essential for the modern researcher.

Keywords: Machine Translation Literacy, Post-Editing, Academic Integrity, Higher Education Pedagogy, Applied Linguistics, Human-in-the-Loop.

Students' Use of AI Tools in Music Learning: A Preliminary Study

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Abstract

The growing use of artificial intelligence (AI) in education has also influenced music learning, offering students new possibilities for study, practice, and creativity. Although AI tools are increasingly accessible, their actual use in music education remains insufficiently documented. This preliminary study explores how university music students use AI tools in their learning process. A total of 36 questionnaires were administered to undergraduate students in music programs (Transilvania Univeristy of Brasov, Romania). The survey investigated frequency of use, preferred platforms, purposes of use, and students' perceptions regarding the benefits and limitations of AI technologies. The results indicate that students mainly use AI tools for quick explanations, idea generation, research support, practice guidance, and study organization. The findings highlight the growing presence of AI in music education and suggest the need for responsible pedagogical integration that supports learning while preserving critical thinking, creativity, and essential musical skills.

Keywords: artificial intelligence, music education, higher education, student learning.

AI Literacy in Education across Regulatory Frameworks: A Comparative Analysis of the European Union, United States and China

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**The views and opinions expressed in this paper are solely those of the author and are made in a strictly private capacity.*

They do not reflect the official policy or position of the European Parliament, any of its bodies, services, Members, political groups or committees. The author does not act on behalf of, or in the name of, the European Parliament.

Abstract

AI literacy is no longer just an educational objective or an individual competence. State authority now uses it as a governance framework to manage risks and assign accountability for AI use in education. Yet, current literature continues to frame the concept almost entirely around user competence and ethical boundaries. This leaves its growing institutional role, specifically how it acts as a mechanism for legal responsibility, largely unexamined. To address this gap, the article examines how AI literacy is defined, framed, and translated into educational responsibility across three important, yet different governance models: the European Union, the United States and China. These frameworks were selected because they represent three different approaches to AI literacy governance in education: a legal-compliance model in the European Union, a decentralised, and incentive-based model in the United States, and a centralised, state led model in China.

Through a qualitative comparative analysis of legal texts, official guidelines, and education-specific policy documents, the study analyses how the same concept is assigned different regulatory and educational functions across three jurisdictions. The findings prove that AI literacy extends far beyond personal skills and competences, and it now operates primarily as a mechanism

of institutional governance, fundamentally reshaping educational policy, teacher liability, and algorithmic responsibility.

Keywords: AI literacy, AI governance, education policy, responsible AI, AI regulation, European Union, United States, China

Predictors of Teacher Burnout Across Career Stages: Evidence from the Romanian Educational Context

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Abstract

The emergence of burnout among teachers represents a major international concern, being associated with reduced teacher well-being, lower levels of engagement, and poorer educational outcomes among students. Although extensive research has examined the phenomenon of burnout, relatively few studies have addressed the relationship between its predictors and teachers' stages of professional development. In this context, the present study investigates the extent to which burnout predictors vary across stages of the teaching career within the Romanian pre-university education system.

The study adopts a quantitative design based on a sociological survey using a questionnaire, administered to a sample of 194 teachers. The variables analyzed include organizational factors (role overload, learning opportunities, and development opportunities), transactional factors (satisfaction of basic psychological needs for autonomy, competence, and relatedness), and individual factors (distress reactivity and stress mindset). These variables are examined in relation to the dimensions of burnout. Data were analyzed using multiple regression analysis, conducted separately for each career stage. The results indicate that burnout predictors vary depending on professional stage, with certain variables exerting stronger effects in the early stages of the career, while others become more relevant in later stages. These differences suggest the need for differentiated interventions tailored to the specific developmental needs of teachers at each stage of their professional trajectory.

This study contributes to the literature by highlighting the dynamic nature of burnout across the teaching career and offers relevant implications for educational policies and teacher support programs.