Teaching in the Digital Age: An Open Educational Platform as a Digital Teaching Tool

Eva Muchová, Bratislava University of Economics and Business, Slovakia
Peter Leško, Bratislava University of Economics and Business, Slovakia

The Asian Conference on Education 2025
Official Conference Proceedings

Abstract

The ongoing digital transformation of higher education has intensified the demand for accessible, and adaptable teaching tools, particularly in economics. This paper presents *Learn Economics* (learneconomics.euba.sk), an interactive open educational platform developed to support teaching and learning the principles of microeconomics and macroeconomics in the Slovak language. The platform integrates short instructional videos, interactive graphs, case studies, self-assessment tests, and complementary reference materials in order to foster independent learning, and enhance student motivation. Empirical insights are drawn from questionnaire-based feedback collected from university students, complemented by descriptive usage analytics of the platform. In addition, the platform is positioned within a comparative overview of selected international digital resources used in economics education. The findings indicate that multimedia-based platforms can effectively complement traditional approach and provide a flexible framework for online and hybrid education in economics.

Keywords: higher education, digital teaching tool, educational platform

iafor
The International Academic Forum
www.iafor.org

Introduction

The current generation of university students is shaped by a socio-economic environment profoundly influenced by rapid technological change. Digital technologies form an integral part of students' everyday lives, particularly in communication, entertainment, gaming, and leisure activities. Consequently, contemporary students are accustomed to interactive, multimedia-rich environments and increasingly expect similar characteristics within the educational process.

In economics education, this trend is reflected in the widespread use of textbooks supplemented by online learning platforms. Leading economics textbooks are routinely accompanied by digital environments such as CourseSmart (Samuelson & Nordhaus), LaunchPad (Mankiw), or MyLab Economics (Acemoglu, Blanchard, Parkin). These platforms provide structured online support aligned with textbook content and include a wide range of multimedia and interactive tools, including instructional videos, applied tasks, quizzes and tests and blogs. Such resources offer significant benefits for both students and instructors by supporting self-paced learning and enhancing conceptual understanding.

The importance of digital educational tools became particularly evident during the COVID-19 pandemic, which caused the largest disruption of education systems in modern history. According to the United Nations (2020), nearly 1.6 billion learners in more than 190 countries were affected by school closures, impacting up to 94% of the global student population. Millions of pupils, secondary and university students were forced to replace face-to-face instruction with various forms of distance learning. These disruptions resulted in measurable learning losses, with potentially long-term consequences for human capital formation.

The pandemic also transformed the role of teachers, who were required to adapt rapidly to online and hybrid modes of instruction. At the university level, this period accelerated the transition toward blended and digitally supported teaching. However, the effectiveness of such formats depends critically on the availability of well-designed, pedagogically grounded, and easily accessible digital learning materials that support both students and instructors.

The paper focuses on open multimedia educational platforms as a tool for innovative approaches to teaching economics in higher education. The paper discusses the rationale for integrating open educational platforms into the teaching process and situates them within broader trends in activating and digitally supported teaching methods. The final section presents a Slovak-language online platform focused on the teaching of the principles of economics, providing a practical example of how digital tools can be implemented in university-level economics education.

Methodology

The paper is based on mixed-methods with the aim to provide an empirically grounded and practice-oriented analysis of digitally supported teaching methods in economics education.

Empirical data were collected through a questionnaire survey conducted among undergraduate students at the Bratislava University of Economics and Business (BUEB) in June 2020. The survey focused on students' perceptions of the teaching of introductory economics, preferred forms of instruction, perceived learning difficulties, and expectations regarding innovative and

digitally supported teaching methods. The questionnaire included both closed-ended and open-ended questions, allowing for the collection of quantitative data as well as qualitative insights.

Quantitative data from the questionnaire were analysed using descriptive statistics in order to identify general trends and patterns in students' responses. Qualitative data obtained from open-ended questions were analysed through thematic interpretation, providing contextual understanding of students' recommendations and attitudes towards economics education.

In addition to the questionnaire survey, the paper presents descriptive usage analytics from the online platform. The analysis of usage statistics serves to identify user preferences and patterns of interaction with different types of digital learning content.

The empirical findings are complemented by a qualitative comparative review of selected international educational platforms used in economics education, including MyLab Economics, CORE Econ, Exploring Economics, and Khan Academy. This comparison focuses on platform design, types of educational content, and pedagogical orientation, and serves to situate the locally developed platform within broader trends in digitally supported and activating teaching methods.

Innovative Approaches to Education

This section draws on selected empirical and theoretical studies in higher education pedagogy in order to contextualise innovative and digitally supported teaching approaches relevant to economics education.The teaching of introductory economics at the authors' home university is, in some student groups, characterised by relatively low motivation to acquire new knowledge. In many cases, learning is reduced to fulfilling minimum course requirements, primarily through compulsory literature prescribed in the course syllabus. This situation highlights the need for teaching approaches that not only transmit knowledge, but also stimulate student engagement and foster a deeper understanding of fundamental economic principles and concepts.

In contemporary educational theory, teaching methods are commonly divided into two broad categories: traditional (conventional) methods and innovative (activating) methods. Traditional teaching approaches focus primarily on the transmission of content. The teacher acts as the central authority and the main source of knowledge, while students assume a largely passive role, receiving theoretical information through lectures or assigned readings.

In contrast, innovative and activating approaches emphasise student involvement and active participation in the learning process. Their primary objective is to transform static, monological teaching into a dynamic and interactive form that naturally engages students and increases their interest in the subject matter. These methods aim to create meaningful connections between theory and practice, enabling students to better understand and apply economic concepts in real-world contexts.

The use of activating methods also reshapes the relationship between teachers and students. While the teacher retains a guiding and coordinating role, greater space is provided for student activity, self-realisation, and independent thinking. Activating approaches encourage collaboration, enabling students to work together on problem-solving exercises, or case studies. As a result, students develop not only subject-specific knowledge, but also transferable skills such as communication and presentation abilities, the capacity to articulate and defend their

own opinions, and creative and critical thinking skills. Critical thinking, in particular, involves the ability to acquire information, evaluate its relevance and reliability, and identify logical and objective relationships.

Student engagement can be significantly enhanced through the systematic introduction of innovation into the educational process. Innovative teaching methods support cognitive development and positively influence students' perception of learning itself. In economics education, core principles can be presented in ways that resonate with a generation immersed in social networks and digital technologies (Angelo & Cross, 1993; Clerici-Arias, 1994; Delemeester et al., 2000).

In higher education, pedagogical approaches that combine digital technologies with activating learning strategies are becoming increasingly prominent. Among the most widely discussed are the flipped classroom model and the broader concept of blended learning, both of which respond to the need for increased student engagement and more effective knowledge acquisition in the context of digital transformation (Van Alten et al., 2019). The flipped classroom model shifts the acquisition of theoretical content outside the classroom, typically through digital study materials, while contact teaching time is devoted to discussion, problem solving, and the application of knowledge. A meta-analysis by Van Alten et al. (2019) demonstrates that flipped classrooms are associated with higher student learning outcomes when face-to-face instructional time is not reduced compared to traditional classroom settings, or when quizzes are incorporated into the flipped classroom design.

More recent research supports these findings. A meta-analysis by Bredow et al. (2021), drawing on evidence from 317 studies, shows that compared to traditional lecture-based instruction, flipped learning has positive effects on academic performance with small to moderate effect sizes. There is considerable variability in the effectiveness of flipped learning, largely influenced by educational context. A systematic literature review by Divjak et al. (2022) examines the use of online flipped classroom approaches in higher education during the COVID-19 pandemic. The authors find that instructors and institutions with prior experience in face-to-face or blended flipped classrooms were more successful in transferring this model to fully online environments.

In addition to the flipped classroom, the literature also emphasizes challenge-based learning, which focuses on addressing authentic problems and explicitly linking theoretical knowledge with practical application. A systematic review by Leijon et al. (2022) analyses research on Challenge-Based Learning (CBL) in higher education. Based on studies published between 2009 and 2020, the review documents a shift of CBL from a concept originally introduced by a multinational technology company for school education to an approach increasingly adopted in higher education as a means of transforming adult learning.

Overall, trends in quality education suggest that continuous improvement in higher education can only be achieved through systematic innovation in the teaching and learning process, while respecting international standards. Ongoing advances in information and communication technologies create new opportunities to enhance teaching effectiveness and offer students diverse forms of learning and knowledge acquisition. In this process, the teacher plays a crucial role as an innovator who actively implements and adapts new methods to the educational context.

Students' Opinions on the Teaching of Economics

At the authors' home university, courses focused on the fundamentals of economics are perceived as among the most demanding subjects in the first level of university study. These courses are traditionally associated with relatively high failure rates, particularly among first-year students. Despite these difficulties, an internal survey conducted among students (Kálovec, 2017) revealed a seemingly paradoxical finding: students are aware of the importance of economics courses and expressed interest in them even if they were offered as optional subjects. This result suggests that the main challenge does not lie in a lack of perceived relevance of economics, but rather in the way the subject matter is taught and communicated.

To gain deeper insight into students' perceptions of economics teaching, an anonymous questionnaire survey was conducted at all faculties of the BUEB (Muchová & Leško, 2020). A total of 429 students participated in the survey, out of 1,351 students who were invited to respond. The majority of respondents (67.8%) were first-year students, while nearly 30% were second-year students enrolled in the first level of study. With respect to prior education, more than half of the respondents were graduates of grammar schools (four- or eight-year programmes), and approximately 32% had graduated from business academies.

The questionnaire consisted of 36 questions and focused on several key areas: a comparison of traditional classroom teaching with distance or online teaching, identification of areas requiring improvement in economics education, and detection of topics in introductory economics that students find particularly difficult to understand.

The results indicate that traditional face-to-face lectures are still perceived as a suitable and effective method for mastering the principles of microeconomics and macroeconomics. Up to 62% of respondents expressed a preference for this form of instruction, confirming that even among digitally oriented students, personal contact with teachers and peers remains an important component of the educational process. At the same time, 33% of respondents stated that they could imagine participating in online lectures delivered via platforms such as Microsoft Teams. Other acceptable forms of instruction included the provision of lecture materials by teachers and access to recorded video lectures. In addition, 11.2% of students reported using private tutoring as a supplementary form of learning during their studies.

Another group of questions focused on areas that should be emphasised during lectures. Students' responses were highly consistent: the most frequently expressed recommendation was to place greater emphasis on the practical application of knowledge and on linking theoretical concepts with real-world economic practice. Other commonly mentioned suggestions included the use of case studies, enhanced online communication, online submission of assignments, and the systematic provision of study materials through educational platforms.

Several questions addressed the organisation and content of seminars. More than 63% of respondents identified the lack of illustrative examples as a major weakness of seminar-based teaching. Students expressed a strong preference for more interactive forms of instruction, greater use of online communication tools, easier access to study materials via platforms such as MOODLE or MSTeams, and the inclusion of case studies as innovative elements of seminar teaching.

During the summer semester of the 2019/2020 academic year, the outbreak of the COVID-19 pandemic necessitated a rapid transition from on-site teaching to distance learning. Survey results indicate that more than half of the students (over 51%) perceived distance learning as less demanding than traditional on-site instruction during the preceding winter semester. Approximately 21.4% of students considered distance or online learning to be more demanding, while nearly 28% perceived both forms of instruction as equally demanding. One possible explanation for the perception of lower demands is the mistaken belief among some students that teachers have limited ability to monitor preparation and assess performance in an online environment, which may lead to an underestimation of academic requirements.

Overall, students' recommendations for making introductory economics courses more engaging can be summarised as follows: increased use of practical examples and application of knowledge to current economic issues; systematic incorporation of case studies; more interactive and engaging teaching methods; greater emphasis on teamwork and collaborative tasks; wider use of online teaching formats; integration of YouTube videos and online resources; and improvement of communication between teachers and students. These findings confirm both the attractiveness of online and multimedia-supported education, while clearly indicating areas in which innovation is necessary to improve the effectiveness of economics education.

Educational Platforms as an Innovative Approach in Economics Education

This section presents selected educational platforms developed primarily in international contexts that may serve as inspiration for the creation and adaptation of similar platforms in languages other than English. These platforms illustrate different approaches to integrating multimedia content, interactivity, and activating teaching methods into economics education.

MyLab Economics

MyLab Economics, developed by Pearson, is a digital educational platform designed primarily for university-level economics education. It offers a comprehensive set of interactive tools aimed at enhancing the learning process, including assessments, tutorials, and customisable content for both students and instructors. The platform can be easily integrated into existing course structures and supports the effective comprehension of complex economic concepts. The platform's interface emphasises a clear and professional design with intuitive navigation. Separate access options are provided for students and instructors. The student version offers interactive exercises, tests, and personalised feedback that support individualised learning and continuous self-assessment. The instructor version enables course creation, monitoring of student progress, and the use of analytical tools to improve teaching effectiveness.

Exploring Economics

Exploring Economics is an open-access e-learning platform dedicated to pluralistic economics. It provides a wide range of educational resources aimed at exploring diverse economic theories, methodologies, and perspectives. The platform includes original content related to various schools of thoughts, such as behavioural, ecological, feminist, and institutional economics. Its user-friendly interface supports easy navigation and encourages active exploration of alternative economic approaches. The platform also enables users to search for courses, articles, and discussions, thereby promoting critical reflection and engagement with contemporary economic debates.

CORE Econ

CORE Econ is an educational platform offering free online textbook and learning resources designed to modernise the teaching and learning of economics. Its approach is grounded in contemporary economic research and addresses pressing global challenges, including climate change, inequality, and technological progress. The underlying vision of CORE Econ is that economics education can contribute to a more just, sustainable, and democratic society. One of the platform's flagship textbooks, *The Economy 2.0*, covers the fundamental principles of microeconomics and macroeconomics while emphasising real-world problem solving. The textbook incorporates interactive graphs, empirical data, and applied examples, making it particularly suitable for innovative and activating teaching approaches.

Khan Academy

Khan Academy is a globally recognised educational platform whose mission is to provide free, high-quality education to anyone, anywhere. The platform offers thousands of instructional videos covering a broad range of subjects, including economics. Through short video explanations and practice exercises, Khan Academy serves as a valuable supplementary resource, particularly for reinforcing basic concepts and supporting independent learning.

Educational platforms such as MyLab Economics, Exploring Economics, CORE Econ, and Khan Academy demonstrate the significant potential of multimedia and interactive tools to enhance student engagement, deepen conceptual understanding, and accommodate diverse learning styles. They illustrate how digital technologies can be effectively combined with activating teaching methods to address persistent challenges in introductory economics education, such as low motivation and high failure rates.

Design of an Online Open Platform Focused on the Principles of Economics

The initial concept and design of an online educational platform aimed at teaching the principles of microeconomics and macroeconomics in the Slovak language were developed and implemented during the period 2020–2022 in the framework of educational project KEGA.[1] The educational platform is publicly accessible at https://learneconomics.euba.sk/

The project was submitted prior to the outbreak of the COVID-19 pandemic as an innovative initiative responding to the growing demand for modern, digitally supported forms of economics education. During the first year of the project, the research team focused on a comparative analysis of the existing approaches to teaching introductory economics courses at Slovak faculties of economics and at selected foreign universities. This analysis provided a broader international perspective on commonly used teaching methods, digital tools, and curricular structures. Subsequently, a questionnaire survey was conducted among university students in order to identify areas in which innovative teaching methods and procedures could be effectively introduced and to better understand students' expectations regarding digital learning resources. The second and third years of the project were devoted to the development of the first functional version of the online platform. This phase included the systematic creation of educational content, graphical design, and technical functionality. Particular attention was paid to usability, clarity of navigation, and the integration of multimedia

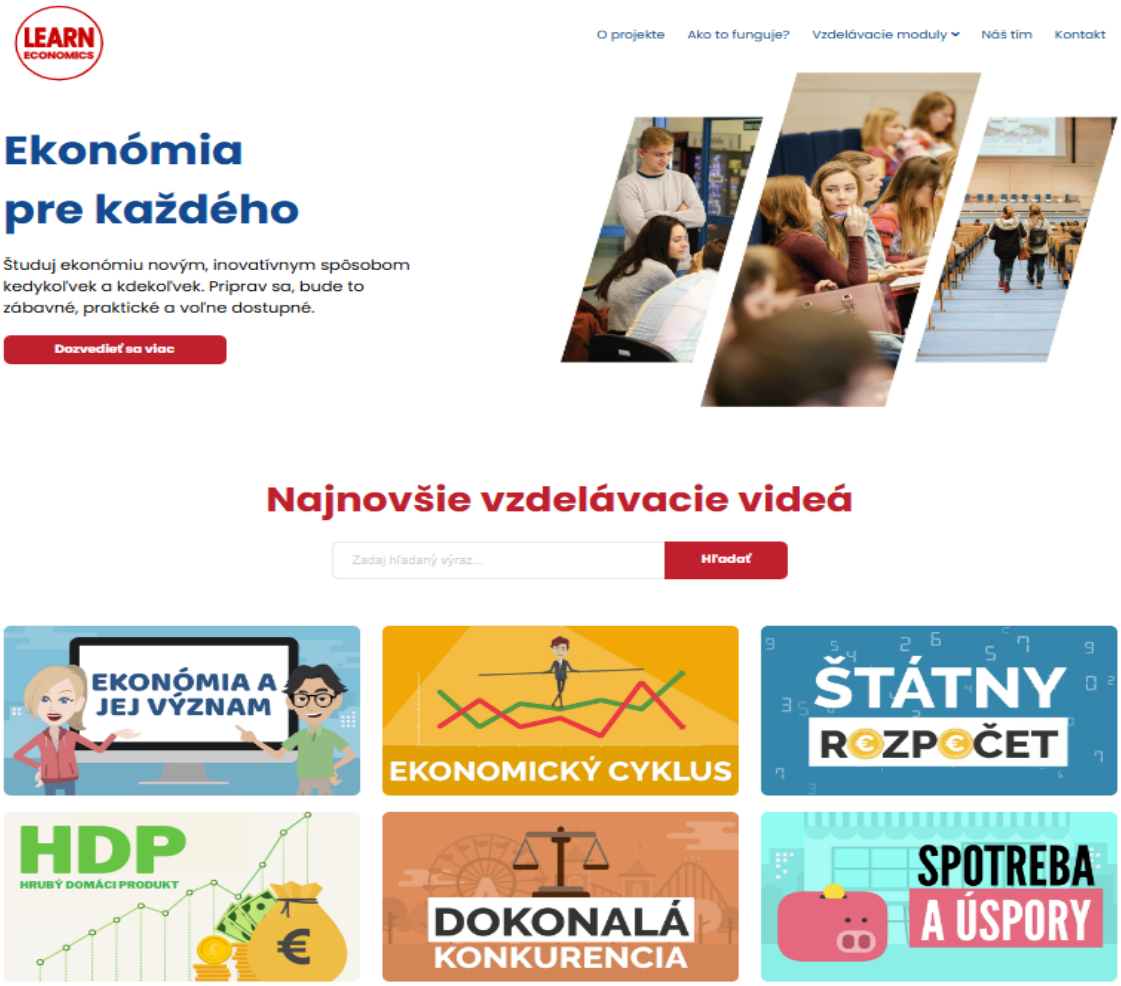
[1] KEGA project entitled "Learn Economics: The Application of E-learning as a New Form of Teaching Economics".

elements. Following the completion of this initial stage, the platform was gradually incorporated into seminar-based teaching as a one of complementary sources at the educational process at the BUEB.

At present, the research team is working on the second stage of the platform's development. The main objective of this phase is to further expand the platform into a comprehensive educational tool that supports active and independent learning. The platform is intended not only for university students, but also as an open-access resource for the general public interested in economics and financial literacy.

Figure 1

Visual Layout of the learneconomics.euba.sk Educational Platform



Source: https://learneconomics.euba.sk/

Figure 1 presents the visual layout of the Learn Economics educational platform. The homepage of the Learn Economics platform is available only in the Slovak language. In the upper left corner, the platform's logo is displayed together with the slogan "Economics for everyone", emphasising its inclusive orientation towards a broad audience interested in understanding modern market economics through an innovative and practice-oriented approach. The top section of the webpage contains the main navigation menu, which includes the following items: About the Project, How Does It Work?, Educational Modules, Our Team, and Contact.

The central part of the homepage is dedicated to the section entitled Latest Educational Videos, which presents newly added video materials covering key topics in microeconomics and macroeconomics. An integrated search function allows visitors to quickly locate specific economic concepts and corresponding educational videos by entering relevant keywords, thereby facilitating targeted learning.

The current content of the educational platform is structured into several educational modules:

- *Educational videos*, which explain specific economic concepts through practical and real-world examples. Each video is developed through a structured process that includes idea formulation, team discussions, script preparation, recording, and final editing.
- *Case studies*, presenting engaging and often non-standard economic problems. Each case study is based on a real economic situation and is accompanied by questions designed to stimulate analytical thinking and reflection.
- *Interactive graphs*, which transform available data into graphical representations commonly used in economic analysis. Students are encouraged to explore these graphs and answer questions related to their interpretation.
- *Test sets,* consisting of multiple-choice questions covering microeconomics and macroeconomics. Each question includes four answer options, with one correct response.
- *A dictionary of economic terms*, providing an alphabetical list of key concepts accompanied by detailed definitions and their English equivalents.
- *Famous economists*, introducing the lives and key contributions of prominent economists who have significantly influenced the development of economic thoughts.
- *Books on economics*, presenting selected domestic and foreign textbooks as well as popular science publications, together with brief descriptions to support students in their choice of literature.
- *Numerical examples*, including numerical and verbal problems of varying levels of difficulty from microeconomics and macroeconomics.
- *Financial literacy*, a newly introduced module focusing on the relationship between economics and personal finance. Given that recent surveys indicate that the level of financial knowledge among Slovak households and students remains below the European Union average, this module aims to enhance users' understanding of fundamental financial concepts.

Table 1 presents summary statistics related to the usage of the learneconomics.euba.sk platform, covering the period from its launch in spring 2021 to autumn 2025.

Table 1
Most Visited Pages From the Main Menu

Page name from the main menu	Total number of page views
Contact	134,074
About the project	2,244
How does it work?	2,085
Why study economics?	1,991
Our team	1,960

Source: Own processing based on data from learneconomics.euba.sk

The data indicate that the Contact page is by far the most frequently visited section of the platform. This suggests a strong interest among users in obtaining contact information about the creators of the platform. From this perspective, it appears appropriate to further develop this section, for example by adding more detailed information or an interactive contact form. The remaining pages record significantly lower levels of traffic, indicating limited user interest in information related to the platform's objectives, functioning, or team composition. These findings provide valuable insights into user behaviour and may serve as a basis for future improvements to the structure and visual presentation of the platform.

Table 2
Most Visited Educational Modules on the Website

Rank	Name of educational module
1	https://learneconomics.euba.sk/vzdelavacie-moduly/interaktivne-grafy/
2	https://learneconomics.euba.sk/vzdelavacie-moduly/vzdelavacie-videa/
3.	https://learneconomics.euba.sk/vzdelavacie-moduly/otestuj-sa/
4.	https://learneconomics.euba.sk/vzdelavacie-moduly/znami-ekonomovia/
5.	https://learneconomics.euba.sk/vzdelavacie-moduly/pripadove-studie/
6.	https://learneconomics.euba.sk/vzdelavacie-moduly/knihy-o-ekonomii/
7.	https://learneconomics.euba.sk/vzdelavacie-moduly/slovnik-ekonomickych-pojmov/

Source: Own processing based on data from learneconomics.euba.sk

Table 2 presents the ranking of visits to individual educational modules on the website. The results show that Interactive Graphs represent the most frequently visited educational module, followed by Educational Videos, which also attract substantial user attention. The third position is occupied by Test Sets, followed by Famous Economists. Case Studies rank fifth in terms of visits, while Books on Economics and the Dictionary of Economic Terms are the least frequently accessed modules. These findings highlight the strong preference of users for

interactive and visually supported learning tools and provide empirical guidance for the future development of the platform.

Conclusion

The digital transformation of higher education has substantially reshaped teaching and learning practices, a process that was significantly accelerated by the COVID-19 pandemic. This period highlighted both the potential and the limitations of online and hybrid instruction. While digital technologies cannot replace direct student–teacher interaction, empirical experience shows that they can meaningfully enhance learning when integrated into pedagogical designs.

This paper examined the role of open educational platforms as digital teaching tools in economics education. The analysis combined theoretical perspectives on activating and digitally supported teaching methods with empirical evidence drawn from a student questionnaire survey, descriptive usage statistics of an educational platform, and a comparative review of selected international platforms. Together, these elements provide a comprehensive view of how digital tools can support the teaching of introductory economics.

Survey results collected among students of the Bratislava University of Economics and Business indicate that traditional face-to-face lectures remain important, yet students consistently express a demand for stronger links between theory and practice, greater use of illustrative examples, and more interactive forms of instruction. These preferences are reflected in the design of the *Learn Economics* platform.

The comparative overview of established platforms, including MyLab Economics, CORE Econ, Exploring Economics, and Khan Academy, reveals common features associated with effective digital economics education, such as modular structure, emphasis on real-world applications, and support for self-regulated learning. The *Learn Economics* platform incorporates these features while responding to local curricular requirements and language accessibility, thereby extending the availability of open educational resources in economics.

Overall, the empirical findings suggest that open, multimedia-based platforms can effectively complement traditional teaching by increasing student engagement and supporting independent learning. These platforms appear particularly suitable for blended learning and flipped classroom models, where digital materials prepare students for more application-oriented activities during contact teaching. Future research should therefore focus on systematically evaluating learning outcomes associated with platform use and on refining digital content based on observed user behaviour. In this way, open educational platforms can contribute to evidence-based innovation in economics education.

Acknowledgment

This paper was supported by the Grant Agency KEGA no. 033EU-4/2024.

References

Angelo, T. A., & Cross, K. P. (1993). *Classroom assessment techniques: A handbook for college teachers* (2nd ed.). Jossey-Bass.

Bredow, C. A., Roehling, P. V., Knorp, A. J., & Sweet, A. M. (2021). To flip or not to flip? A meta-analysis of the efficacy of flipped learning in higher education. *Review of Educational Research, 91*(6), 878–918. https://doi.org/10.3102/00346543211019122

Clerici-Arias, M. (1994). *An integral approach to teaching economics*. Stanford University. http://web.stanford.edu/~marcelo/Teaching/Papers/teachint.pdf

CORE Econ. (n.d.). The Economy. https://www.core-econ.org/

Delemeester, Greg & Brauer, Jurgen. (2000). Games Economists Play: Noncomputerized Classroom Games. *Journal of Economic Education*, *31*(4), 406. https://doi.org/10.1080/00220480009596459

Divjak, B., Rienties, B., Iniesto, F., Vondra, P., & Žižak, M. (2022). Flipped classrooms in higher education during the COVID-19 pandemic: Findings and future research recommendations. *International Journal of Educational Technology in Higher Education, 19*, Article 9. https://doi.org/10.1186/s41239-021-00316-4

Exploring Economics. (n.d.). Exploring Economics. https://www.exploring-economics.org/en/

Kálovec, M. (2017). *Quo vadis ekonomická teória?* [Quo vadis Economics?]. (Unpublished final paper, supplementary pedagogical studies). Bratislava University of Economics and Business.

Khan Academy. (n.d.). Khan Academy. https://www.khanacademy.org/

Leijon, M., Gudmundsson, P., Staaf, P., & Christersson, C. (2022). Challenge-based learning in higher education: A systematic literature review. *Innovations in Education and Teaching International, 58*(5), 609–620. https://doi.org/10.1080/14703297.2021.1892503

Muchová, E., Leško, P. (2020). *Výsledky dotazníkového prieskumu o výučbe základov ekonómie 1 a základov ekonómie 2* [Results of a questionnaire survey on the teaching of Principles of Economics 1 and Principles of Economics 2]. Unpublished report. Bratislava University of Economics and Business.

Pearson. (n.d.). MyLab Economics. https://www.pearson.com/en-us/higher-education/mylab/economics.html

Van Alten, D. C. D., Phielix, C., Janssen, J., & Kester, L. (2019). Effects of flipping the classroom on learning outcomes and satisfaction: A meta-analysis. *Educational Research Review, 28*, 100281. https://doi.org/10.1016/j.edurev.2019.05.003

United Nations. (2020). *Policy brief: Education during COVID-19 and beyond*. https://unsdg.un.org/sites/default/files/2020-08/sg_policy_brief_covid-19_and_education_august_2020.pdf