ISSN:2308-5703
Impact factor:13.5 *International Multidisciplinary Online Journal* October, 2026

MECHANISMS FOR INTEGRATING THE INDIVIDUAL LEARNING ACTIVITIES AND RESEARCH COMPETENCIES OF FUTURE ENGINEERS THROUGH DIGITAL PEDAGOGICAL TECHNOLOGIES

Kobulov Ilhomjon Turg‘unboyevich
Andijan State Technical Institute
Assistant Lecturer, Department of Accounting
doi:https://doi.org/10.5281/zenodo.23874847

Abstract. This article examines the integration of the individual learning activities and research competencies of future engineers through digital pedagogical technologies. It analyses the possibilities of organising individual learning activities by means of digital learning platforms, adaptive learning resources, electronic portfolios, learning analytics, virtual laboratories and artificial intelligence tools. It also substantiates mechanisms for developing students’ independent research and practical activities based on their individual levels of knowledge, interests, learning pace and professional orientation.

Keywords: digital pedagogical technologies, individual learning activities, research competence, future engineer, adaptive learning.

Introduction.

One of the important characteristics of the development of modern engineering education is the need not only to improve the educational process through digital technologies but also to take into account each student’s individual abilities and professional development needs. Technological changes taking place in the engineering sector require future specialists not only to acquire theoretical knowledge but also to develop the ability to learn independently, identify technical problems, analyse scientific information, conduct experiments and develop innovative solutions.

In traditional education, the same learning content and assignments may be presented to all students in an identical manner. However, students differ in their prior knowledge, speed of information processing, ability to work independently, professional interests and readiness for research activities. Consequently, applying a single learning pathway to all students may, in some cases, prevent them from fully realising their individual potential. Digital pedagogical technologies make it possible to adapt learning content, task complexity, learning pace and forms of feedback to students’ needs.

Individual learning activity refers to a student’s process of setting learning objectives, selecting resources, completing assignments, monitoring the learning process and evaluating outcomes in accordance with their level of knowledge, interests, needs and intended learning outcomes. Research competence, in turn, encompasses the ability to identify a scientific or technical problem, search for information, select research methods, conduct experiments and analytical work, interpret results and draw evidence-based conclusions.

The integration of these two areas is particularly important. Individual learning activities enable students to develop their knowledge and skills independently, whereas research activities direct them towards applying that knowledge to solve a specific scientific or engineering problem. Digital

technologies serve as the means of bringing these activities together within a unified pedagogical process.

An article published in 2024 by Eileen du Plooy, Daleen Casteleijn and Denise Franzsen synthesised 69 scholarly studies on adaptive and personalised learning in higher education. The authors reported improvements in academic performance in 59 per cent of the studies analysed and increased student engagement in 36 per cent. At the same time, technological infrastructure and time resources were identified as important constraints on the implementation of adaptive learning [1].

The European Framework for the Digital Competence of Educators, developed by the European Commission's Joint Research Centre, identifies as important educator competencies the individualisation of learning through digital technologies, enabling learners to progress at different levels and paces, supporting independent learning and analysing the outcomes of digital activities [2].

In the Republic of Uzbekistan, the individualisation of higher education through digital technologies, the development of distance-learning services and the introduction of modern teaching methods have also been identified as priority areas of public policy. In particular, the Concept for the Development of the Higher Education System of the Republic of Uzbekistan until 2030, approved by Presidential Decree No. PF-5847 of 8 October 2019, sets out objectives to individualise educational processes through digital technologies and expand approaches such as blended learning and the flipped classroom [3]. Accordingly, this article aims to provide a theoretical substantiation of mechanisms for integrating the individual learning activities and research competencies of future engineers through digital pedagogical technologies, identify their constituent elements and formulate practical recommendations for their application in higher engineering education.

Research Methodology.

The article draws on a systems approach, analysis of scholarly sources, comparative analysis, synthesis, classification and pedagogical modelling. These methods were used to identify the relationship between individual learning activities and research competencies, assess the pedagogical potential of digital technologies and represent these elements within a unified mechanism.

Analysis and Results.

When organising the individual learning activities of future engineers, it is not sufficient to consider only their academic achievement in individual subjects. Their readiness for independent learning, ability to identify problems, capacity to work with scientific information, use of technical tools and ability to analyse their own activities should also be taken into account. This is because many problems arising in engineering practice cannot be addressed through standard solutions alone. Solving them requires independently seeking new knowledge, comparing existing solutions and testing them through experimentation.

Individual learning activities create the personal and organisational foundation required for the development of research competence. For example, one student may be interested in the design of mechanical devices, another in automation, and a third in energy efficiency. A digital learning environment makes it possible to retain the common compulsory learning outcomes while adapting independent assignments, additional resources and research project topics to students' individual interests. The relationship between individual learning activities and research competencies can be represented as a logical sequence: identifying the student's initial level of knowledge; setting

individual learning objectives; selecting appropriate digital resources; completing a research-oriented practical task; analysing the results; and evaluating one's own performance. As this process is repeated, students develop the ability to manage their own learning while also gaining experience in solving research problems.

The Structural Relationship between the Individual Learning Activities and Research Competencies of Future Engineers

Table 1.

Components of individual learning activity	**Corresponding area of research competence**	**Digital pedagogical tool**	**Expected learning outcome**
Setting individual goals and plans	Identifying a research problem and setting objectives	Electronic learning plan, digital calendar	Ability to plan independently
Assessing individual knowledge level	Assessing existing knowledge related to the problem	Diagnostic test, electronic questionnaire	Identification of knowledge gaps
Selecting individual resources	Searching for and selecting scholarly sources	Digital library, scholarly databases	Independent work with information
Completing independent assignments	Selecting methods, performing calculations and modelling	Virtual laboratory, engineering software	Practical and methodological skills
Recording results	Collecting and processing data	Spreadsheet, digital laboratory logbook	Systematisation of results
Evaluating one's own activities	Identifying errors and drawing conclusions	Electronic portfolio, self-assessment tool	Reflective and critical thinking

Source: Compiled by the author on the basis of an analysis of sources [1], [2], [4] and [5].

As the table demonstrates, each component of individual learning activity can be linked to a specific stage of research activity. For example, setting individual goals contributes to identifying a research problem; independently selecting resources supports the search for scientific information; and digital laboratory assignments facilitate experimentation and modelling. Therefore, individual learning activities should not be limited to the independent completion of learning assignments; they should be enriched with consistent research and practical activities.

Digital pedagogical technologies perform several important functions in integrating individual learning activities and research competencies. First, they make it possible to identify students' learning progress and educational needs. Second, they help adapt learning content to individual levels. Third, they create a digital environment for organising independent research and practical activities and documenting their outcomes.

Adaptive learning platforms. Such platforms can recommend learning materials based on students' prior knowledge, assignment results and learning pace. For example, in a Materials Science course, students may complete tasks of varying levels of difficulty when studying the mechanical properties of materials. Based on diagnostic results, some students may be offered tasks to reinforce theoretical concepts, while others may be assigned more complex calculations and engineering analysis. In this way, all students can achieve the common learning outcomes established for the course, while following different individual learning pathways.

A review article on adaptive and personalised learning published in 2024 analysed 69 scholarly studies. In 40 of these studies, or 58 per cent, tests assessing prior knowledge were used as an indicator for adapting learning materials. In 15 studies, or 22 per cent, students' digital engagement was used, including their interactions with the platform and activity logs recorded by the system [1]. These findings indicate that the design of individual learning pathways should take account not only of final grades but also of data generated throughout the learning process.

Virtual laboratories and engineering simulation. In engineering education, virtual laboratories enable students to model in a digital environment processes that may be difficult, costly or dangerous to carry out in a physical laboratory. For example, assembling electrical circuits, applying loads to mechanical structures, modelling fluid flow or testing the operating algorithms of automated systems can be performed in a virtual environment. By independently changing experimental parameters, comparing results and formulating their own conclusions, students develop their research competencies.

Electronic portfolio. An electronic portfolio makes it possible to systematically store the outcomes accumulated by students during their individual learning and research-oriented practical activities. It may contain completed projects, laboratory reports, software code, drawings, experimental results, presentations, research articles and self-assessment materials. A portfolio makes it possible to monitor not only a student's final results but also their development over time.

Learning analytics. Learning analytics helps identify students' engagement in the learning process, the pace at which they complete assignments, the topics they find challenging and the dynamics of their academic progress by analysing data generated on digital platforms. However, such data do not fully represent a student's knowledge. Therefore, platform engagement indicators should be assessed together with laboratory results, project quality, written assignments and teachers' observations.

Artificial intelligence tools. AI-based tools can be used as support tools for searching scholarly sources, organising preliminary data, identifying errors in code, explaining computational processes and providing individual feedback on learning assignments. However, the responses generated by these tools are not always accurate. Students must therefore independently verify the information they obtain, acknowledge the sources they use and retain personal responsibility for their final research conclusions. In its 2023 guidance on the use of generative AI in education and research, the United Nations Educational, Scientific and Cultural Organization emphasises the need to safeguard human interests, protect personal data, observe ethical standards and ensure pedagogical appropriateness [4].

The Functions of Digital Pedagogical Technologies in Integrating Individual Learning Activities and Research Competencies

Table 2.

Digital technology	Function in	Function in research	Example of

	individual learning	activity	practical application
Adaptive learning platform	Recommending assignments and resources suited to the student's level of knowledge	Step-by-step acquisition of the knowledge required to address a problem	Individual assignments in an engineering subject
Virtual laboratory	Enabling students to practise at their own pace	Conducting experiments and comparing results	Simulation of an electrical circuit or mechanical system
Electronic portfolio	Storing evidence of individual development	Bringing together research projects, reports and experimental results	A student's semester-long research and practical work
Learning analytics	Identifying difficulties in learning	Monitoring progress in the implementation of a research project	Assignment completion and development dynamics
Artificial intelligence tools	Providing individual explanations and learning support	Assisting with source searches, preliminary analysis and coding	Checking software code and organising data
Cloud-based collaboration tools	Storing and managing independent work	Discussing team projects and research findings	Shared project document and data repository

Source: Developed by the author on the basis of sources [1], [2] and [4].

The technologies presented in the table do not replace one another; rather, they complement one another. For example, the results of an experiment conducted in a virtual laboratory can be stored in an electronic portfolio, selected process indicators can be analysed using learning analytics, and the results can be discussed within a project group through cloud-based tools. In this way, individual learning and research-oriented practical activities are connected within a unified digital environment.

Conclusions and Recommendations.

In conclusion, the theoretical and comparative analysis conducted in this article substantiates that integrating the individual learning activities and research competencies of future engineers through digital pedagogical technologies is an important pedagogical direction that can improve the effectiveness of the educational process. Individual learning activities enable students to plan and manage their learning in accordance with their level of knowledge, interests, needs and professional goals. Research competencies, in turn, develop the ability to apply the knowledge acquired through these activities to solving research and practical problems, conducting experiments, analysing data and drawing evidence-based conclusions. Digital pedagogical technologies provide the tools required to bring these two processes together within a unified learning environment.

The integration of individual learning activities and research competencies through digital pedagogical technologies helps prepare future engineers to become independent learners, specialists

capable of solving technical problems on a scientific basis and professionals able to develop innovative solutions. To achieve this, the use of digital tools alone is insufficient; these tools must be closely aligned with clearly defined pedagogical objectives, individual learning needs and research-oriented practical assignments.

References:

1. du Plooy E., Casteleijn D., Franzsen D. Personalized adaptive learning in higher education: A scoping review of key characteristics and impact on academic performance and engagement // Heliyon. – 2024. – Vol. 10, Issue 21. – Article e39630. – DOI: 10.1016/j.heliyon.2024.e39630.
2. Redecker C. European Framework for the Digital Competence of Educators: DigCompEdu / ed. by Y. Punie. – Luxembourg: Publications Office of the European Union, 2017. – EUR 28775 EN. – DOI: 10.2760/159770.
3. Decree of the President of the Republic of Uzbekistan No. PF-5847 of 8 October 2019, "On Approval of the Concept for the Development of the Higher Education System of the Republic of Uzbekistan until 2030". – Available at: https://lex.uz/docs/4545884
4. Miao F., Holmes W. Guidance for Generative AI in Education and Research. – Paris: United Nations Educational, Scientific and Cultural Organization, 2023. – Available at: https://unesdoc.unesco.org/ark:/48223/pf000038669
5. Accreditation Board for Engineering and Technology. Criteria for Accrediting Engineering Programs, 2025–2026. – Baltimore: ABET, 2024. – Available at: https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2025-2026/
6. Decree of the President of the Republic of Uzbekistan No. PF-6079 of 5 October 2020, "On Approval of the Digital Uzbekistan – 2030 Strategy and Measures for Its Effective Implementation". – Available at: https://lex.uz/docs/5030957