International Journal of Pedagogics

VOLUME Vol.06 Issue03 2026
PAGE NO. 354-361
DOI 10.37547/ijp/Volume06Issue03-74

Adaptive Digital Learning Route Method for Teaching the Course "Information Technologies in Technical Systems" To Technical University Students

Khasanova Makhinur Yuldashbayevna
PhD doctoral student of Namangan state technical university, Uzbekistan

Received: 12 February 2026; **Accepted:** 08 March 2026; **Published:** 31 March 2026

Abstract: This paper substantiates the pedagogical potential of the Adaptive Digital Learning Route Method in teaching the course "Information Technologies in Technical Systems" at technical universities. The study addresses the problem of heterogeneity in students' academic preparedness, digital competence, and readiness for independent engineering-oriented learning. The proposed method is based on personalization, level differentiation, continuous diagnostics, route flexibility, and digital pedagogical support. The research applies theoretical analysis, pedagogical modeling, structural design, and methodological generalization to develop the conceptual and procedural foundations of the method. The method includes five interrelated stages: diagnostic-orientation, profiling, route design, corrective-developmental support, and reflective-evaluative assessment. Its implementation is expected to improve students' motivation, increase the quality of mastering theoretical and practical content, strengthen independent learning skills, and enhance professional readiness in the field of information technologies in technical systems. The study contributes to the theory and methodology of professional education by proposing a route-based adaptive model specifically designed for engineering disciplines.

Keywords: Adaptive learning, personalized instruction, engineering education, technical university, digital learning route, information technologies in technical systems, pedagogical modeling.

Introduction: The transformation of contemporary engineering education is closely associated with the growing demand for flexible, student-centered, and practice-oriented instructional models. Technical universities are increasingly expected to prepare graduates who are able not only to reproduce theoretical knowledge but also to apply digital tools, solve engineering problems, analyze system behavior, and operate in complex technological environments. Under these conditions, the effectiveness of professional training depends largely on the degree to which the educational process responds to students' individual academic needs and professional trajectories.

One of the persistent challenges in teaching technical disciplines is the heterogeneity of student cohorts. Learners enter higher education with different levels of prior knowledge, digital literacy, analytical thinking, and practical preparedness. This heterogeneity becomes particularly evident in the course "Information Technologies in Technical Systems," which integrates programming logic, digital data processing, hardware-software interaction, system analysis, and applied engineering tasks [1, 2]. In a conventional linear teaching model, where all students study the same content in the same sequence and at the same pace, such differences often lead to unequal learning outcomes. Students with limited background knowledge experience cognitive overload and loss of motivation, whereas more advanced learners often remain underchallenged.

These contradictions reveal the need for adaptive pedagogical solutions capable of ensuring both accessibility and academic rigor. In this regard, adaptive learning is not simply a technological innovation but a methodological response to the objective complexity of engineering education. Its pedagogical value lies in the possibility of organizing differentiated educational pathways without fragmenting the curriculum or weakening professional standards. For technical disciplines, this means that adaptation should concern not only the complexity of educational tasks, but also the pace of study, the amount of instructional support, the structure of practice, and the degree of learner autonomy [3]. Despite the growing interest in personalization and digital pedagogy, there remains a need for methodological models specifically designed for the context of technical higher education and for courses that combine theoretical, algorithmic, and engineering-practical content. Therefore, the present study focuses on the development and theoretical substantiation of the Adaptive Digital Learning Route Method, intended for teaching the course “Information Technologies in Technical Systems” to technical university students.

The purpose of the study is to develop and theoretically substantiate an adaptive pedagogical method that enables students to master the course through individualized digital learning routes aligned with their initial preparedness, learning progress, and professional orientation.

METHODS

The study is theoretical and methodological in nature. It is based on pedagogical modeling and aimed at designing a method for adaptive instruction in technical higher education. The research does not seek to test a fully completed large-scale intervention within this paper; rather, it develops the conceptual, structural, and procedural foundations of the proposed method and identifies the pedagogical conditions for its implementation [4, 5].

The development of the Adaptive Digital Learning Route Method was based on a set of interrelated methodological approaches that together provided its conceptual and pedagogical foundation. The competence-based approach made it possible to interpret the educational process as a means of developing professionally significant knowledge, skills, and practical abilities required in the field of technical systems. At the same time, the student-centered approach ensured consideration of individual differences in students’ prior preparation, learning pace, cognitive style, and level of autonomy. The integrity of the proposed method was supported by the system approach, which linked goals, content, instructional procedures, digital tools, diagnostic mechanisms, and expected outcomes into a coherent pedagogical structure. A central role was played by the adaptive approach, which allowed the learning route to be modified in accordance with students’ educational needs and current progress. In addition, the practice-oriented approach ensured the professional relevance of the method by aligning course tasks with real or simulated engineering situations [6, 10].

The following methods were used in the study:

- analysis of pedagogical, didactic, and methodological literature on adaptive and personalized learning [7, 12];

- comparison and generalization of existing approaches to teaching technical disciplines;

- pedagogical modeling for the design of the proposed method;

- structural-functional analysis of the components and stages of the method;

- methodological forecasting to determine expected educational outcomes.

The Adaptive Digital Learning Route Method was designed for the course “Information Technologies in Technical Systems,” which includes theoretical and applied modules such as digital data acquisition, microcontroller-based solutions, signal processing, system monitoring, communication interfaces, and software-hardware integration [8-11].

The method includes five successive and interconnected stages:

1. **Diagnostic-orientation stage**. At this stage, the initial level of student preparedness is identified using entry tests, practical mini-tasks, self-assessment tools, and tasks aimed at determining digital and algorithmic readiness.

2. **Profiling stage**. Based on diagnostic results, students are assigned to условные adaptive profiles, such as basic, applied, and project-oriented. These profiles are flexible and may change during the course.

3. **Route-design stage**. At this stage, an

individualized digital learning route is created. It determines the sequence of modules, the level of task difficulty, the amount of practical work, the form of support, and the checkpoints for formative assessment.

4. **Corrective-developmental stage**. The route is continuously updated on the basis of current learning performance. Students who progress successfully are offered more complex tasks, while those facing difficulties receive additional instructional support, scaffolding materials, visual explanations, and targeted consultations.

5. **Reflective-evaluative stage**. At the final stage, students' achievements are assessed in terms of theoretical knowledge, practical skills, professional application, independence, and reflection on their own progress.

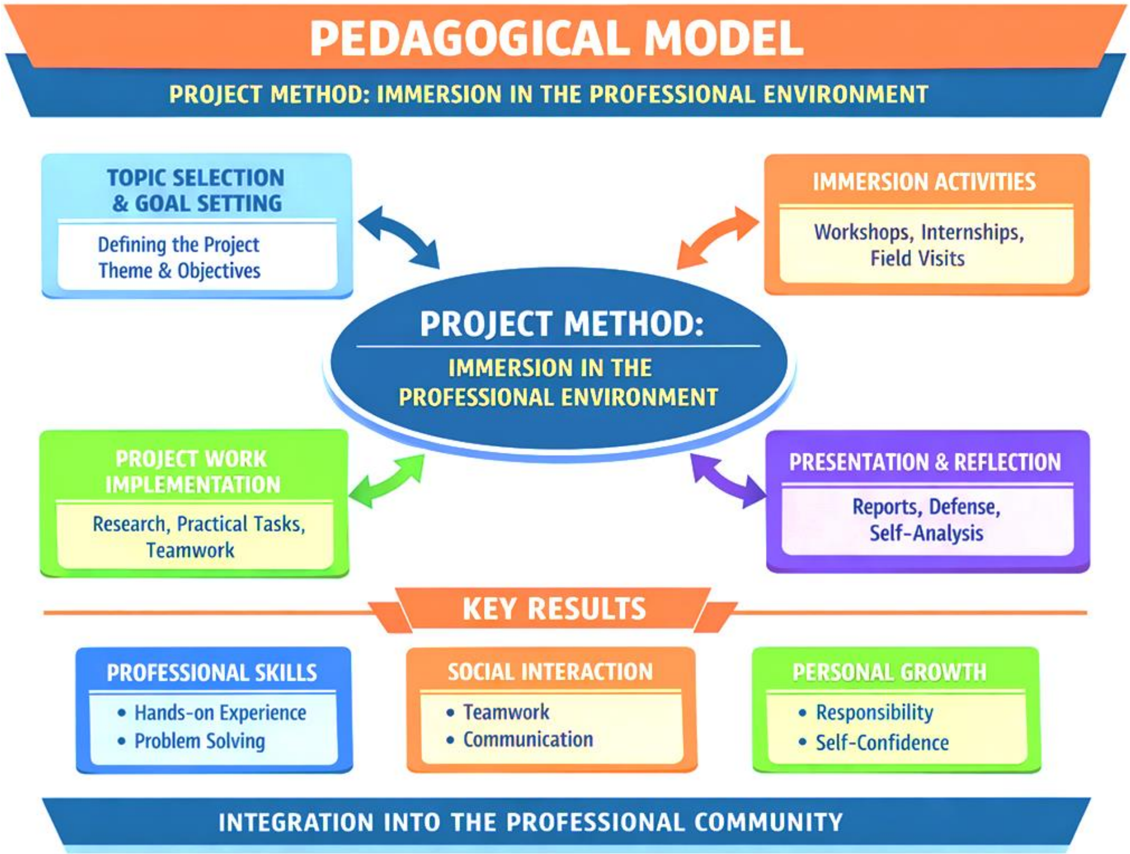

Figure 1. Pedagogical Model of the Adaptive Digital Learning Route Method for Teaching the Course "Information Technologies in Technical Systems" to Technical University Students

The effective implementation of the method requires a number of pedagogical conditions. These include modular organization of course content, availability of digital educational tools, the teacher's readiness to act as diagnostician and tutor, flexible formative assessment procedures, and the inclusion of practice-oriented technical tasks reflecting future professional activity.

RESULTS

The main result of the study is the development of the Adaptive Digital Learning Route Method as a structured pedagogical solution for teaching "Information Technologies in Technical Systems" in technical universities. Unlike traditional linear instruction, the proposed method organizes learning through individualized routes that preserve common educational goals while differentiating the paths toward their achievement.

A structural model of the method was developed. It integrates the target component, methodological principles, procedural stages, instructional tools, teacher functions, student activities, and expected outcomes. This structure demonstrates that adaptation is not limited to simplifying or complicating tasks; rather, it becomes a multidimensional pedagogical process involving route flexibility, diagnostic feedback, corrective support, and reflective learning.

The study identifies the main procedural mechanism of adaptive route-based teaching in technical education. This mechanism includes:

1. diagnosing students' starting level;
2. assigning an adaptive profile;
3. designing an individual route;
4. supporting students through differentiated learning resources and tasks;
5. correcting the route according to current results;
6. assessing learning outcomes and professional growth.

This mechanism makes it possible to combine personalization with the integrity of a unified academic discipline.

The educational significance of the proposed method lies in its ability to address one of the key contradictions of technical higher education: the need to maintain common professional standards while accounting for significant differences among students. The method creates conditions for more accessible and sustainable learning for students with weaker backgrounds and, at the same time, offers expanded opportunities for deeper mastery and project-based engagement for more advanced learners.

The expected educational outcomes of implementing the Adaptive Digital Learning Route Method are presented in Table 1. The results indicate that the proposed method may positively influence students' motivation, academic achievement, practical skills, learner autonomy, reflective ability, and professional orientation in the process of mastering the course "Information Technologies in Technical Systems".

Table-1.

Expected educational results of implementing the Adaptive Digital Learning Route Method

Result dimension	Indicator	Manifestation in traditional instruction	Expected change under the Adaptive Digital Learning Route Method	Pedagogical significance
Learning motivation	Degree of student engagement in course activities	Motivation is unstable; weak students lose confidence, strong students lose interest	Higher engagement due to personalized task difficulty and flexible route design	Supports sustained participation in the learning process
Academic achievement	Quality of mastering theoretical course content	Uneven understanding of core concepts across student groups	More stable and differentiated mastery of theoretical material according to students' initial preparedness	Improves accessibility and quality of knowledge acquisition
Practical skills	Ability to complete applied technical tasks	Practical performance depends heavily on prior background	Better development of applied skills through differentiated practice and	Strengthens professional readiness in technical contexts

		and external support	route-based task sequencing	
Independent learning	Degree of learner autonomy in solving educational tasks	Students often depend on direct teacher explanation and fixed instructions	Increased autonomy through individual routes, digital resources, and self-paced progression	Forms self-regulation and responsibility for learning
Adaptation to learning difficulty	Ability to overcome academic barriers	Students experiencing difficulties tend to accumulate gaps and fall behind	Faster identification of learning difficulties and timely pedagogical correction	Reduces the risk of persistent academic underachievement
Reflective ability	Capacity for self-analysis of progress and errors	Reflection is usually fragmented and not systematically supported	More conscious learning behavior through route monitoring and reflective evaluation	Enhances self-assessment and self-correction
Professional orientation	Connection between course content and future engineering activity	The professional relevance of tasks is not always explicit	Stronger connection between learning tasks and technical-system applications	Increases the practical value of the discipline
Learning flexibility	Opportunity to progress at an individual pace and level	One pace and one sequence are imposed on all students	Students progress through differentiated routes adapted to their readiness and growth	Ensures pedagogical responsiveness to learner diversity

The criteria-based structure of the expected educational outcomes under the Adaptive Digital Learning Route Method is presented in Table 2. The table reflects the qualitative differentiation of student achievement according to five major criteria: cognitive, operational, motivational, reflective, and adaptive-activity. Each criterion is described through low, medium, and high levels, which makes it possible to evaluate not only the final learning result but also the developmental dynamics of students in the process of mastering the course “Information Technologies in Technical Systems”.

Table 2.

Criteria-Based Levels of Educational Outcomes under the Adaptive Digital Learning Route Method

Criterion	Low level	Medium level	High level	Expected dynamics after implementation
Cognitive criterion	Fragmentary understanding of concepts	Basic understanding of core topics	Systematic and conscious understanding of technical and digital concepts	Shift from fragmented to system-based knowledge
Operational criterion	Difficulty in performing applied tasks	Performs typical tasks with support	Independently solves applied technical tasks	Growth of practical and technological competence
Motivational criterion	Low interest in the discipline	Situational interest	Stable professional and cognitive motivation	Strengthening of learning motivation
Reflective criterion	Weak self-analysis	Partial awareness of errors and progress	Consistent self-assessment and correction	Development of reflective learning behavior
Adaptive-activity criterion	Inability to work independently in a flexible route	Partial adaptation to differentiated tasks	Confident progress along an individualized learning route	Improved adaptability and learner autonomy

As shown in Table 2, the proposed method is expected to ensure positive dynamics across all selected criteria. In the cognitive dimension, students are expected to move from fragmented understanding of technical and digital concepts toward a more systematic and conscious mastery of course content. In the operational dimension, the method supports the transition from difficulty in completing practical tasks to the independent performance of applied technical assignments. In addition, the method is expected to strengthen students' motivation, develop reflective self-assessment, and improve their capacity to work productively within an individualized learning route. Therefore, the criteria-based analysis confirms that the Adaptive Digital Learning Route Method has the potential to enhance not only academic achievement but also the broader professional and personal readiness of technical university students.

The implementation of the method is expected to lead to several pedagogically significant effects:

- increased motivation due to the correspondence between task difficulty and student capability;
- improved mastery of technical and digital content;
- stronger practical skills in working with technological and information systems;
- growth of learner autonomy and responsibility;
- enhanced readiness for project and engineering activity;
- improved reflective ability in relation to one's own educational progress.

The findings of the study confirm that adaptive learning in technical higher education should be interpreted not as isolated differentiation of assignments, but as a holistic pedagogical system in which diagnostic data, route design, digital tools, and professional tasks are brought into functional unity. In this sense, the proposed method broadens the methodological understanding of adaptive instruction by transferring it into the domain of engineering education.

The course “Information Technologies in Technical Systems” requires students to combine abstract conceptual understanding with practical action, algorithmic logic, and system thinking. Therefore, a route-based adaptive method appears especially appropriate in this context. It enables the teacher to preserve the integrity of the discipline while diversifying the route, support mechanisms, and degree of learner independence. This is particularly important in technical universities, where the quality of education depends not only on content delivery but also on the organization of professionally meaningful practice.

Another important point is that the proposed method redefines the role of the teacher. Within this framework, the teacher is no longer merely a transmitter of information. Instead, the teacher functions as a diagnostician, route designer, consultant, moderator of learning progress, and organizer of reflective analysis. Such a transformation is pedagogically significant because adaptive learning cannot be effectively implemented without deliberate instructional management. At the same time, the present study has certain limitations. It is primarily theoretical and conceptual. Therefore, the next stage of research should involve pedagogical experimentation aimed at testing the effectiveness of the method in real educational conditions, measuring its impact on students’ academic achievement, professional competencies, and motivation.

CONCLUSION

The study has substantiated the relevance and pedagogical potential of the Adaptive Digital Learning Route Method for teaching the course “Information Technologies in Technical Systems” to students of technical universities. The method was developed as a response to the heterogeneity of student preparedness and to the need for more flexible, personalized, and professionally oriented educational models in engineering education.

The proposed method integrates diagnostic procedures, adaptive profiling, route design, differentiated support, and reflective evaluation into a coherent pedagogical system. Its theoretical significance lies in expanding the methodological foundations of adaptive learning in technical higher education. Its practical significance lies in the possibility of using the method to organize instruction in a way that increases motivation, improves mastery of technical content, strengthens practical skills, and supports the development of professional competencies.

Further research should focus on the experimental verification of the method, the development of assessment criteria for route effectiveness, and the adaptation of this model to other engineering and information-technological disciplines.

REFERENCE

1. Zhong, L. (2023). A systematic review of personalized learning in higher education: learning content structure, learning materials sequence, and learning readiness support. Interactive Learning Environments, 31(10), 7053–7073. doi:10.1080/10494820.2022.2061006.
2. Du Plooy, E., Casteleijn, D., & Franzsen, D. (2024). Personalized adaptive learning in higher education: A scoping review of key characteristics and impact on academic performance and engagement. Heliyon, 10(21), e39630. doi:10.1016/j.heliyon.2024.e39630.
3. Gligorea, I., Cioca, M., Oancea, R., Gorski, A.-T., Gorski, H., & Tudorache, P. (2023). Adaptive Learning Using Artificial Intelligence in e-Learning: A Literature Review. Education Sciences, 13(12), 1216. doi:10.3390/educsci13121216.
4. Ifenthaler, D., & Yau, J. Y.-K. (2020). Utilising learning analytics to support study success in higher education: a systematic review. Educational Technology Research and Development, 68, 1961–1990. doi:10.1007/s11423-020-09788-z.
5. Banihashem, S. K., Noroozi, O., van Ginkel, S., Macfadyen, L. P., & Biemans, H. J. A. (2022). A systematic review of the role of learning analytics in enhancing feedback practices in higher education. Educational Research Review, 37, 100489. doi:10.1016/j.edurev.2022.100489.

6. Aldowah, H., Al-Samarraie, H., & Fauzy, W. M. (2019). Educational data mining and learning analytics for 21st century higher education: A review and synthesis. Telematics and Informatics, 37, 13–49. doi:10.1016/j.tele.2019.01.007.
7. Yalamov G. Yu., Shikhnabieva T. Sh. Adaptive educational information systems: approaches to intellectualization // Man and education. 2018. No. 4 (57). P. 84–90.
8. Malmqvist, J., Lundqvist, U., Rosén, A., & Edström, K. (2022). The CDIO Syllabus 3.0 – An Updated Statement of Goals. In Proceedings of the 18th International CDIO Conference.
9. Mukhammadiev F. G. The possibilities of information technologies in education in the professional training of students // Physics, mathematics and computer science. 2022. No. 3. P. 139–144.
10. Kataev M. Yu., Sukhorukov A. A., Bulysheva L. A. Network planning methodology in the problem of adaptive learning of university students // Informatics and education. 2020. No. 8 (317). P. 45–56. DOI: 10.32517/0234-0453-2020-35-8-45-56.
11. Kasimakhunova A.M., Atajonova S.B. (2022) Study of interdisciplinary connections between physics and special objects of the specialty "Mechatronics and Robotics" // Bulletin of the National University of Uzbekistan (ACTAUZ), [1/2]. P. 83-86.
12. Khasanova, M. (2026). Principles of developing adaptive methods of teaching students of technical universities. International Online Multidisciplinary Conference, 995–998.