Journal of Engineering Science and Technology
Vol. 20, No. 6 (2025) 1959 - 1973

ORGANIZING SELF-EDUCATION FOR ENGINEERING STUDENTS THROUGH AN INDIVIDUAL APPROACH: A SCIENCE AND TECHNOLOGY PERSPECTIVE TO SUPPORT SUSTAINABLE DEVELOPMENT GOALS (SDGS)

URAL DOBILOVICH KHIDIROV[1],
MUZAFFAR FARMONOVICH TURAEV[2],*, SAODAT KHAMIDOVNA GAYUPOVA[3], SOBIR JUMAKULOVICH YAXYAYEV[4],
LOLA RAHMATULLAYEVNA RAJABOVA[5], GULBAHOR XUSHMURODOVNA ESHMURODOVA[6], NARGIZA TOXIROVNA AVULOVA[7], GULBAXOR XAZRATKULOVNA ESHBEKOVA[8]

[1]Center for Strengthening the Material and Technical Base of Higher and Professional Educational Institutions, Tashkent, Uzbekistan
[2]University of Information Technologies and Management, Karshi, Uzbekistan
[3]Chirchik State Pedagogical University, Chirchik, Uzbekistan
[4]Karshi State Technical University, Karshi, Uzbekistan
[5]Karshi State University, Karshi, Uzbekistan
[6]University of Information Technologies and Management, Karshi, Uzbekistan
[7]Samarkand State University named after Sharof Rashidov, Samarkand, Uzbekistan
[8]Pedagogical Skills Center of Samarkand Region, Samarkand, Uzbekistan
*Corresponding Author: mturayev92@gmail.com

Abstract

This study examined mechanisms for organizing self-education of engineering students through an individual approach grounded in science and technology perspectives. We reviewed policy, pedagogy, and practice, and synthesized procedures for dialogic, group, and role-based activities supported by digital platforms, adaptive guidance, and learning analytics. The approach clarified goals, tasks, and schedules, strengthened mutual learning in small groups, and improved autonomy, reflection, and skill formation. Individualization works because it aligns cognitive and motivational differences with technology-enabled monitoring, feedback, and practice at scale while preserving human guidance. The framework helps programs operationalize self-education within credit module reforms, informs course design for technical and electrotechnical contexts, and guides institutions in prioritizing infrastructure, teacher development, and collaboration. We outline practical conditions for independent activity planning, control work design, minimal task sets, and clear submission windows, and map these to monitoring, action analysis, systematization, and psychodidactic review through authentic workplace simulations. This study supports current issues in sustainable development goals (SDGs).

Keywords: Autodidactic learning, Engineering education Individual approach, Learning analytics, Pedagogical technology.

1. Introduction

In recent years, global developments in educational reform and digital transformation have reshaped the expectations of higher education systems, especially in developing countries [1]. Many reports regarding this digitalization have been well-documented [2-7]. In Uzbekistan, this transformation is guided by national policy (specifically the Presidential Decree No. PF-5847 (2019)), which mandates the implementation of a credit-module system across higher education institutions by 2030. Within this structure, a significant portion of the academic workload is allocated to independent study, with a proposed 40/60 ratio between classroom instruction and self-directed learning, respectively (Decree of the President of the Republic of Uzbekistan, 2019). This shift necessitates a fundamental revaluation of pedagogical strategies, particularly in the field of engineering education, where content complexity, technological application, and professional preparedness converge.

Engineering education inherently demands more than the passive acquisition of theoretical knowledge. Many reports regarding science and engineering education have been well-documented [8, 9]. It requires active problem-solving, systems thinking, design-based decision-making, and the development of practical competencies. These demands position self-directed learning not as a supplement, but as a critical pedagogical priority. However, effective self-education is not a default outcome of curriculum reform; it must be carefully organized, supported by institutional structures, technological tools, and pedagogical frameworks that are sensitive to the psychological and cognitive development of learners [10].

Despite the growing relevance of independent learning, much of the existing instructional design in engineering remains teacher-centred, rigid, and uniform. Traditional methods prioritize content delivery through lectures, standardized tasks, and exam-based assessment. These approaches often neglect individual differences in learning pace, interests, or motivation. They also fail to fully leverage technological tools for feedback, personalization, or monitoring. Consequently, students may struggle with autonomy, time management, or applying theoretical knowledge in real-life scenarios.

A growing body of pedagogical literature advocates for a shift toward individualized learning models, ones that empower students to make informed decisions about their learning goals, schedules, tools, and outcomes. In the Uzbek context, several national researchers have explored aspects of independent learning, including its psychological foundations, organizational structures [11], and methodological design in various subjects such as geometry, physics, and literature. While these studies contribute important disciplinary insights, they often lack integration with technological innovation or system-level implementation aligned with current reform agendas.

To address this gap, it is necessary to construct a comprehensive framework for individualized self-education that merges principles from cognitive psychology, educational technology, and engineering pedagogy. Such a framework must consider the role of the teacher as a facilitator of learning environments, not merely a transmitter of content. It must also incorporate digital tools such as learning analytics, adaptive learning platforms, and simulation software to monitor student engagement and provide personalized feedback. Importantly, this approach recognizes that student autonomy must be scaffolded through planning, coaching, and reflective assessment, particularly in technical disciplines where prerequisite mastery and logical sequencing are critical.

The framework also emphasizes humanization in engineering education, the idea that learners should be treated as capable individuals with diverse needs, motivations, and developmental trajectories. Humanization demands that the institutional culture support learner agency, dignity, and growth. It also requires a balanced integration of collaborative practices such as group learning and mutual feedback, which enhance cognitive flexibility and communication (both essential skills in professional engineering environments) [12].

Finally, the implementation of such an individualized model of self-education is not only a pedagogical challenge but a strategic institutional concern. It requires investment in infrastructure, development of faculty competencies, digital governance, and curriculum flexibility. Leadership must support experimentation, encourage formative assessment models, and create ecosystems that value student-driven inquiry over passive compliance [13, 14].

The purpose of this study is to explore the mechanisms, conditions, and technological enablers for organizing individualized self-education among engineering students in Uzbekistan. It draws upon national and international scholarship to propose a context-sensitive, scalable, and technology-integrated pedagogical model. The novelty of this paper lies in its holistic perspective, merging policy, pedagogy, and platform design to articulate a science-and-technology-informed framework that supports autonomy, adaptability, and professional readiness in engineering education. This study supports current issues in sustainable development goals (SDGs).

2. Literature Review

The concept of independent learning has long been a subject of interest among pedagogical scholars, especially in the context of training professionals capable of adapting to complex and dynamic environments. In the engineering domain, where technology, cognition, and design converge, the need for structured and personalized self-education has become even more pronounced. This section synthesizes major theoretical and empirical contributions related to self-education, individual approaches, and technology-enhanced pedagogy within higher education.

Several researchers have contributed substantially to the discourse on independent learning. One work emphasized autodidactic learning as a central component of vocational teacher education, defining it as the development of autonomy in acquiring knowledge, and underscoring the need for institutional mechanisms that support student-driven learning. Further studies explored the pedagogical conditions required for independent thinking and professional readiness, especially among future teachers.

Other scholars have investigated discipline-specific strategies for organizing independent study. Methods for developing competencies through structured self-work in geometry education were proposed. Independent educational activities in physics learning were examined, while the formation of inventive and independent thinking in students was addressed through problem-solving and individualized task assignments. A methodology of independent work in literature classes showed how creative activities could encourage deeper engagement, even if independent thinking was not the explicit focus.

These national studies align with international perspectives on self-regulated learning and autonomy in higher education. The importance of giving students opportunities to plan, monitor, and evaluate their own learning processes was emphasized, with the argument that true independence requires the ability to regulate actions without continuous external guidance. Competence development was linked to the management of independent cognitive activity, with self-organization seen as a key factor in transforming knowledge into applicable skill sets.

Technological integration into education has also been a central theme in the literature. The didactic potential of computer technologies to support individualized learning was highlighted, with digital tools shown to enable learners to select resources, visualize concepts, and track progress according to individual learning styles and paces. Educational technologies were further described as vehicles for personalization, competency development, and systemic reform.

In engineering education, the inclusion of technical parameters in learning processes (such as action monitoring, systematization, automation, and psychodidactic analysis) was explored in research on technical learning tools like the spinning extractor, offering insights into how engineering tasks can be embedded into pedagogical design for experiential learning [15]. Such works support the alignment of engineering-specific objectives with pedagogical models of individualization.

Group-based learning as a structured form of autonomy also appears frequently in the literature. The concept of mutual learning and dialogic interaction was framed within the educational process as a system requiring both collaborative and independent participation [11]. This has particular relevance in engineering contexts where interdisciplinary coordination and teamwork are essential.

Institutional and systemic considerations are likewise recognized as essential for effective self-education. Educational clusters were seen as valuable for enabling collaborative resource sharing, faculty development, and inter-institutional integration [12]. These clusters create both formal and informal pathways for student-led learning through academic platforms and shared infrastructure.

Further studies emphasized governance, faculty competence, and digital transformation as critical elements in fostering sustainable self-education ecosystems [13, 14]. These works suggest that policy reform, technological investment, and academic leadership must converge to support a robust culture of independent learning.

This review demonstrates a scholarly consensus that organizing self-education requires a comprehensive approach incorporating cognitive, motivational, organizational, and technological elements. In engineering education, such approaches must also integrate real-world technical parameters into pedagogical design. The present study builds on these insights by proposing a science- and technology-enabled framework for individualized independent learning, adapted to the structure and needs of engineering education in Uzbekistan.

3. Method

This study employed a qualitative-descriptive approach to analyse how individual approaches can be implemented in organizing self-education among engineering students. The method consisted of three core components: theoretical analysis, policy review, and pedagogical modelling. Together, these stages formed the basis for outlining a framework that integrates psychological, organizational, and technological aspects of independent learning tailored to engineering education.

The first component involved the conceptual analysis of independent learning based on previous pedagogical research. Key insights were derived from foundational works, which examined autodidacticism and self-regulated education. This stage helped identify core elements such as autonomy, reflection, planning, and motivation, which are essential for successful self-education. The literature also highlighted the significance of contextual variables such as field of study, level of training, and technological infrastructure in shaping the process of independent learning.

In the second stage, we conducted a critical review of Uzbekistan's educational reforms, particularly the transition to the credit-module system as outlined in Presidential Decree No. PF-5847 in 2019). The reform mandates that students allocate the majority of their academic time (on average, 60%) to self-directed activities. This policy context served as the foundation for developing mechanisms of independent learning that align with national standards and institutional goals. The review further emphasized the need to prepare students for lifelong learning and market adaptability, especially in technical and engineering disciplines.

The third component consisted of modelling pedagogical mechanisms for individualization in self-education. This modelling process drew from educational technology literature and focused on integrating technological systems such as learning analytics, adaptive learning platforms, and digital resource management into the pedagogical structure. Specifically, the model included four operational layers:

(i) Personalization of Learning Goals: Using diagnostic tools and teacher consultations to identify student interests, prior knowledge, and learning styles.

(ii) Design of Task Structures and Schedules: Students were guided to construct learning plans that focused on deliverables, deadlines, and time budgets. Schedules also included independent and control assignments linked to real-world engineering tasks.

(iii) Implementation of Feedback and Monitoring Tools: Digital systems were proposed for capturing learning behaviours, assessing performance, and enabling formative feedback cycles. This approach aligned with the notion of information transmission and correction loops between student and teacher.

(iv) Group-Based and Dialogic Activities: Mutual learning environments were integrated into the model to enhance independent learning through collaboration, discussion, and peer evaluation.

Additionally, task modelling was informed by workplace simulation logic. Parameters such as type and sequence of operations, level of automation, and systematization of tasks were embedded in the instructional design, based on the framework of psychodidactic analysis proposed in the original study. These components enabled the alignment of educational goals with production tasks in technical and electrotechnical settings.

To ensure humanization within the engineering learning process, the model incorporated value-based education principles. Students' cognitive development was contextualized within motivational and emotional dimensions, requiring educators to balance standardized requirements with individualized scaffolding. The model also required teachers to engage at the level of pedagogical mastery, adjusting tactics based on students' cognitive pace, problem-solving ability, and self-regulatory capacity.

The method also emphasized the importance of socialization and professionalization through educational design. These elements were addressed through cooperative projects, role-based training, and reflective discussions on professional identity. Instructors acted as mediators, not merely information providers, ensuring that students' self-education experiences were structured, scaffolded, and reflective of workplace realities.

Overall, this multifaceted methodological approach combined theoretical analysis, policy alignment, and model construction to propose an integrated framework for organizing self-education among engineering students. It positioned technology not merely as a support tool but as an enabler of pedagogical transformation, capable of expanding the scope, precision, and personalization of learning in engineering education.

4. Results and Discussion

4.1. Framework of individualized self-education in engineering

In modern scientific literature, the educational process is conceptualized as a multi-level system composed of a series of interrelated tasks aimed at achieving defined learning outcomes. These tasks are organized and executed through the collaboration of teachers and students. According to this view, the relationship between teacher and student is multifactorial and dynamic, ranging from subject-subject to subject-object interactions. The core of these relationships lies in the teacher's ability to organize the student's educational activities, ensuring the mastery of educational content.

Figure 1 illustrates the conceptual framework of individualized self-education based on three primary domains: psychological foundations, technological infrastructure, and pedagogical strategies.

The individualized approach empowers students to take responsibility for selecting goals, determining their learning pace, managing resources, and setting schedules. This autonomy in self-directed education is not merely a logistical adjustment; it represents a philosophical shift in how learners are positioned within the educational process. The belief that "nothing can be taught, but everything can be learned" underlines the student's central role in knowledge acquisition. From this perspective, the task of the teacher shifts from transmission of information to the orchestration of learning environments where students can build understanding collaboratively and independently.

One of the critical issues in engineering education is the integration of independent activities with professional preparation. Engineering students must develop competencies not only in theoretical knowledge but also in practical problem-solving and real-world applications. To address this, the framework incorporates psychodidactic principles that consider cognitive functions (such as attention, memory, and imagination) as well as motivational and emotional factors that influence learning. Educators must align learning strategies with these psychophysiological characteristics to support the student's development at both academic and personal levels.

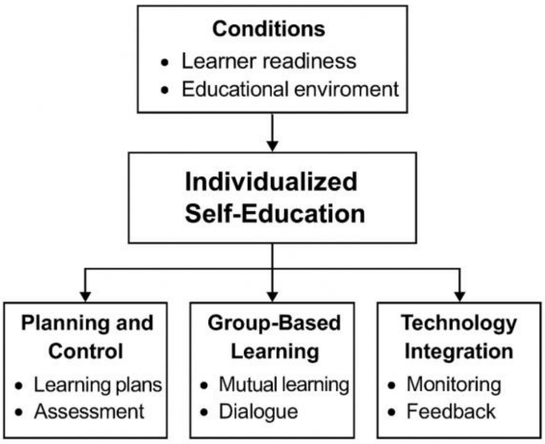

Fig. 1. Conceptual framework for individualized self-education in engineering education.

A central aspect of the framework is the organization of the educational process as a system. In this context, “organization” refers to more than institutional structure; it encompasses purposeful coordination around shared goals, roles, and responsibilities. The literature defines organization as a system characterized by several features: a defined goal, complementary actors (students, teachers, administrators), internal management structures, bounded identity, and a shared cultural environment [11]. This systemic perspective ensures that self-education efforts are not isolated activities but are part of a cohesive institutional process supported by infrastructure, policies, and values.

Another feature of this framework is the inclusion of learning analytics and adaptive technologies as tools to enhance individualized instruction. These technologies serve as instruments for feedback, assessment, and progress tracking. Learning analytics, for example, provide insights into students’ engagement levels, pace of learning, and areas of difficulty. This data allows educators to intervene strategically and adjust instruction based on evidence. Adaptive learning platforms also enable the automatic delivery of personalized content sequences, fostering student autonomy while maintaining instructional coherence.

Moreover, the framework emphasizes humanization in engineering education. Humanization refers to recognizing the student as a whole person with rights to self-determination, personal development, and meaningful learning experiences. This perspective requires the alignment of professional training with students’ values, interests, and psychological needs. It also implies that educational institutions must shift from rigid, standardized approaches toward flexible, student-centred strategies that support identity formation and social integration.

4.2. Conditions for independent activity planning and control work

To implement individualized self-education effectively, several pedagogical and procedural conditions must be met. These conditions address both the structural and cognitive dimensions of learning and are intended to facilitate the development of student independence in a systematic and manageable way.

A number of researchers proposed essential conditions for planning and organizing independent educational activities. These include the establishment of a clear learning schedule, integration of control tasks, and the provision of instructional scaffolding. According to this model, a student's learning plan should focus on the final product of learning. This could be a written report, project outcome, or practical task related to engineering concepts. The product-oriented structure encourages goal-setting, accountability, and self-assessment.

Table 1 outlines the recommended structure for organizing self-education plans based on literature and policy analysis.

Table 1. Recommended structure for independent learning plans in engineering education.

Component	Description
Final Product Focus	Each learning plan should be directed toward a tangible outcome (e.g., report, project, simulation result).
Integrated Task List	Includes both independent and control assignments with clear expectations.
Minimum Required Tasks	Specifies the essential learning activities to prevent cognitive overload.
Time Budget Alignment	Tasks are planned based on realistic time management principles.
Task Limit	A maximum of two active tasks per 1–2 month period to ensure depth over breadth.
Submission Deadlines	Clear schedule for each task, including control work.
Support References	Includes learning modules, methodological guides, and digital tools.

In designing the schedule, all planned tasks (including independent and control work) should be listed alongside their expected outcomes and submission deadlines. The control work serves as a measure of the student’s capacity for independent thinking and synthesis of content. It represents a high degree of independence and should reflect both the classroom instruction and self-directed efforts. These control works must be aligned with specific learning objectives and technical competencies in engineering, ensuring authenticity and relevance.

Assignments for independent activity should also include a minimum essential task list, accounting for realistic time budgets. Students should not be overwhelmed with volume but rather be encouraged to engage deeply with fewer, more meaningful tasks. To foster planning and time management skills, students should be provided with tools such as progress charts, checklists, and milestone tracking forms. These tools reduce unproductive time and focus attention on deliberate practice and reflection.

Another recommendation involves limiting the number of simultaneous tasks to prevent cognitive overload. Research suggests that assigning no more than two independent projects within a one to two-month window enables deeper engagement and better quality of output. Scheduling must also indicate deadlines for submission and evaluation of tasks, helping students to develop discipline, self-regulation, and a sense of ownership over their learning trajectory.

To support these conditions, students should be provided with methodological references, including digital learning modules, department handbooks, and electronic learning programs tailored for independent study. These resources offer structure, guidance, and content-specific scaffolds to facilitate self-directed inquiry and problem-solving.

By incorporating these conditions, educators create a stable yet flexible learning environment that allows for individual trajectories within a standardized curriculum. This balance is essential in engineering education, where both accreditation standards and personal creativity must be accommodated. The implementation of such structured autonomy builds competence, confidence, and motivation among students while aligning learning processes with broader institutional and professional goals.

4.3. Group-Based mutual learning and dialogic interactions

Figure 2 presents the model of communication in group-based learning environments, where knowledge construction occurs through peer interaction and self-expression.

A distinctive feature of effective self-education in engineering is the incorporation of dialogic and group-based strategies to complement individualized efforts. Group learning provides an opportunity for students to externalize internal cognitive processes, validate their understanding through discourse, and receive feedback in real-time. These dynamics enhance not only the assimilation of knowledge but also the development of communication and collaboration skills, which are essential in the engineering profession.

The structure of group work should involve various roles, including facilitators, presenters, questioners, and evaluators [11]. Students are encouraged to rotate through these roles to develop multifaceted perspectives. In this setting, learning becomes a co-construction of knowledge rather than an individual accumulation. Each student contributes to and benefits from the shared intellectual effort.

To assess participation and learning outcomes in group settings, several indicators are useful: number and quality of questions posed, originality of proposed solutions, responsiveness to peer feedback, and clarity of task execution. These criteria offer measurable markers for evaluating student engagement and cognitive growth. Encouraging students to defend their ideas within group discussions cultivates both critical thinking and scientific reasoning, core competencies in technical education.

Furthermore, group learning activities often take the form of problem-solving workshops, where students work collaboratively to address engineering challenges grounded in real-world contexts. The use of technical case studies, simulations, and role-playing allows students to apply theoretical knowledge in practical settings. This kind of experiential learning is particularly effective in promoting inventive thinking and applied creativity.

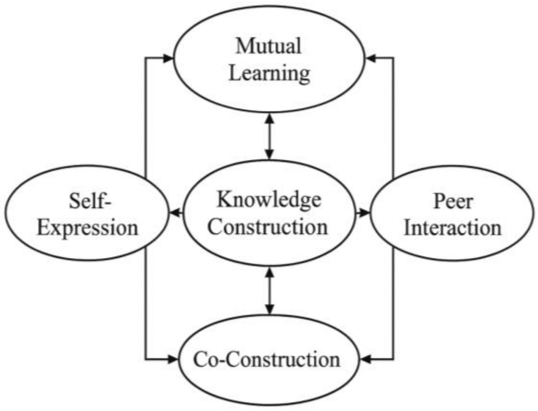

Fig. 2. Model of dialogic interaction and mutual learning in group-based self-education.

An important component of this process is mutual learning (a pedagogical orientation in which students learn by teaching and explaining concepts to one another). This “self-educating community” model transforms passive learners into active knowledge creators. The feedback loop is immediate and multidirectional, reinforcing understanding and retention.

Group work also plays a role in shaping organizational culture. When students enter higher education institutions, they are gradually socialized into the values, norms, and behaviours expected within academic and professional communities. The group becomes not only a cognitive environment but also a cultural unit where identity, motivation, and collaboration are cultivated.

In engineering education, this collaborative mode also reflects workplace realities, where most projects are team-based. Therefore, mastering the interpersonal and collaborative aspects of learning becomes essential preparation for post-graduate employment. The integration of group-based self-education within the curriculum ensures that students do not develop in isolation but are embedded in a supportive, intellectually stimulating environment.

4.4. Technology-Enabled monitoring and feedback systems

As shown in Table 2, the successful implementation of individualized self-education in engineering relies on various types of educational technologies that support personalization, monitoring, and feedback.

The introduction of educational technologies (such as learning management systems (LMS), intelligent tutoring systems, and learning analytics dashboards) has transformed the landscape of self-directed learning. In the context of engineering education, these technologies enable fine-tuned observation of student behaviours, allowing instructors to diagnose learning difficulties early and intervene appropriately.

Learning analytics tools track indicators such as time-on-task, number of attempts, and performance progression. These data points are aggregated into dashboards that help both students and teachers make informed decisions. For example, a student who consistently spends less time on certain tasks may be flagged for potential disengagement, prompting instructors to offer support or adjust instructional strategies.

Table 2. Key educational technologies for supporting individualized self-education.

Technology Tool	Function in Self-Education
Learning Analytics Dashboards	Track engagement, performance trends, and time-on-task to guide timely intervention.
Adaptive Learning Systems	Deliver personalized learning pathways and auto-adjust content sequencing.
LMS Platforms (e.g., Moodle)	Provide structured access to tasks, assessments, feedback, and communication tools.
Simulation Software	Enable experiential, workplace-aligned practice through digital engineering labs.
E-Portfolios	Help students track long-term progress, reflect on work, and curate outcomes.
Feedback Engines	Offer real-time formative feedback on task completion, comprehension, and errors.

Adaptive learning systems also play a significant role. These platforms use algorithms to personalize learning pathways based on user input and performance. In doing so, they respect the individual pace, style, and preferences of learners. This is particularly useful in engineering courses that often contain layered, prerequisite-based content, such as physics, calculus, and systems design.

Importantly, digital tools also facilitate feedback loops that are immediate, individualized, and actionable. This stands in contrast to traditional feedback mechanisms, which are often delayed and generalized. The immediacy and relevance of feedback are crucial in maintaining motivation and guiding correction. Technological systems thus support not just the monitoring of learning, but also its regulation and reinforcement.

To ensure accessibility and effectiveness, the implementation of these technologies must be accompanied by faculty training, infrastructure investment, and the development of data governance policies. These considerations are critical in environments with limited digital maturity. Collaborative resource-sharing and regional educational clusters can help offset disparities in technological capacity across institutions [12].

Another technological tool discussed in the literature is the digital simulator, which mimics real-world environments for practicing engineering tasks. These systems allow students to experiment, observe, and make decisions in controlled settings. Simulators bridge the gap between theory and practice and provide low-risk environments for skill development and failure-based learning [15].

Taken together, these technologies not only support self-education but redefine it. They shift the focus from passive content consumption to active, data-informed engagement, where learners and educators collaborate in real time to optimize learning trajectories. In this digitally augmented model, independence does not equate to isolation; rather, it reflects empowered agency within a richly resourced and responsive learning ecosystem.

4.5. Integrating workplace simulation and psychodidactic structuring

The nature of engineering education necessitates a connection between academic knowledge and practical workplace readiness. As such, a critical dimension in organizing individualized self-education lies in the simulation of authentic work environments within the learning process. Figure 3 introduces the structuring of learning activities based on psychodidactic logic rooted in engineering contexts.

To ensure that students' independent learning is not disconnected from professional realities, tasks should mirror engineering operations through the inclusion of parameters such as operation type, level of automation, and sequence complexity. These alignments allow students to internalize professional workflows while developing transferable cognitive and procedural skills [15]. The structuring process includes four key stages:

(i) Monitoring: Identifying and observing core actions involved in technical operations.

(ii) Action Analysis: Deconstructing complex operations into individual components.

(iii) Systematization: Establishing relationships among sub-tasks and organizing them into efficient workflows.

(iv) Psychodidactic Review: Evaluating cognitive loads, decision points, and error-prone areas to refine instructional design.

This instructional modelling promotes metacognition and strategic thinking, key skills required for high-level engineering practice. Students are no longer only recipients of content but become system-thinkers capable of analysing processes, simulating scenarios, and optimizing performance through repeated self-guided engagement.

Moreover, this model respects cognitive ergonomics, reducing extraneous load while amplifying germane processing. The complexity of engineering concepts requires a careful balance between autonomy and structure. Overloading students with ill-defined tasks may result in cognitive fatigue or disengagement. Therefore, simulation-based assignments are sequenced with increasing complexity, guided by scaffolded autonomy, which fades gradually as competence increases.

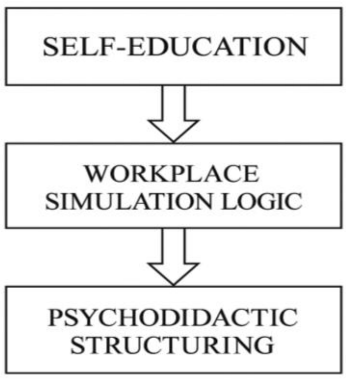

Fig. 3. Psychodidactic structuring of self-education based on workplace simulation logic.

4.6. Human-Cantered digitalization of engineering education

While technological tools provide scale, efficiency, and precision in self-education, their implementation must remain grounded in human-centred pedagogy. The danger of over-automating instructional processes is the potential detachment of learners from meaningful engagement. Therefore, the digitalization of education must reinforce, not replace, the human aspects of learning (motivation, curiosity, self-efficacy, and reflection).

The role of teachers is crucial in this context. Pedagogical systems must be designed to allow teacher flexibility and discretion in responding to students' developmental needs. Digital platforms should empower educators to personalize pathways, provide formative diagnostics, and facilitate empathetic interventions (not merely deliver standardized content).

Moreover, technology must adapt to diverse learner identities. Students differ in learning preferences, cultural backgrounds, and prior experiences. A rigid one-size-fits-all system may exacerbate educational inequalities. Human-centred digital education, therefore, must integrate tools for accessibility, multilingual support, and diverse content formats.

Engineering educators must also foster digital literacy as a parallel outcome of self-education. Students must be equipped not only to consume content through digital media but also to evaluate, organize, and produce knowledge using technological tools. This reflects a broader aim of developing critical digital competence, which is essential for both academic and professional success in the 21st century.

4.7. Building a culture of self-education within institutions

Beyond the individual and technological dimensions, the success of self-education depends on the cultivation of a supportive organizational culture. Institutions must foster environments that value curiosity, experimentation, and autonomous inquiry. This requires a shift in assessment practices, faculty development, and institutional leadership.

Firstly, assessment systems must move beyond summative grading to include process-oriented evaluation, peer feedback, and portfolio-based assessments. This enables students to track their progress holistically, reflecting on both product and process. Institutions should invest in developing educators' capacity to design such assessments and interpret them constructively.

Secondly, the development of faculty as facilitators of self-education is essential. This involves training in mentoring, coaching, and technological mediation. Faculty members must be able to model self-directed learning themselves, guiding students in setting goals, navigating ambiguity, and evaluating progress. As shown in cluster-based education models, collaborative faculty development within institutional networks enhances pedagogical resilience and innovation [12].

Thirdly, leadership must align policies and resources with the pedagogical goals of individualized education. This includes ensuring stable internet access, digital libraries, online communication platforms, and technical support. Leaders must also reward innovation in teaching practices and support flexible curriculum structures that allow for individualized pacing and content sequencing [13, 14].

Finally, students should be socialized into a community of practice that promotes lifelong learning. From orientation programs to capstone projects, students must repeatedly engage in reflective dialogues about their learning strategies, career paths, and identity formation. This recursive engagement nurtures the metacognitive and motivational foundation for sustained self-education. This study supports current issues in SDGs, as reported elsewhere [10, 16-19].

5. Conclusions

The results discussed above demonstrate that organizing self-education based on an individual approach in engineering education requires a balanced integration of cognitive science, educational technology, and collaborative pedagogies. Through structures such as learning plans, controlled work, mutual group learning, and adaptive systems, institutions can offer a framework that empowers students while maintaining academic rigor. The findings also reinforce the importance of context: the successful implementation of these mechanisms depends heavily on institutional readiness, teacher competencies, and infrastructure support. As Uzbekistan's higher education reforms continue, aligning individualization strategies with national policy and local capacities will be essential.

References

1. Al Husaeni, D.F.; Al Husaeni, D.N.; Nandiyanto, A.B.D.; Rokhman, M.; Chalim, S.; Chano, J.; Al-Obaidi, A.S.M.; and Roestamy, M. (2024). How technology can change educational research? Definition, factors for improving quality of education and computational bibliometric analysis. *ASEAN Journal of Science and Engineering*, 4(2), 127-166.
2. Risnandar, R.; and Sakti, A.W. (2022). Optimizing Instagram in sociology materials to improve digital literacy for junior high school students. *ASEAN Journal of Educational Research and Technology*, 1(1), 39-46.
3. Ariyanti, L.S.; and Nandiyanto, A.B.D. (2022). Distance teaching of stress materials to junior high school students using digital media. *ASEAN Journal of Community Service and Education*, 1(1), 7-14.
4. Hartanto, V.A.; and Nandiyanto, A.B.D. (2022). Fun simple style and airplane science teaching to digital-based elementary school students. *ASEAN Journal of Community Service and Education*, 1(1), 15-22.
5. Wijaya, S.; and Nandiyanto, A.B.D. (2022). Weather and Its effect learning on digital-based early childhood education students. *ASEAN Journal of Community Service and Education*, 1(1), 69-76.
6. Hidayat, A.Z.; and Nandiyanto, A.B.D. (2022). Socialization of digital literacy in compiling a balanced healthy menu to members of POKJA III the PKK Movement Team of Purwakarta Regency. *ASEAN Journal of Community Service and Education*, 1(1), 77-82.
7. Musayaroh, S.; Asmiati, N.; Utami, Y.T.; Mulia, D.; Sidik, S.A.; Abadi, R.F.; Pratama, T.Y.; Maslahah, S.; and Pramudyo, A.S. (2023). A digital accessibility and inclusive design-based e-module in higher education: Does it work in a classroom with a deaf student? *ASEAN Journal of Community and Special Needs Education*, 2(1), 55-60.
8. Fiandini, M.; Mukhamedov, G.I.; Khimmataliev, D.O.; and Nandiyanto, A.B.D. (2025). Advancing sustainability and green engineering in mechanical

engineering education: Concepts, research trends, challenges, and implementation strategies. *ASEAN Journal for Science and Engineering in Materials*, 4(2), 169-224.

9. Susilawati, A. (2024). A bibliometric analysis of global trends in engineering education research. *ASEAN Journal of Educational Research and Technology*, 3(1), 103-110.
10. Yu, X.; Chano, J.; and Wongsaphan, M. (2026). Enhancing occupational identity and self-efficacy through a self-education model in art and design education aligned with sustainable development goals (SDGs). *ASEAN Journal of Educational Research and Technology*, 4(1), 19-46.
11. Tolipova, J. (2002). Organization of independent education of students. *Public Education*, 4, 102-103.
12. Khimmataliev, D.O.; Elmurzayeva, N.Kh.; Sharakhmatova, A.K.; Sotbarov, A.A.; Khalmatova, D.A.; and Jamoldinova, S.N. (2022). Development of the pedagogical (educational) cluster in the regional educational space. *Journal of Pharmaceutical Negative Results*, 13(Special Issue 7), 5629-5633.
13. Usarov, J.E.; Khimmataliev, D.O.; Kiyamov, N.S.; Kodirova, F.U.; Abdujalilova, S.A.; Koraev, S.B.; Elmurzaeva, N.Kh.; and Saidov, Z.Kh. (2022). Formation of pedagogical clusters of scientific and methodical cooperation educational organizations of regions. *Journal of Pharmaceutical Negative Results*, 13(Special Issue 7), 5639-5644.
14. Haitov, O.; Berdalieva, G.; Abdullayeva, S.; and Sharipova, G. (2022). Improvement of pedagogical mechanisms of application and management of the principle of integrity in the system of training of physical education and sports specialists. *Journal of Pharmaceutical Negative Results*, 13(Special Issue 7), 5019-5022.
15. Mukhammedov, G.; Djumabaev, G.X.; Makhmudova, D.; Usarov, J.; and Khimmataliev, D.O. (2023). The basis of the parameters of the spin extractor tool on the interned spinning machine. *E3S Web of Conferences*, 402, 14033.
16. Xing, G.; Chano, J.; Thadanatthaphak, Y.; and Wu, C.C. (2025). Physical adaptation of college students in high-altitude training: Empirical findings and curriculum development insights to support sustainable development goals (SDGs). *ASEAN Journal of Educational Research and Technology*, 4(2), 215-236.
17. Imaniyati, N.; Ratnasari, C.D.; and Adman, A. (2025). Enhancing job satisfaction through human resource information systems and communication: A commitment-based approach to achieve Sustainable Development Goals (SDGs) in education-oriented organizations. *ASEAN Journal of Educational Research and Technology*, 4(2), 237-254.
18. Wiyanarti, E.; and Nurjannah, A.N. (2026). Influence of self-efficacy on affective learning outcomes in social studies education toward achieving sustainable development goals (SDGs). *ASEAN Journal of Educational Research and Technology*, 4(1), 1-18.
19. Ragadhita, R.; Fiandini, M.; Al Husaeni, D.N.; and Nandiyanto, A.B.D. (2026). Sustainable development goals (SDGs) in engineering education: Definitions, research trends, bibliometric insights, and strategic approaches. *Indonesian Journal of Science and Technology*, 11(1), 1-26.