Teacher Education through Learning Engineering: An Action Research on Faculty Transformation

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This study aims to examine the digital transformation process conducting in the faculty of education through an action research approach. The process began in the beginning of 2025 with comprehensive needs analysis and continued with focus group interviews with key stakeholders. Based on the findings, the learning engineering approach has been adopted to the curriculum of faculty of education as a guiding framework. Accordingly, professional development seminars have been conducted for faculty members, courses have been revising, and the design and implementation of four new courses have been planned for the initial phase. The study follows a qualitative research design utilizing action research within a single case study framework. As the transformation of the faculty continues on the basis of the learning engineering framework, this study aims to provide information about the process and the outcomes so far.

Introduction

In today's world, technological changes and societal expectations are rapidly transforming the scope of the teaching profession and the approach to teacher education. The education system and the teaching profession were shaped to meet the needs of the First Industrial Revolution and designed to suit the economic and social structure of that era. A standardized, hierarchical, and teacher-centered structure, similar to a factory layout, was adopted for schools. This system aimed to cultivate a disciplined workforce with basic skills for a mass-production-based economy. However, in the age of digitalization, artificial intelligence, automation, and globalization brought by the Fourth Industrial Revolution, this educational model can no longer meet the requirements of the modern world (OECD, 2025a, UNESCO, 2021).

Today, a world order based on the knowledge economy necessitates raising individuals who prioritize skills such as problem-solving, creativity, collaboration, and critical thinking (World Economic Forum, 2025). Especially with the rise of artificial intelligence, the requirements for 21st century are becoming prominent, allowing each student to learn at their own pace and according to their needs. However, existing education systems, operating on the industrial paradigm of the 19th century, are proving insufficient in equipping students with the competencies required by this era. The teaching profession and the education system must be updated with new paradigms such as individualized learning, digital literacy, and continuous learning. For this, utilization of the learning engineering approach may be a solution to make educational processes more dynamic, personalized, and effective.

According to UNESCO’s Global Report on Teachers (UNESCO & International Task Force on Teachers for Education 2030, 2024) teaching profession has challenges in terms of status and sustainability of profession. The report highlights a critical global shortage of teachers, estimating a need for 44 million additional primary and secondary teachers by 2030. A central

cause of these shortages is the declining social status and attractiveness of the teaching profession worldwide. In many countries, the teaching profession is increasingly viewed as less prestigious and less appealing for younger generations. Unattractive salaries, challenging working conditions, and increasing workloads discourage candidates from both entering and remaining in the profession.

Whereas as it is stated in the report (UNESCO & International Task Force on Teachers for Education 2030, 2024), teachers are fundamental to ensuring high-quality education. Therefore, all teachers should receive adequate, relevant and pedagogically sound training aligned with system curricula and contextual needs. However, many teacher preparation systems currently fall short. Many new teachers report feeling unprepared for diverse classrooms, particularly those involving mixed abilities, multilingual students, or vulnerable learners. Moreover, the lack of adequate training in ICT competencies is another challenge. Looking forward, UNESCO emphasizes the need for a new social contract for education that elevates teaching as a collaborative, autonomous, research-informed profession. Teachers are positioning as creative guides who use technology to enhance learning and communication.

Similar to other countries, same problems in teaching profession has been arising in Turkey (OECD, 2025b). The teaching profession is showing a tendency to lose its attractiveness, a situation that threatens the future of education faculties. To train teachers suitable for the requirements of the 21st century, education faculties must transform not only their content and methods but also the fundamental paradigms of the teaching profession. The rapid advancement of technology has necessitated a rethinking of the structure of faculties of education and the processes of teacher education. Traditional teaching roles need to be replaced by technology-integrated, data-driven, and learner-centered roles. In this context, digital transformation refers not only to technological infrastructure but also to pedagogical and structural changes. This study aims to present how a digital transformation process was designed and is been implementing within TED University Faculty of Education.

At this point, learning engineering offers a compelling and systemic pathway to address the multifaceted challenges facing the teaching profession. Learning Engineering is defined as a “process and practice that applies the learning sciences using human-centered engineering design methodologies and data-informed decision making to support learners and their development” (Goodell & Kolodner, p10, 2023) By integrating learning sciences, human-centered design, data analytics, and technology, learning engineering provides structured processes that strengthen both teacher preparation and school-level instructional ecosystems. This approach equips pre-service and in-service teachers not only with pedagogical knowledge but also with future-oriented competencies such as problem-solving, evidence generation, learning analytics, and innovative technology use. “Teaching methods, subject areas, technologies, and data-driven algorithms will change the character of their jobs. Their roles will evolve from “sage on the stage” (a more passive approach focused on information transfer) to “guide on the side” (an active mentor who helps scaffold knowledge and offer coaching across mental, social, emotional, and physical domains)” (Goodell & Kolodner, p405, 2023). Moreover, learning engineering’s iterative design cycles (analyze–design–prototype–test–iterate) foster teacher autonomy, collaboration, and continuous improvement—features that directly align with UNESCO’s vision of a lifelong learning ecosystem for educators. In doing so, learning engineering can enhance the quality of pre-service teaching education programmes, improve professional development, reduce the stress associated with technology integration, and strengthen teachers’ sense of efficacy and motivation. Ultimately, the approach contributes to rebuilding the attractiveness, status, and sustainability of the teaching profession.

Method

This study adopts an action research approach within a single case study design (Fraenkel,Wallen & Hyun, 2012). The researchers took an active role in the planning, implementation, and evaluation of the process. This paper describes the first nine months of ongoing study. The case is TED University's Faculty of Education. The TED University is a private nonprofit institution dedicated to an English-language liberal arts model in Turkey. Faculty of Education offers bachelor’s degrees in Early Childhood Education, Primary Education, Mathematics Education, English Language Education, and Guidance & Psychological

Counseling, alongside graduate and doctoral programs. With robust accreditations, modern pedagogical and psychology labs, a strong emphasis on practice through K-12 Schools, and supportive systems like the Center for Teaching and Learning, the Faculty actively cultivates innovation, student-centered learning, double majors/minors, Erasmus+ exchanges, and scholarly research (Turkish Education Association University, n.d.).

The faculty's transformation process is being examined through action research (Fraenkel, Wallen & Hyun, 2012). In this multifaceted study, the planning and implementation phases are progressing simultaneously. The observation and reflection phases have not yet been reached. In the first nine months, data were collected through focus group interviews, document analysis, and meeting notes. The collected data were analyzed using thematic analysis.

Focus Group Interviews

In the initial phase, focus group interviews were conducted with stakeholders including academics, preservice teachers, and representatives from schools and edtech private sector. The main question for which the answer was looked for is “How can faculties of education be restructured to train teachers who can keep pace with the digital transformation?”. Based on the main question four sub questions were asked to respondents in each focus group:

1. How do you foresee the teaching profession changing in response to rapid technological advancements? What will be the role of teachers and students?
2. How do you envision the transformation that Faculties of Education will undergo in order to train teachers who can keep up with this rapid change in technology?
3. What kinds of needs might arise during this process and what solutions can be offered to address these needs?
4. When structuring the technological transformation of Faculties of Education, which national and international policy documents, standards, qualification frameworks, and different practice examples (examples of updated teacher training programs) can be used as a basis? Why?

There were 10 participants in the focus group with academics in Türkiye, 8 in the focus group with academics abroad, 8 in the focus group with private sector representatives, and 15 in the focus group with students. Participants were reached with convenience sampling. The student group consists of preservice teachers from various universities in Ankara, including students from elementary education (five 4th year, two 1st year), elementary mathematics education (one 4th year) early childhood education (five 4th year), guidance and psychological counseling (two 4th year). The academics abroad were graduates of faculty of education in Turkey and were pursuing their studies in the United States, Germany and the United Kingdom. The academics in Turkey were affiliated with different universities, representing educational faculties and center for teaching and learning.

All interviews were recorded, transcribed and thematically analyzed to explore perspectives on the future roles of teachers and students, the structure of faculties of education, and the nature of teaching and learning processes. Table 1 shows the result of the thematic analysis.

Table 1. Results of thematic analysis

Themes		Participants			
		Student	Sector	Academician (Abroad)	Academician (Turkey)
Faculty of Education	Micro-Credential	x	x	x	x
	Academic Training	x	x	x	x

	International Cooperation Internship		x	x	x	x
	Interdisciplinary Work		x		x	x
	More Internships and Practices		x	x		
	Alternative Measurement and Evaluation		x	x	x	
	AI-Powered Application Area				x	x
	AI-Powered System			x		
	Support Centers				x	
	New Courses	Use of Artificial Intelligence in Education	x	x	x	x
		Virtual Reality	x			
		Technology Integration	x			
		Entrepreneurial	x			
		Digital Technologies			x	x
		Data Analysis- Data Education- Data Literacy		x	x	x
		Coding			x	
		Teaching Productivity Tools			x	
		Ethics-Digital Ethics		x	x	x
		Neuroscience for Faculty of Education			x	
	Social Skills					x
The Role of the Teacher	Guidance		x	x	x	x
The Role of the Student	Individualized Learning		x			x
	Social Skills Development		x			
	Managing Your Own Learning Process			x	x	

Education and Training Processes	Learning in the Classroom	x				
	Virtual, Hybrid, Face to face	x	x	x		
	Flipped Learning					x
	Simulation, AI		x			

Deciding of the Approach: Learning Engineering

Based on the results and a comprehensive literature review, the learning engineering (Goodle & Kolodner, 2022) approach was adopted as the most suitable framework for the faculty of education's transformation. Looking ahead to the 2025–2026 academic year, our vision is to redefine teacher education, talent development, corporate training and lifelong learning through Learning Engineering so that graduates are fully prepared to leverage evidence-based methodologies, emerging technologies, and design thinking in diverse professional contexts. This initiative aims to prepare the next generation of educators and learning professionals not only as content experts but as learning engineers—equipped with technological, pedagogical, and ethical competencies to meet the demands of modern education and training.

Key Elements of Our Learning Engineering Approach:

- Interdisciplinary Curriculum:

Faculties of education must move beyond traditional pedagogical competencies and equip pre-service teachers with interdisciplinary 21st-century skills such as data literacy, digital pedagogical competence, design thinking, and human-centered design. Modular and flexible course structures should encourage students to take courses from fields such as engineering, information technologies, social sciences, and psychology. STEAM-based learning, design-driven problem solving, and soft-skill development should also be integrated into the curriculum.

- Integration of Advanced Technologies

Teacher education programs should embed advanced technologies—including artificial intelligence (AI), augmented and virtual reality (AR/VR), learning analytics, and coding—within existing courses and expand them through new courses and micro-credential pathways. Eye-tracking for classroom management, material development, and analysis of learner–teacher–technology interaction should be used to support professional growth. Hybrid and flexible learning environments should be strengthened through modular synchronous and asynchronous learning opportunities. All theoretical and practical courses are being enhanced through AI, virtual and augmented reality, smart robotics, and wearable technologies to create more effective, efficient, and engaging learning experiences.

- Expansion into Lifelong Learning and Talent Development

Faculties of education should embrace a lifelong learning perspective by offering flexible learning pathways to K-12 teachers. Micro-learning–based certifications should be created to support continuous professional development in areas such as data literacy, digital pedagogy, ethics, leadership, and creative problem solving. These pathways should nurture long-term talent development across the teaching profession.

- Graduate Programs and Certification Pathways

New graduate programs should align with international competency frameworks and offer specialization opportunities in educational technology, learning engineering, digital ethics, and education for learners with special needs. Certification pathways aligned with the European Qualifications Framework (EQF) should be established. Portfolio-based assessment, process-oriented evaluation, and data-driven assessment practices should shape these programs.

- European Union Projects and International Collaboration

Faculties of education should actively participate in EU-funded initiatives (e.g., Erasmus+, Horizon Europe, MSCA projects) to build international partnerships, support student and faculty mobility, and promote innovation-driven educational practices. Collaborative projects in AR/VR, STEAM, digital ethics, and learning engineering should be encouraged, with systematic mechanisms for knowledge and resource sharing.

- Global Partnerships

Strategic collaborations with leading institutions should be developed to establish dual-degree programs, co-taught courses, international internships, and joint research. These global partnerships will help pre-service teachers cultivate globally competitive teaching competencies and broaden their access to international professional opportunities.

- Institution-Wide Participation

Transforming teacher education requires an institution-wide approach that extends beyond education faculties. Cross-faculty collaborations, joint course designs, integration with university technology centers, and continuous professional development for academic staff should form the foundation of institutional digital transformation and curriculum renewal.

- Micro-Projects for Social Impact

Teacher education programs should integrate community-based micro-projects that allow pre-service teachers to design solutions to real societal problems. Through these projects, future teachers gain experience in creating social impact, responding to authentic needs, and engaging meaningfully with communities.

Faculty Development

As one of the results of the focus group and as noted in the literature (Judge & O'Bannon, 2008), faculty members who will be implementing the new approach need training to familiarize them with and embrace the learning engineering approach and to enhance their technological competencies. Therefore, Professional development seminars have been organized, conducted, and will continue to be held regularly throughout the process. Some of the seminars are listed below:

- The Use of Artificial Intelligence in Education
- Efficiency and Productivity Training with Artificial Intelligence
- Course Design and Evaluation Training with Generative Artificial Intelligence
- Introduction to Learning Engineering
- The Nature of Engineering and Its Place in STEAM Education
- IEEE ICICLE Learning Engineering Working Group Meetings (IEEE Standards Association, 2025)
- The Use of Eye Tracking Technology in Education
- Augmented Reality Tutor (ART.)
- Developing Future Learning Leaders: Corporate Academy Expertise

Enhancing Courses Offered in Terms of Technology Integration

As part of the digital transformation process undertaken in the faculty, faculty members with strong technological competencies have been identified in each department to review the courses within their department and to lead the department-level process of technology-enhanced curriculum transformation. These faculty members form the task force responsible for the revision process. This structure aims to ensure that the process is developed rapidly, effectively, and through coordinated collaboration across the entire faculty. One faculty member from each department has been designated as a "task force" coordinator. Under the leadership of these coordinators the digital transformation process was initiated by selecting two courses from each department. The departments and selected courses are listed below:

- Elementary Mathematics Education
    - Mathematics Teaching
    - Calculus I
- Elementary Education
    - Fundamental Mathematics in Primary School
    - Character and Values Education
- Early Childhood Education
    - Teaching Practice
    - Children and Media
- English Language Teaching
    - Teaching Reading Skills
    - Teaching Speaking Skills
- Educational Sciences
    - Educational Psychology
    - Instructional Principles and Methods
- Guidance and Psychological Counseling
    - Individual Counseling Practice I
    - Psychology of Learning

Following the identification of courses, meetings were held within each department to discuss how these courses could be enriched in collaboration with the task force representatives. These meetings focused on course syllabi, assignments, and tools used in the courses. Department-specific tools and methods were also discussed. A range of technology integration strategies were explored and planned during the meetings, including AI applications, VR-AR technologies, interactive content, digital materials, assessment tools, eye tracking, classroom-based or virtual simulations, and web 2.0 tools. Below is a summary of selected initiatives discussed:

- Proposing an e-portfolio system to allow students to showcase the work they produce
- Use of eye-tracking to gather data during micro-teaching activities
- Revise rubrics to include items that encourage effective integration of technology
- Guidelines for AI use in assignments.
- Specific tools and their applications across disciplines.

- Flipped learning strategies and use of tools like ART (İren, n.d), NotebookLM, H5P
- Integration of augmented and virtual reality technologies
- Use of virtual client simulations in counseling programs or virtual classroom scenarios in primary education courses.

Throughout the following semester, the proposed implementations have been applied in the courses listed above. During this process, data has been collected, observations have been conducted, and the effective and less effective aspects of the implementations will be identified. After the data is gathered and analyzed, the status of technology integration in the courses will be evaluated, and necessary revisions will be made accordingly. The enhancement of other courses in the faculty in terms of technology integration will begin based on the feedback obtained from the initial implementations.

Educational Forum: Learning Engineering

In May 2025, TED University organized an international education forum whose theme was Learning Engineering, bringing together scholars, practitioners, and policymakers from around the world (Türk Eğitim Derneği, 2025). The Forum aimed to provide a scientific foundation for redesigning teaching and learning processes, emphasizing effectiveness, inclusivity, and sustainability. By bringing together diverse stakeholders, the event served as a platform for collective thinking and collaborative innovation. The forum opened a multifaceted discussion on how to structure learning processes in a more effective, inclusive, and sustainable manner The Forum included discussions on the evolving role of the teaching profession, digital competencies, instructional design knowledge, and technology-supported pedagogical skills. In this context, models of teacher preparation were examined through the lens of learning engineering and how they may be transformed with about 2000 participants. To our knowledge, this event was the largest and most widely attended gathering ever held globally dedicated specifically to Learning Engineering.

Offering New Courses

Considering that learning engineering is an interdisciplinary process and practice, all courses offered in the faculty of education were examined from this perspective. In the Faculty of Education curriculum, several courses related to instructional technologies, the use of AI in education, and mathematical instructional design were already offered, including:

- EMT 370: Data-Driven Mathematics Instructional Design
- ED 320: Exploratory Data Analysis for Learning Environments
- ED 310: Trends and Emerging Practices in Educational Technology
- ED 330: Digital Classroom Design and Management
- ED 340: Advanced Digital Learning Material Development
- EMT 304: Technology in Mathematics Education
- ED 430: Artificial Intelligence in Education
- ED 305: 21st Century Skills for Teachers

In addition to these courses offered in previous semesters; to support the learning engineering approach some additional courses were determined to open for the first following semester. The first decision was to offer an under graduated level course titled Introduction to Learning Engineering. This course was designed as a case-based course focusing on the foundations of learning engineering, principles and stages of human-centered design methodologies, and core concepts from cognitive science and learning sciences. Students taking this course would learn the fundamental pillars of learning engineering and apply them in a practical, project-based case study.

The second course is Learning Experience Design. This practice-oriented course integrates learning engineering with human-centered design principles, combining UX and UI design methodologies. Students would produce videos, interactive learning materials, and visuals, while also using wireframing tools. The course aims to provide foundational yet applied knowledge for creating effective learning experiences.

In alignment with these two courses, the decision was made to open Educational Data Science, a course constituting a key component of learning engineering. Through this course, students would gain comprehensive knowledge of data analysis processes, enabling them to analyze the data they collect during the design and implementation stages.

In addition to these courses, it was decided to introduce an e-portfolio course that all students in the faculty would take. This course will house all products students create during their studies in educational faculty. Every student who begins a degree program in the faculty will take this course and will showcase all their academic outputs throughout their education. The e-portfolio system, integrated with the LMS, will allow students to continue sharing their work even after graduation. In this way, they will have the opportunity to demonstrate their competencies and strengthen their prospects in the job market.

Conclusion and Recommendations

This ongoing study presents an in-depth exploration of the digital transformation process within the Faculty of Education in TED University in the light of learning engineering approach. Although the observation and reflection phases are yet to be completed, the planning and implementation stages have yielded significant progress in the first year. Through focus group interviews, document analysis, and meeting notes, valuable data have been gathered and analyzed using thematic analysis, providing a robust foundation for data-informed decisions.

Key initiatives have included professional development seminars for faculty members, the ongoing enhancement of existing courses with a focus on technology integration, and the planning and introduction of new, future-oriented courses aligned with the learning engineering approach. Furthermore, the organization of a large-scale forum, engaging approximately 2,000 participants, has demonstrated the institution’s commitment to inclusive dialogue and collaborative reform.

The early outcomes suggest that a structured and participatory transformation process—guided by learning engineering principles and supported by action research—holds promise for redefining the pedagogical and institutional landscape of teacher education. As the study progresses into the observation and reflection stages, it is expected to yield deeper insights into the effectiveness and sustainability of these initiatives, ultimately offering a model for faculties of education undergoing similar transformation efforts.

Contemporary educational systems face unprecedented challenges driven by technological transformation, shifting learner needs, and increasing demands for personalized learning. In this context, traditional models of teaching—primarily based on knowledge transmission—prove insufficient. Learning engineering emerges as a multidisciplinary field that integrates educational technology, computer science, data science, human–computer interaction (UX), cognitive science, and pedagogical design to optimize learning through scientific and technology-supported methods. This approach offers a transformative framework for redefining the teaching profession.

Learning engineering focuses on designing, implementing, and evaluating learning experiences using systematic and evidence-based processes. Learning engineers:

- Develop instructional materials and digital tools,
- Analyze learning data to evaluate instructional effectiveness,
- Design personalized learning pathways,
- Integrate emerging technologies such as AI, AR/VR, and learning analytics,
- Contribute to the creation of adaptive and inclusive learning environments.

This expanded professional profile positions educators as strategic designers and innovators rather than solely as content deliverers. The integration of learning engineering into teacher preparation reshapes the professional identity of teachers. Teachers evolve into learning architects who design instruction tailored to individual learner needs, moving beyond the

traditional role of information provider. Through learning analytics and AI-supported tools, teachers analyze student performance, identify specific learning challenges, and design personalized learning plans. They integrate AR/VR, artificial intelligence, gamification, and other emerging technologies to enrich learning both inside and outside the classroom. Teachers develop and apply innovative pedagogical tools and methods that optimize learning processes. Teachers support students not only in academic contexts but also in preparing them for continuous learning throughout life. Moreover, they incorporate insights from neuroscience to plan learning environments aligned with students' cognitive and emotional development. Furthermore, teachers guide students in the ethical and effective use of AI, data science tools, IoT, eye-tracking technologies, and AR/VR systems and cultivate learners' digital literacy, critical thinking, and responsible technology use. Based on these new roles and responsibilities of teachers they become moreover an instructional designer, a data-driven decision maker, an educational technology specialist, a problem solver and innovator, a lifelong learning guide, a critical thinking and digital ethics facilitator and a technology mentor.

To conclude, adopting learning engineering principles offers substantial benefits for both teachers and educational systems. By enabling teachers to better understand individual learner needs, learning engineering supports the design of personalized and differentiated learning experiences that place the learner at the center of instruction. At the same time, the integration of data science and technology-supported design processes increases the efficiency and effectiveness of teaching, allowing educators to make more informed decisions and streamline instructional practices. This shift also enhances the professional prestige of the teaching profession. As teachers move from a traditional knowledge-transmission role to that of a "learning engineer," they become recognized as strategic designers and analytical thinkers, which strengthens the societal perception and status of their work.

For education systems, the transition toward learning engineering may offer transformative advantages. It redefines the teaching profession through the use of scientific and technological tools that optimize learning processes, contributing to greater recognition and attractiveness of the field. Teachers who acquire learning engineering competencies also benefit from increasingly diversified career pathways, gaining opportunities to work in educational technology companies, consultancy organizations, international research projects, and innovation-oriented educational initiatives. Moreover, learning engineering enhances teachers' ability to respond effectively to the demands of the digital era and the Fourth Industrial Revolution by supporting more adaptive, technology-rich, and future-focused educational practices.

Ultimately, integrating learning engineering into teacher education represents a paradigm shift that can introduce deep and systemic innovation into educational systems. Teachers are positioned at the center of 21st-century learning as designers, data analysts, technology leaders, and guides of lifelong learning. Realizing this vision requires structural, conceptual, and pedagogical transformation both within teacher education programs and institutional cultures. Such a transition not only elevates the prestige and attractiveness of the teaching profession but also significantly enhances the quality and effectiveness of education as a whole.

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