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ENHANCING ARTIFICIAL INTELLIGENCE (AI) LITERACY FOR ECONOMIC GROWTH AND DIGITAL TRANSFORMATION: THE ROLE OF HIGHER EDUCATION IN KAZAKHSTAN

Abstract

National governments increasingly treat artificial intelligence (AI) skills as both an education reform priority and an innovation-policy instrument. The purpose of the article is to analyse and evaluate the AI Sana program as a comprehensive policy mix in the field of AI skills development in the higher education system of Kazakhstan. This paper develops a document-based case study of Kazakhstan's AI-Sana program, launched in late 2024 as a staged pipeline intended to move learners from foundational AI literacy to mentored projects and, for a smaller subset, startup acceleration. Using program reference materials provided by the authors and triangulating them with open-access government communications, reputable reporting, and official descriptions of comparable international initiatives, we reconstruct AI-Sana's policy architecture and argue that it should be analysed as a policy mix rather than a single training intervention. The mix bundles (i) mandate-backed curricular mainstreaming, (ii) platform partnerships and localised micro-credentials, (iii) implementation capacity via regional "anchor" universities, (iv) innovation-funnel instruments linking projects to commercialisation, and (v) enabling infrastructure through national compute investments. The analysis also highlights measurement challenges typical of fast-scaling initiatives, especially the conflation of certificates, unique learners, and competency gains and treats reporting variance as an analytic finding. Building on micro-credential governance scholarship, digital education governance research, and responsible generative AI guidance, we propose an evaluation blueprint with a minimum reporting standard and stage-aligned indicators that can support international comparability. Kazakhstan is globally informative because it combines system-wide higher-education delivery with explicit innovation translation and compute infrastructure, illuminating how national AI strategies can be operationalised through universities while raising acute questions about quality assurance, integrity, and platform dependence.

Keywords: economic growth, assessment, AI in higher education, AI literacy, innovation policy, AI management.

Introduction

Higher education systems are under growing pressure to respond to two closely connected developments. First, labour markets and public sectors increasingly demand artificial intelligence (AI)-related skills, prompting governments to expand AI education at scale. Second, generative AI (GenAI) tools are rapidly diffusing into academic work, reshaping how students write, how faculty assess, and how universities deliver services such as admissions, advising, and student support (UNESCO, 2023). Together, these shifts transform AI from a narrow curricular topic into a system-level governance issue involving credential meaning, academic integrity, data protection, institutional legitimacy, and the future organisation of academic work [1].

Kazakhstan's AI-Sana programme offers a timely case through which to examine these developments. The programme operationalises national ambitions around AI through a coordinated, staged design delivered through higher education, and public reporting suggests rapid mainstreaming of AI within the university sector. In August 2025, national reporting indicated that AI had become a mandatory discipline across Kazakh universities and that large numbers of students had already completed AI courses (The Astana Times, 2025). AI-Sana is embedded in Kazakhstan's broader AI development agenda for 2024–2029, which links human capital development to infrastructure, innovation, and governance investments [2]. Rather than treating AI education as a single curriculum reform, AI-Sana frames a staged pipeline, often summarised as "skills, projects, startups", supported by anchor universities, platform partnerships, and emerging compute capacity.

Research on AI in higher education is expanding rapidly, but it remains uneven both geographically and conceptually. In a systematic review of research published between 2007 and 2018, (missed in-text citation) found that half of the literature came from four countries, the United

States, China, Taiwan, and Turkey, and argued that educators' perspectives were comparatively underrepresented. National-scale initiatives outside dominant centres of knowledge production are therefore important not only empirically, but also theoretically, because they broaden the range of institutional and policy settings through which AI in higher education can be understood. In particular, they make it possible to examine how AI is being operationalised not only as a pedagogical innovation, but also as a governance instrument embedded in national development strategies.

This paper makes three contributions. First, it reconstructs AI-Sana's architecture and governance as a policy mix and clarifies how its instruments are intended to interact across capability formation, implementation, innovation translation, and infrastructure. Second, it imposes measurement discipline by distinguishing targets, reported outputs, and indicative operational indicators, an essential analytical step in contexts where programmes scale more quickly than evaluation systems. Third, it situates Kazakhstan's approach within an international design space by comparing AI-Sana with widely cited models of mass AI literacy, selective deep-skilling, system-level readiness, and regulation-linked AI literacy obligations. Building on these strands, the paper proposes an evaluation blueprint grounded in programme-theory evaluation to support more credible, internationally comparable evidence on learning, adoption, integrity, and the translation of innovation.

Two research questions guide the analysis. First, how is AI-Sana designed and governed as a national higher education AI capability pipeline? Second, what is publicly reported about participation and outputs, and what measurement ambiguities emerge as the programme scales? By addressing these questions, the paper argues that AI-Sana is best understood not as a single training intervention, but as a national policy mix through which higher education is being mobilised to serve both capability-building and innovation-policy goals.

Literature and Theoretical Framing

This paper draws together three strands of scholarship to develop an analytical framework for understanding national AI education initiatives delivered through higher education: innovation-policy research on policy mixes and capability building, higher education research on micro-credentials and platformisation, and governance frameworks for responsible generative AI. Taken together, these literatures make it possible to analyse AI-Sana not simply as a training programme, but as a compound governance arrangement that links educational delivery, institutional coordination, technological infrastructures, and innovation-oriented policy goals.

Policy-mix research provides the first pillar of this framework. Complex capability goals are rarely achieved through a single instrument; rather, outcomes emerge from the interaction of multiple policies operating across levels, institutions, and time horizons [3]. As Flanagan et al. (2011) argue, the concept of a policy mix becomes analytically useful when it captures complementarities, tensions, and dynamic adjustment among instruments, rather than merely listing policies as a static menu. This perspective is particularly relevant for AI capability formation, where educational expansion depends not only on curricula, but also on enabling conditions such as access to compute and data, mentoring capacity, procurement arrangements, and innovation finance. A national innovation systems perspective similarly highlights how universities, firms, and state agencies co-produce capability through institution-building and interactive learning [4]. From this viewpoint, national AI initiatives can be understood as attempts to reconfigure relationships among higher education institutions, industry partners, platform providers, and infrastructure operators.

A closely related line of thought comes from mission-oriented innovation policy. Mission-oriented approaches emphasise that strategic capability building requires more than isolated projects; it depends on the creation of institutions, linkages, and learning mechanisms that reorganise the wider system around a public objective [5]. AI-Sana's 'skills-projects-startups' framing reflects such a mission logic, insofar as it aims to use universities not only for broad capability formation but also for the translation of learning into applied innovation. This orientation raises questions of coordination, sequencing, and governance quality, all of which are central to the analysis of policy mixes.

The second pillar of the framework concerns micro-credentials. Micro-credentials have become central to contemporary scaling strategies because they are modular, updateable, and compatible with

online or blended delivery. Analyses by the Organisation for Economic Co-operation and Development (OECD) suggest that micro-credentials can support upskilling and flexible learning; however, they also face recurring challenges related to variable rigour, unclear metadata, limited portability, and uncertain labour-market signalling [6]. The Council of the European Union (2022) has similarly stressed the importance of common definitions and minimum information standards as a way of stabilising meaning in rapidly expanding credential ecosystems. Beyond policy reports, systematic reviews show that quality assurance, assessment design, and employer recognition remain key bottlenecks to the long-term value of micro-credentials [7]. These concerns are especially relevant to AI-Sana, where platform-based provision and staged certification are central to the programme's scale and public visibility.

The third pillar of the framework is platformisation and digital education governance. Williamson (2016) argues that universities are increasingly governed through digital infrastructures and platform markets that reshape accountability, data flows, and decision-making. More recent work by Komljenovic and Williamson (2024) highlights the political economy of higher education platformisation, including lock-in risks, proprietary infrastructures, and the redistribution of authority through contractual and technical dependencies. For AI-Sana, platform partnerships may be a pragmatic solution to the problem of rapid scale and content updating, but they also raise broader questions about control over curriculum, credential meaning, procurement, and the governance of learner data. These issues are not peripheral to AI education; they form part of the institutional architecture through which AI capability is being built.

Responsible GenAI governance provides the fourth element of the theoretical framing. UNESCO's guidance on generative AI in education and research emphasises human-centred governance, transparency, privacy protection, and institutional readiness to evaluate tools and impacts. At the same time, regulatory developments are beginning to redefine AI literacy as an organisational obligation. European Commission guidance on Article 4 of the AI Act specifies that providers and deployers of AI systems should take measures to ensure a sufficient level of AI literacy among relevant staff [8]. This shifts the focus from AI literacy as a desirable curricular outcome to AI literacy as an institutional governance requirement, especially in universities that deploy AI in admissions, assessment, student support, or other consequential processes.

Bringing these literatures together, the paper conceptualises AI-Sana as a policy mix oriented toward an AI capability trajectory with four interacting components: (1) capability formation at scale through curriculum and micro-credentials, (2) institutional modernisation through AI-enabled services and changing assessment regimes, (3) innovation translation through project-to-startup mechanisms and ecosystem supports, and (4) legitimacy and governance through quality assurance, integrity, privacy, accountability, and evaluation. This framework underpins both the analysis of AI-Sana itself and the comparative section that situates it within a wider international design space. The core theoretical claim advanced here is that large-scale AI education is most likely to generate durable national capability when these components are aligned; where they are weakly aligned, high outputs, such as certificates issued or participation counts, may coexist with weak outcomes in competence, innovation, trust, and institutional legitimacy.

Materials and methods of research

This study employs a document-based qualitative case study approach suitable for analysing policy instruments and initial implementation, especially when learner-level outcome data are not yet systematically accessible. The aim is not to estimate causal impact but to (i) reconstruct programme logic and governance, (ii) transparently compile reported indicators, and (iii) define testable hypotheses and an evaluation plan.

Data were collected from two sources of evidence. First, the authors examined internal programme reference materials and an implementation slide deck (supplied by the authors) to identify the staged design, target populations, reported outputs, and institutional use cases. Second, we triangulated open-access sources (December 2024–March 2026), including Kazakhstan government communications (e.g., national AI concept, AI-Sana announcements), reputable reports on higher education policy and infrastructure, and official pages of comparator initiatives (Elements of AI,

AIAP, AI Leap, EU AI literacy policy). When quantitative claims varied across sources, the differences were regarded as meaningful and were attributed to definitional variations (e.g., certificates versus unique learners), reporting periods, or measurement practices.

To minimise over-interpretation of preliminary metrics, quantitative statements were categorised as (a) targets (planned coverage), (b) reported outputs (certificates issued, participating institutions), or (c) indicative operational indicators (e.g., percentage efficiency gains) requiring independent verification. The evaluation blueprint is based on programme theory evaluation principles, which emphasise articulating causal mechanisms and aligning measures with each stage of a theory of change. Limitations include selective reporting, a lack of standardised outcome measures, and the absence of audited administrative data for many indicators.

Kazakhstan Policy Context and AI-Sana Overview

Kazakhstan's AI-Sana programme is part of a broader national AI policy agenda. In mid-2024, the Government adopted a Concept for the Development of Artificial Intelligence for 2024–2029, positioning AI as a tool for cross-sector modernisation and linking human capital development to infrastructure and governance measures. In higher education, national reporting indicates a shift from pilot projects to system-level mainstreaming: AI is reported as becoming a compulsory discipline across universities in the 2025–2026 academic year, with large-scale curriculum integration and instructor certification underway.

AI-Sana was launched in December 2024 as a staged program targeting university students and early-career researchers. Open-access descriptions summarise a four-stage pipeline moving from basic AI skills to advanced education, business acceleration, and scaling [9-10].

Table 1 - AI-Sana staged design and target coverage.

Stage	Focus	Reported target coverage
Stage 1	Basic AI skills (introductory courses via partner platforms)	≈650,000 students
Stage 2	Advanced education (AI programming, ML, entrepreneurship)	≈100,000 students
Stage 3	Business acceleration (project development with industry orientation)	≈60,000 graduates/students
Stage 4	Scaling (pre-acceleration, acceleration, post-acceleration)	≈1,500 startups/projects
Note: Compiled by authors on the basis of sources EKTU (2025)		

To support rollout, 27 regional "anchor universities" were selected based on criteria including infrastructure and computing capacity (Qazinform, 2026a). The delivery model blends university provision with partnerships involving global learning platforms and technology providers, alongside localisation into Kazakh and Russian and a stated emphasis on applied projects and entrepreneurship.

AI-Sana's feasibility and policy ambition are strengthened by ecosystem signals concerning compute infrastructure. Kazakhstan launched a national supercomputing cluster at the Alemcloud National Supercomputing Center in 2025, reported as powered by NVIDIA H200 processors and capable of delivering up to two exaflops (FP8), with planned access for universities and startups. The combination of skills, institutional modernisation, innovation translation, and compute capacity makes Kazakhstan a valuable case for understanding how higher education can be mobilised as part of an AI strategy, while also raising questions about quality assurance, platform dependence, and governance of AI systems used in university decision-making.

AI-Sana as a National Policy

Viewed through the lens of policy-mix research, AI-Sana combines instruments that operate across capability supply, implementation capacity, innovation translation, and enabling infrastructure. Its novelty lies not in any single component, as many countries sponsor AI courses, digital credentials, or entrepreneurship programmes, but in the attempt to align these elements through higher education at a national scale.This alignment is precisely what makes AI-Sana analytically significant. Rather than representing an isolated educational reform, the programme seeks to coordinate multiple instruments whose value depends on their interaction over time [11].

The first major component is capability formation through curricular mainstreaming and micro-credential-style provision. Mandate-backed curriculum integration addresses the participation problem by ensuring broad exposure to AI content across the higher education system. However, it

simultaneously shifts attention toward questions of credential meaning, assessment quality, and instructional capacity. As OECD work on micro-credentials has shown, scale and flexibility can be achieved relatively quickly through modular digital provision, but this often intensifies uncertainty around standards, verification, and recognition [12]. The Council of the European Union (2022) similarly highlights the importance of clear definitions and minimum information standards if micro-credentials are to function as meaningful signals rather than as loosely comparable participation records. In the context of AI-Sana, these issues are particularly important because the programme's legitimacy depends not only on how many learners participate, but on whether the resulting credentials can credibly represent competence.

The second component of the policy mix is implementation capacity, which is channelled through the anchor-university model. Anchor institutions act as regional nodes that can concentrate expertise, coordinate training delivery, and potentially support more standardised reporting and quality assurance across the system. This arrangement is consistent with multi-level governance strategies in which selected institutions mediate between central policy ambition and local implementation. Yet it also introduces important governance challenges. Differences in institutional infrastructure, academic capacity, and regional context may affect how consistently the programme is delivered and how equitably opportunities are distributed across the system. In this sense, anchor universities function not only as enablers of scale, but also as sites where policy ambition encounters institutional variation.

The third component is the innovation-funnel logic built into the programme's staged architecture. AI-Sana does not stop at broad-based upskilling; it attempts to channel participants from literacy to applied projects, and from projects to startup formation and commercialisation pathways. This design can be interpreted through innovation systems and mission-oriented perspectives, both of which stress that capability-building requires more than instruction alone. Freeman (1995) emphasises that innovation capacity emerges through linkages among universities, firms, and public institutions, while mission-oriented policy approaches highlight the importance of coordinated pathways that connect strategic goals to institutional learning and application. AI-Sana's staged movement from education to innovation thus represents an effort to address a recurring "missing middle" in skills policy: the gap between large participation outputs and meaningful applied outcomes.

The fourth component is enabling infrastructure, particularly compute. Recent research on compute governance argues that computing capacity is increasingly treated by governments as strategic infrastructure because it is quantifiable, allocable, and directly tied to the feasibility of AI development. Kazakhstan's investment in a national supercomputing cluster can therefore be interpreted as both a research and development input and a policy lever. It provides a material basis for applied AI work, signals commitment to the national AI agenda, and potentially strengthens the linkage between educational expansion and innovation capacity. At the same time, compute infrastructure raises its own governance questions, including how access is prioritised, which institutions benefit most, and whether infrastructure use is translated into research outputs, pedagogical value, or viable ventures. Infrastructure, in other words, is not simply a neutral backdrop to AI-Sana; it is part of the policy architecture that shapes the programme's opportunities and constraints.

A fifth and cross-cutting element concerns institutional modernisation and the governance of AI-enabled university processes. As universities adopt AI in admissions, assessment support, advising, and other services, they enter the wider terrain of digital education governance and platformisation [13]. In this context, AI-Sana is not only about building student capability. It also participates in a broader transformation in which universities become sites of AI deployment, data extraction, and platform-mediated governance. This makes responsible GenAI governance a necessary complement to AI upskilling. UNESCO (2023) stresses that privacy protection, transparency, human oversight, and impact evaluation are central to the responsible use of generative AI in education. If AI-Sana is to produce durable and legitimate institutional change, these safeguards must be treated as integral to the programme rather than as secondary ethical concerns.

Taken together, these components show that AI-Sana is best analysed as a national policy mix whose effectiveness depends on alignment across multiple instrument types. The programme seeks to integrate curriculum, credentials, institutional coordination, innovation pathways, and infrastructure into a single capability-building architecture. That ambition is what makes it significant, but it is also what makes it vulnerable. The more complex the mix, the greater the importance of coherence across stages, clarity in measurement, and governance arrangements capable of managing institutional variation, platform dependence, and infrastructural inequality. The next section therefore turns to the question of reporting and measurement, examining what is currently visible in AI-Sana's public metrics and what remains ambiguous.

Kazakhstan in a Global Comparative Perspective

Comparative analysis helps clarify what is distinctive about AI-Sana and what lessons travel internationally. We situate AI-Sana within a design space defined by two core dimensions: (i) breadth versus depth of capability (mass literacy versus intensive specialist training) and (ii) education-only versus education-to-innovation orientation (training as an end versus training embedded in project and commercialisation pathways). A third, cross-cutting dimension concerns governance mode: voluntary and open participation versus mandate-backed or regulation-linked obligations.

Finland's Elements of AI represents an archetypal mass-literacy model: open-access courses designed for broad audiences, which reached over one million learners internationally and were translated into many languages [14]. Its comparative value lies in demonstrating how scale and localisation can be achieved with a relatively lightweight institutional apparatus, but it largely externalises innovation translation to other parts of the ecosystem.

Singapore's AI Apprenticeship Programme (AIAP) is positioned at the opposite end of the breadth–depth spectrum: it emphasizes intensive deep-skilling and project deployment, supported by structured mentorship and full-time formatting (AIAP, n.d.). Its strength is the tight linkage between learning and deployment, while its limitation is bounded scale and selectivity.

Estonia's AI Leap illustrates a system-readiness model focused on equitable access to AI tools and teacher training, treating GenAI as a pervasive educational infrastructure rather than primarily as a specialist field [15]. This model surfaces governance questions, privacy, pedagogy, and equity early because it assumes widespread tool use rather than limited specialist pipelines.

At the regional level, the European Union increasingly frames AI literacy as an organisational responsibility. European Commission guidance on Article 4 of the AI Act specifies that providers and deployers of AI systems should take measures to ensure sufficient AI literacy among relevant staff, shifting the locus of AI literacy from education policy alone to compliance-oriented governance. For universities, this implies that staff capacity and governance cannot be treated as optional adjuncts when AI systems are deployed in high-stakes processes.

AI-Sana is distinctive because it attempts to span multiple quadrants of this design space. It combines mass higher-education delivery (akin to Elements of AI's breadth) with staged deepening and a stated innovation funnel (closer to the AIAP logic), while also coupling the program to system-level governance (mandate-backed curriculum integration and anchor institutions) and enabling infrastructure (national compute). This hybridisation increases potential returns but also increases governance complexity. The comparative implication is that AI-Sana's success depends less on scaling Stage 1 participation and more on coordinating the 'middle' of the pipeline: consistent quality standards, mentoring capacity, compute and data access, and credible measurement linking micro-credentials to applied competence and innovation outcomes.

Results and their discussion

The AI-Sana case supports three broader arguments that extend current scholarship on artificial intelligence in higher education beyond questions of classroom use or technological adoption alone. First, the case suggests that once AI is scaled through mandate-backed curriculum integration, the central policy problem shifts from participation to meaning. This point resonates with scholarship on policy mixes, which emphasises that complex capability goals are not achieved through a single intervention but through the interaction of multiple instruments, each carrying its own assumptions, incentives, and implementation demands (Flanagan et al., 2011). In the context of AI-Sana, the issue is therefore not simply whether students are exposed to AI content, but whether the credentials they

obtain represent validated competence, whether assessment regimes remain credible under conditions of widespread generative AI use, and whether the reported outputs of the programme can be interpreted consistently across stages and institutions.

This shift from access to meaning is also consistent with the literature on micro-credentials. OECD analyses have repeatedly noted that micro-credentials may widen access and support flexible learning, but that their policy value depends on the clarity of standards, metadata, verification, and portability. Similarly, the Council of the European Union (2022) treats minimum information standards as essential to the interpretability of micro-credentials across contexts. The AI-Sana case reinforces these concerns. As the analysis has shown, public and internal reporting currently draws on a mix of targets, certificates, participation figures, and project counts, not all of which capture the same underlying phenomenon. In this respect, the distinction between certificates, unique learners, and competency gains is not a technical detail but a governance issue, because what is counted shapes what institutions prioritize and what policymakers can plausibly claim as success.

Second, the case highlights the extent to which national AI education policy is now inseparable from broader processes of digital education governance and platformisation. Williamson (2016) argues that digital infrastructures increasingly shape how educational systems are governed, not only by supporting delivery but also by reorganising accountability, decision-making, and data flows. More recently, Komljenovic and Williamson have shown how platformisation reconfigures higher education through proprietary systems, contractual dependencies, and new forms of governance by external providers. AI-Sana strongly reflects this dynamic. Although the programme is state-led, its operation depends in significant part on platform-based courses, localized digital credentials, and external technological infrastructures, making platform partnerships not peripheral but constitutive of the policy model itself.

This platformised architecture creates both opportunities and dependencies. On the one hand, platform partnerships offer speed, scalable delivery, and the possibility of rapidly updating AI-related content. On the other hand, they raise familiar concerns about control over curriculum, the governance of learner data, procurement transparency, and long-term dependence on external providers.The Kazakhstan case, therefore, supports the view that AI literacy policy should not be analysed only as a matter of human capital formation; it must also be understood as part of the wider reconfiguration of higher education governance through digital infrastructures and platform markets.

This argument is reinforced by emerging debates on responsible AI. UNESCO's guidance on generative AI in education stresses that institutional adoption should be accompanied by attention to transparency, privacy, human oversight, and the evaluation of educational impact. Similarly, recent European Commission guidance on Article 4 of the AI Act reframes AI literacy as an organisational obligation for providers and deployers of AI systems, not merely as a desirable educational outcome. For universities, this implies that student upskilling cannot be separated from staff capacity, oversight arrangements, integrity safeguards, and mechanisms of contestability in AI-mediated processes. In this respect, AI-Sana illustrates how quickly AI policy moves from curriculum reform into the domain of institutional governance.

Third, AI-Sana is globally informative because it links mass higher education delivery to an explicit innovation pipeline and to enabling compute infrastructure. This combination can be interpreted through both national innovation systems thinking and mission-oriented innovation policy. Freeman emphasises that capability is built through interaction among universities, firms, and state institutions, rather than through isolated educational interventions. Likewise, mission-oriented approaches stress that strategic capability building requires not only training but also new institutions, coordination mechanisms, and pathways for translation into application [16]. AI-Sana's 'skills-projects-startups' logic closely reflects this orientation.

Comparatively, this makes AI-Sana distinct from better-known international models. Finland's Elements of AI demonstrates the reach of open, large-scale AI literacy but does not directly integrate that literacy into an innovation funnel. Singapore's AI Apprenticeship Programme offers a much deeper and deployment-oriented model, but at smaller scale and with a more selective entry structure (AIAP, n.d.). Estonia's AI Leap foregrounds system readiness, teacher capacity, and equitable access

to tools, thereby bringing governance issues such as privacy and pedagogy to the forefront. The European Union, in turn, increasingly frames AI literacy in terms of compliance and organisational governance rather than mass education per se. AI-Sana attempts to combine aspects of all of these models: mass delivery, staged deepening, innovation translation, and governance-backed infrastructure.

Yet the ambition of this hybrid design also explains its fragility. The analysis suggests that the most difficult part of the AI-Sana architecture is not initial participation, but the middle of the pipeline: the transition from foundational literacy to applied capability, from applied capability to credible projects, and from projects to viable startup or deployment outcomes. This diagnosis is consistent with both policy-mix theory and programme theory evaluation. Flanagan et al. argue that the value of a policy mix lies in how instruments interact over time, including where complementarities fail or where bottlenecks emerge. Weiss, similarly, stresses that evaluation should track causal mechanisms and intermediate transitions rather than focus only on final outputs. In AI-Sana, those intermediate transitions include progression across stages, access to mentoring, integration into disciplinary contexts, access to data and compute, and the presence of robust standards for judging project maturity and competence.

The case also points to the importance of infrastructure as a governance issue in its own right. Recent work on compute governance argues that compute is increasingly a strategic resource that can be measured, allocated, and governed as part of national AI capacity-building efforts. Kazakhstan's investment in national computing infrastructure is therefore not merely a technical background condition; it is part of the policy mix that shapes what kinds of AI work become possible in universities and who gains access to them. At the same time, infrastructure does not automatically translate into capability. Without transparent access rules, institutional support, and meaningful integration into teaching and research, compute investment may remain symbolically powerful but unevenly utilised.

These findings extend scholarship in three ways. First, they suggest that national AI education initiatives should be conceptualised as compound governance arrangements rather than stand-alone training programmes. Second, they show that the quality and meaning of outputs become more important, not less, as scale increases. Third, they demonstrate that universities are increasingly being positioned as operational sites of AI statecraft, where curriculum, platform governance, innovation policy, and infrastructure investment intersect. In this sense, AI-Sana is valuable not only as a national case of rapid AI mainstreaming but also as a lens through which to examine the changing relationship between higher education and state-led technological transformation.

The evaluation blueprint proposed in this paper is intended as a practical response to these issues. Grounded in programme theory evaluation , micro-credential governance concerns and responsible AI principles, it offers a way to move from activity counts toward more credible evidence on capability, progression, governance quality, and innovation outcomes [17]. Without such measurement discipline, fast-scaling national AI initiatives risk conflating visibility with effectiveness. The long-term significance of AI-Sana for both policy and scholarship will therefore depend not only on how many learners it reaches, but on whether it can demonstrate validated competence, meaningful stage progression, and trustworthy governance across the higher education system.

Conclusion

This paper has argued that Kazakhstan's AI-Sana programme is best understood not as a stand-alone training initiative, but as a national policy mix that mobilises higher education for both capability formation and innovation-policy goals. Its significance lies in the attempt to align curricular mainstreaming, micro-credential provision, anchor-university implementation, innovation-funnel mechanisms, and compute infrastructure within a single architecture of AI capability building.

The analysis has also shown that the value of such initiatives cannot be judged by scale alone. As research on micro-credentials suggests, participation and certification counts do not by themselves demonstrate quality, portability, or validated competence [18]. In AI-Sana, the distinction between certificates, unique learners, and demonstrated capability is therefore central to evaluating whether the programme is generating durable outcomes or primarily visible outputs.

More broadly, the case shows that AI education policy increasingly overlaps with digital education governance framework. AI-Sana depends on platform-mediated delivery, institutional coordination, and emerging infrastructure, while also raising questions about quality assurance, data governance, platform dependence, and the responsible use of AI in university settings. Kazakhstan is therefore globally informative because it illustrates how universities can serve as operational sites for a national AI strategy.

The paper's practical contribution is a minimum reporting standard and a stage-aligned evaluation blueprint designed to improve interpretation, comparability, and policy learning across similar initiatives**.** Ultimately, the significance of AI-Sana will depend not only on how many learners it reaches, but on whether it can demonstrate credible progression from exposure to competence, from competence to application, and from application to meaningful educational and innovation outcomes.

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ЭКОНОМИКАЛЫҚ ӨСУ ЖӘНЕ ЦИФРЛЫҚ ТРАНСФОРМАЦИЯ КОНТЕКСТІНДЕ AI-САУАТТЫЛЫҚТЫ АРТТЫРУ: ЖОҒАРЫ БІЛІМНІҢ ҮЛЕСІ (ҚАЗАҚСТАН МЫСАЛЫНДА)

Аңдатпа

Үкімет жасанды интеллект (ЖИ) саласындағы дағдыларды барған сайын білім беру реформасының басымдығы әрі инновациялық саясаттың құралы ретінде қарастырып отыр. Мақаланың мақсаты Қазақстанның жоғары білім беру жүйесінде жасанды интеллект дағдыларын дамыту саласындағы AI Sana бағдарламасын кешенді policy mix ретінде талдау және бағалау болып табылады. Бұл мақала 2024 жылдың соңында іске қосылған Қазақстанның AI-Sana бағдарламасына қатысты құжаттарға негізделген кейс-стади ұсынады. Бағдарлама білім алушыларды бастапқы AI сауаттылығынан менторлық сүйемелдеудегі жобаларға, ал аз бөлігі үшін стартаптарды акселерациялауға бағытталған кезеңдік траектория ретінде құрылған. Авторлар ұсынған бағдарламалық анықтамалық материалдарды ашық қолжетімді үкіметтік коммуникациялармен, беделді жарияланымдармен және ұқсас халықаралық бастамалардың ресми сипаттамаларымен салыстыра отырып, біз AI-Sana-ның саясаттық архитектурасын қалпына келтіреміз және оны жеке бір оқыту араласуы ретінде емес, policy mix ретінде талдау қажет деп тұжырымдаймыз. Бұл policy mix келесі элементтерді біріктіреді: (i) нормативтік мандатқа сүйенген оқу бағдарламаларын негізгі жүйеге енгізу; (ii) платформалық әріптестіктер және жергіліктендірілген микро-біліктіліктер; (iii) өңірлік «якорлық» университеттер арқылы іске асыру әлеуеті; (iv) жобаларды коммерцияландырумен байланыстыратын инновациялық воронка құралдары; және (v) ұлттық есептеу инфрақұрылымына инвестициялар арқылы қамтамасыз етілетін қолдаушы инфрақұрылым. Талдау сонымен қатар жылдам ауқымданатын бастамаларға тән өлшеу мәселелерін — әсіресе сертификаттар, бірегей білім алушылар саны және құзыреттердің өсуі арасындағы айырмашылықтың көмескіленуін, айқындайды және есеп беру деректеріндегі вариацияны талдамалық тұрғыдан маңызды нәтиже ретінде қарастырады. Микро-біліктіліктерді басқару, цифрлық білім беруді басқару және жауапты генеративті ЖИ бойынша зерттеулерге сүйене отырып, біз ең төменгі есеп беру стандартын және кезеңдерге үйлестірілген индикаторларды қамтитын бағалау тұжырымдамасын ұсынамыз; бұл халықаралық салыстырмалылықты қамтамасыз етуге мүмкіндік береді. Қазақстан жаһандық тұрғыдан айрықша маңызды мысал болып табылады, өйткені ол жоғары білімді жүйелік деңгейде қамтуды, инновацияны трансляциялауды және есептеу инфрақұрылымын ұштастырады; бұл ұлттық ЖИ стратегияларының университеттер арқылы қалай іске асырылатынын көрсетіп, сонымен қатар сапаны қамтамасыз ету, академиялық адалдық және платформаларға тәуелділік мәселелерін өткір қояды.

Негізгі сөздер: экономикалық өсу, бағалау, жоғары білім берудегі АИ, АИ-сауаттылық, инновациялық саясат, АИ басқару.

ПОВЫШЕНИЕ AI-ГРАМОТНОСТИ В КОНТЕКСТЕ ЭКОНОМИЧЕСКОГО РОСТА И ЦИФРОВОЙ ТРАНСФОРМАЦИИ: ВКЛАД ВЫСШЕГО ОБРАЗОВАНИЯ (НА ПРИМЕРЕ КАЗАХСТАНА)

Аннотация

Правительство все чаще рассматривает навыки в области искусственного интеллекта (AI) одновременно как приоритет реформы образования и как инструмент инновационной политики. Цель статьи заключается в анализе и оценке программы AI Sana как комплексного policy mix в сфере развития навыков искусственного интеллекта в системе высшего образования Казахстана. В данной статье представлена оценка на основе документов кейс-стади программы AI-Sana в Казахстане, запущенной в конце 2024 года как поэтапная траектория, призванная перевести обучающихся от базовой AI-грамотности к проектам под наставничеством и, для меньшей части участников, к акселерации стартапов. Используя справочные материалы программы, предоставленные авторами, и сопоставляя их с открытыми правительственными сообщениями, авторитетными публикациями и официальными описаниями сопоставимых международных инициатив, мы реконструируем архитектуру политики AI-Sana и утверждаем, что ее следует анализировать как policy mix, а не как единичную обучающую интервенцию. Данный policy mix включает: (i) внедрение AI в основную учебную повестку на основе нормативного мандата; (ii) партнерства с платформами и локализованные микро-квалификации; (iii) реализационную способность через региональные «якорные» университеты; (iv) инструменты инновационного воронкообразного отбора, связывающие проекты с коммерциализацией; и (v) обеспечивающую инфраструктуру через национальные инвестиции в вычислительные мощности. Анализ также выявляет типичные для инициатив быстрого масштабирования проблемы измерения, особенно смешение сертификатов, уникальных обучающихся и прироста компетенций, и рассматривает вариативность отчетности как аналитически значимый результат. Опираясь на исследования в области управления микро-квалификациями, цифрового управления образованием и руководства по ответственному использованию генеративного AI, мы предлагаем схему оценки с минимальным стандартом отчетности и индикаторами, согласованными с этапами реализации, которые могут обеспечить международную сопоставимость. Казахстан представляет собой особенно информативный глобальный пример, поскольку сочетает системный охват высшего образования с явной трансляцией инноваций

и вычислительной инфраструктурой, показывая, как национальные стратегии AI могут быть операционализированы через университеты, одновременно поднимая острые вопросы о гарантии качества, академической добросовестности и зависимости от платформ.

Ключевые слова: экономический рост, оценка, ИИ в высшем образовании, ИИ-грамотность, инновационная политика, управление ИИ.

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