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ГАСТРОНОМИЧЕСКИЙ ТУРИЗМ: РОЛЬ В БРЕНДИНГЕ ТЕРРИТОРИЙ

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Аннотация. *В статье рассматриваются вопросы развития гастрономического туризма как одного из важных направлений международного туризма. Раскрывается роль гастрономического туризма в формировании бренда территории.*

Ключевые слова: *гастрономический туризм, бренд, территория, национальная кухня, культура питания.*

Гастрономический туризм – новое направление развития мирового туризма, которое может являться одним из возможных направлений сохранения и развития экономики традиционного хозяйства, культурного наследия и фактором устойчивого развития территорий [1].

Цель гастрономических туров – познакомиться с особенностями кухни той или иной страны. При этом важно узнать особенности местной рецептуры, которая веками вбирала в себя традиции и обычаи местных жителей, их культуру приготовления пищи. Гастрономическое путешествие называют «палитрой, с помощью которой турист может нарисовать свое представление о той или иной стране. Еда приоткрывает тайну духа народа, помогает понять его менталитет» [2].

Туроператоры все чаще отмечают, что люди выбирают места для отдыха не по числу пляжей или памятников истории, а, в том числе, оценивая гастрономическую привлекательность страны. Популярными странами данного направления традиционно являются европейские государства и азиатские страны, такие как Индия, Таиланд, Япония, Китай. Гастрономический тур как услуга – это нечто большее, чем просто путешествие, поскольку он является хорошо продуманным комплексом мероприятий для дегустации 2 традиционных в определенной местности блюд, а также отдельных ингредиентов, не встречающихся больше нигде в мире, имеющих особый вкус. Гастрономические туры обычно рассчитаны на 6–8 дней. Причем в тур может быть включено не только посещение лучших ресторанов, но и участие в технологии приготовления блюд, традиционном празднике с культурной программой, экскурсии на предприятия, а также посещение кулинарных и винных курсов. Для организации гастрономического тура следуют правильно поставить цели и задачи, определить ресурсы и возможности той или иной территории. От этого будет меняться концепция разработанного тура, объекты показа и форма работы с туристами на маршруте. Во-первых, интерес организаторов и туристов вызывает заданная территория, на которой имеется пищевое сырье для гастрономического тура. Во-вторых, внимание туристов может привлечь переработка этого сырья, т.е. технологии, применяющиеся на предприятиях по производству конечного продукта. В-третьих, необходимо организовать дегустацию полученного продукта, которая является одной из самых популярных форм работы с экскурсантами. В-четвертых, желательно наличие точки продажи для приобретения данного продукта для личного употребления и в качестве сувенира [3].

Одной из форм работы является музей при предприятии или отдельно стоящий музейный комплекс, рассказывающий об истории изготовления продукта, совершенствовании технологий сбора и переработки сырья. Плюсом является наличие площадки с возможностью проведения мастер-классов, дегустаций и тематических праздников. Так как данный вид туризма имеет общие черты с другими видами, гастрономический туризм может быть частью комплексного тура или же обладать некоторыми признаками других видов туризма, по которым можно провести классификацию: – сельский («зеленый) гастрономический туризм; – деловой (городской) гастрономический туризм; – событийный (фестивальный) гастрономический туризм; – культурно-познавательный гастрономический туризм. Сельский гастрономический туризм напрямую связан с агротуризмом. Во время таких туров люди находятся в естественной природной среде, познают сельскую культуру и быт, стараются изолироваться от современного мира и стремятся жить, как их предки: занимаются собирательством, живут без особых удобств, помогают фермерам заниматься сельскохозяйственными работами и употребляют в пищу экологически чистые продукты. Во время деловых поездок посещаются фабрики, цеха на заводах, знаменитые предприятия питания и «ресторанные цепи», проводятся презентации новых брендов и блюд, мастер-классы. Событийный или фестивальный гастрономический тур имеет своей целью посещение конкретного события или гастрономического фестиваля, которые периодически проводятся по всему миру и имеют огромную популярность. Например, сентябрь – время Устричного фестиваля в Ирландии и Октоберфеста в Мюнхене. В июле традиционно проходит праздник испанской национальной еды Сан-Фермин и Бонтон – фестиваль тунца в Италии, а в ноябре во Франции – Божоле Нуво – праздник молодого вина и фестиваль белых трюфелей в СанМиниато. Понятие «культурно-познавательный гастрономический туризм» достаточно абстрактное, так как в данном случае речь идет о комбинированном туре. Это может быть поездка в страну с богатыми кулинарными традициями, знакомство с ее достопримечательностями, включая и особенности кухни во время обедов с элементами национальной кухни. Можно говорить о роли продовольствия в туризме на разных этапах путешествия: – предварительное посещение (pre-visit): еда из региона потребляется дома, перед поездкой в качестве пробы; – путешествия до места назначения: во время этой фазы, местные продукты встречаются на пути к месту назначения, например, в самолетах, поездах, иных точках питания по дороге; – в пункте назначения: это основной этап гастрономического тура, который состоит из дегустации, изучения кулинарии и опыта в месте назначения; – путешествия от места назначения; – после посещения (post-visit): этот этап состоит из потребления и кулинарного впечатления от еды, после возвращения из места назначения [4].

Каждый кулинарный опыт является воспоминанием о месте назначения, каждый запах и вкус укрепляет и восстанавливает воспоминания о поездке. Пища и место связываются между собой, формируя основу, которая включена в современное развитие экономики впечатлений, и дает возможность увидеть новый вариант использования территории или среды [5].

Производители продуктов питания различными способами используют интерес потребителей к еде, ассоциирующейся с профилем региона, где 4 некоторые моменты могут умалчиваться, а на других, наоборот, делаться акцент. Таким образом, появляется понятие «бренд территории». Брендинг территорий – стратегия повышения конкурентоспособности городов, областей, регионов, географических зон и государств с целью завоевания внешних рынков, привлечения инвесторов, туристов, новых жителей и квалифицированных мигрантов [6].

Расширенное толкование гастрономического бренда предусматривает продвижение территории как экспортера уникальной высококачественной продукции. Узкое толкование гастрономического бренда подразумевает поиск особенностей региональной кухни, часто выражающихся в наличии одного или нескольких местных блюд, встречающихся только в данном регионе или обладающих особой аутентичностью [7].

Компоненты гастрономического бренда: – хорошо развитая сфера гастрономии; – энергичное гастрономическое сообщество с традиционными ресторанами и поварами; – местные ингредиенты, используемые в традиционной кухне / местное ноу-хау в кулинарии; – традиционные продовольственные рынки и пищевая промышленность; – гастрономические фестивали, награды, конкурсы; – уважение к окружающей среде; – продвижение гастрономии в образовательные учреждения. Разные земли и территории стран могут очень отличаться своими кулинарными традициями, кроме того, на кулинарию оказывают влияние кухни соседних регионов. Некоторые блюда даже носят названия географической местности: шварцвальдская ветчина, нюрнбергские пряники, сыр Эдем, Рокфор, краковская колбаса, орлеанские континьяки, кофе по-венски, петух в вине по-бургундски и т. д. Связь географических названий или территорий с едой возникла еще до начала процесса торговли продуктами на рынке, и давно используется для классифицирования продуктов. Репутация местности может даже добавлять ценность продукту.

В настоящее время пища становится не просто едой, а нечто большим, чем ценность ее питательности. Пища – один из старейших инструментов и самых конкретных культурных проявлений, которые заявляют о том, кто мы есть и к какой группе хотим относиться. Культура питания значима сама по себе как инструмент развития туристского направления. Выделяются стереотипные пищевые профили, делается акцент на пищевых предпочтениях ведущей группы общества, ценится эксклюзивность и создаются определенные культурные символы того или иного места. Страны, взявшие для себя ориентиром гастрономические туры, стремятся к уникальности и борются за положительные бренды своей территории, преследуя коммерческие и политические цели в виде формирования региональной идентичности рынка [8].

Гастрономический туризм показал себя достаточно доходной статьей государственной экономики, и не случайно за его развитие взялись даже те страны, о гастрономической культуре которых обывателю раньше ничего не было известно. Популяризировать национальную кухню принялись многие страны Средиземноморья. Причем трудности в виде отсутствия четкого определения национальной кухни не являются для них преградой. Общепринятые бренды некоторых стран отлично работают на туриндустрию. В Казахстане гастрономический туризм еще только зарождается, элементы гастротуров операторы включают в основные туристские программы, а собственно гастрономическая концепция поездки – большая редкость. Нет на данный момент и четкой системы гастрономических туров, как например во Франции.

Гастрономия зачастую принципиальным образом влияет на выбор путешественником направления поездки, люди готовы тратить на питание большие средства. Бывает и так, что желание познакомиться с уникальными блюдами является главной причиной поездки. Турист рассматривает местную кухню как способ лучше познакомиться с обычаями, традициями и культурой.

Таким образом, стратегия повышения конкурентоспособности городов, областей, регионов, географических зон с целью завоевания внешних рынков, привлечения инвесторов, туристов, новых жителей и квалифицированных мигрантов может осуществляться за счет гастрономических брендов.

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AI AVATARS AS PERSONAL TUTORS: A NEW PEDAGOGICAL PARADIGM

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Annotation. *In the context of the rapid digital transformation of society, education finds itself at the epicenter of contradictions: on the one hand, it must maintain the humanistic mission of personality formation, on the other — adapt to new technological realities. One of the most radical and breakthrough solutions on this path are AI avatars, which are capable of radically changing the pedagogical paradigm. Unlike traditional digital tools limited to content delivery and administration functions, AI avatars integrate the capabilities of generative artificial intelligence, multimodal interaction and emotional analytics, which allows them to act as personal mentors — flexible, adaptive and empathic.*

This technological evolution opens up new horizons: the transition from "mass standardized learning" to hyper-personalized educational trajectories; the formation of a culture of support and mentoring accessible to every student, regardless of social and geographical context; transformation of the role of the teacher, who ceases to be the only source of knowledge and becomes a curator of meanings, a mediator and an architect of the educational environment.

However, the introduction of AI avatars is not limited to a technological upgrade — it is about changing the very logic of education, where a digital mentor becomes not an auxiliary tool, but a full-fledged participant in pedagogical interaction. This requires the development of new methodologies, a revision of educational standards, and the development of ethical regulators. Otherwise, there is a threat of "digital colonization of the consciousness" of students, increased inequality, and the loss of the humanistic core of pedagogy.

Keywords: *artificial intelligence, AI avatars, digital pedagogy, personalization of learning, educational technologies.*

Modern education is going through a period of tectonic shifts. If in the 20th century the main challenge of the education system was the expansion of mass access and the creation of universal standards, then in the 21st century the priority has shifted to personalization, flexibility and continuity of learning. However, existing digital pedagogy tools — e-courses, LMS platforms, online libraries — only partially meet these challenges. They reproduce the industrial logic of the "mass flow of knowledge", where each student is forced to adapt to predetermined formats.

Against this background, the need for a qualitatively new tool that is capable of not only transmitting knowledge, but also adapting to the cognitive, emotional and social characteristics of each student is becoming increasingly obvious. This is the role that AI avatars, created on the basis of generative artificial intelligence and multimodal technologies, are beginning to play [1].

An AI avatar is not a static digital object, but a dynamic pedagogical partner capable of conducting a dialogue, recognizing emotions, taking into account the style of thinking, and building a unique educational trajectory. It combines the functions of a tutor, mentor, and moderator, while possessing scalability that is unattainable for humans. Unlike traditional EdTech technologies that enhance the functionality of a teacher, an AI avatar opens the way to a new pedagogical paradigm, where artificial intelligence acts as a full-fledged actor in the educational process [1].

This innovation changes the very nature of the "teacher-student" interaction. The teacher ceases to be the only source of knowledge and turns into the architect of the educational environment, where AI mentors provide constant support and feedback. This creates the preconditions for the formation of a hybrid education model, in which humans and artificial intelligence work in symbiosis, enhancing each other's strengths [2,3].

Dependence" come to the fore [4]. The introduction of AI avatars into educational systems must be accompanied by the development of new pedagogical methodologies, regulatory frameworks and strategies for digital inclusion. Thus, the relevance of the study is due to the need to understand the phenomenon of AI avatars not as a temporary technological trend, but as a fundamentally new stage in the development of education that determines its future. The article is aimed at a theoretical and methodological analysis of this phenomenon, an assessment of the pedagogical potential of AI avatars, identifying risks and formulating prospects for their integration into national and global educational systems.

The history of education shows that pedagogy has always reflected the socio-economic and technological structure of the era. In industrial society, the key task of the school and university was standardized mass education, providing training for industry. The teacher acted as a transmitter of knowledge, and students were objects of pedagogical influence, adapting to the given norms and curricula.

However, the transition to a post-industrial and digital society has radically changed the demand for education. Today, the system is expected not only to acquire knowledge, but also to develop critical thinking, creativity, emotional intelligence, and the ability to learn throughout life. In this logic, the teacher ceases to be the only source of information: he becomes a facilitator , mentor, curator of meanings who accompanies individual educational trajectories.

AI avatars fit organically into this transformation. They take on some of the support functions: they can adapt the pace and style of learning, provide instant feedback, and adjust tasks to the cognitive level and emotional state of the student. Unlike traditional digital tools that enhance the role of the teacher as a "knowledge manager," the AI avatar acts as a personal mentor, available to each student 24/7. Thus, the introduction of AI avatars marks the transition from the paradigm of "knowledge transmission" to the paradigm of "pedagogical support and mentoring". This does not mean the displacement of a living teacher, but leads to a new distribution of roles: a person retains the function of forming values, developing critical thinking and cultural context, while AI takes on the task of personalized support and intellectual support [5].

The idea of creating digital twins — virtual reflections of a person in a digital environment — is actively developing in medicine, industry, and business. In education, this concept is of particular importance, as it allows modeling not only the cognitive profile of a student, but also his emotional, behavioral, and social characteristics.

An AI avatar acting as a digital mentor can function as a digital twin of the learner. It accumulates data on the style of information perception, the speed of assimilation of material, preferred forms of learning (visual, auditory, kinesthetic) and even the level of motivation. Based on this information, a hyper-personalized educational trajectory is built, in which each step, task or form of interaction is adapted to individual needs.

The phenomenon of cognitive personalization is of particular importance. If classical pedagogy relied on the average "average student," then AI avatars allow us to abandon this model in favor of an individually oriented approach. Algorithms are able to predict which topics will cause difficulties, which tasks will increase motivation, and which, on the contrary, will lead to overload. As a result, the learning process becomes not linear, but adaptive, adjusting to the cognitive dynamics of the individual.

The digital twin can also record long-term changes — track progress in the development of critical thinking, creativity, and communication skills. Thus, the AI avatar ceases to be just a “digital tutor” and turns into a self-learning support system capable of growing with the student, anticipating his educational needs, and adjusting the development trajectory.

However, cognitive personalization also creates new challenges. There is a risk of “algorithmic determination,” when a digital twin assigns a specific profile to a student, depriving them of freedom of choice and the opportunity to go beyond predictable scenarios. This is why the introduction of AI avatars requires a combination of flexible algorithms and pedagogical control so that the digital twin does not replace real personal dynamics, but complements it.

Classical pedagogy has always relied on the personality of the teacher as a bearer of not only knowledge, but also emotional support. Empathy, the ability to grasp the mood of a student, to support or correct behavior in time - these are qualities that were considered exclusively human for many decades. However, the development of technologies for analyzing voice, facial expressions, gestures and biometric data makes it possible to integrate elements of emotional intelligence (EI) into the functionality of AI avatars.

An AI avatar equipped with emotional analytics mechanisms is able to determine the level of fatigue or anxiety of a student based on the timbre of their speech or facial expression; adapt the communication style (softer or, on the contrary, stimulating) depending on the emotional state; offer timely pauses, concentration exercises, or motivational remarks; build a long-term interaction strategy based on understanding the emotional profile of the individual.

Thus, the AI mentor becomes not just a “knowledge transmitter,” but an empathic partner capable of regulating the psychological climate of learning. This is especially important in the context of digital education, where students often experience a feeling of isolation, decreased motivation, and lack of live contact with the teacher.

However, integrating emotional intelligence into AI avatars also raises a number of difficult questions. On the one hand, there is a possibility of developing “emotional dependence” on a digital mentor, when a student begins to trust a virtual partner more than a real teacher or peer community. On the other hand, there is a risk of manipulation if algorithms use emotional data not for educational purposes, but for commercial or control purposes.

Therefore, the key task is to form ethical standards for emotional AI pedagogy, which will define the boundaries of acceptable intervention in the emotional sphere of a student. In the future, it is the combination of cognitive and emotional personalization that will allow AI avatars to perform the functions of a full-fledged mentor, but at the same time not to replace the unique value of live human communication.

The foundation for the creation and operation of AI avatars is generative artificial intelligence (GenAI), which is a qualitatively new class of technologies in the field of machine learning. Unlike traditional algorithms limited to data recognition and classification, generative models are capable of generating new texts, images, audiovisual materials and even complex interaction scenarios, approaching the forms of human creativity [6].

Large language models (LLMs) such as GPT, PaLM, LLaMA and their analogues play a key role here. These systems are trained on large data corpora and have the ability to: conduct coherent and context-sensitive dialogue; adapt the speech style to the age, level of knowledge and cognitive characteristics of the user; offer solutions to educational problems in the logic of “step-by-step mentoring”; model individual educational scenarios.

In the educational context, generative AI becomes the core that turns a digital platform into an interactive interlocutor capable of conducting a full-fledged pedagogical dialogue. If e-courses reproduced ready-made content, then an AI avatar based on GenAI is capable of creating a dynamic educational experience, generating new examples, tasks, and explanations relevant to a specific student [7].

Of particular importance is that generative AI allows adaptive learning models to be integrated into the AI avatar . Such models can predict the trajectory of knowledge development, offer corrective tasks, and even adapt to the user's emotional background. This creates the basis for the emergence of so-called "on-demand learning", where the AI mentor forms the educational material not in advance, but in the process of interaction, based on the needs of the learner "here and now".

However, the potential of generative AI comes with challenges, including the issue of reliability; ethical risks; the need for pedagogical control . Thus, generative artificial intelligence becomes the basic technological platform of AI avatars, ensuring their intelligence, adaptability and creativity. Without GenAI, it is impossible to imagine a qualitative transition from static digital tools to dynamic, living and empathic digital mentors.

One of the most important factors that distinguishes AI avatars from classical e-learning systems is their multimodality – the ability to simultaneously use various channels of perception and communication: text, voice, image, video, gestures, facial expressions and even tactile elements.

Multimodal technologies create the effect of "presence" and make interaction with a digital mentor as close as possible to live communication. This is achieved by synchronizing several components: AI avatars can not only conduct a dialogue in real time, but also take into account the intonation, speech rate, pauses and emotional nuances of the learner's voice. Facial expression and gesture analysis systems allow the avatar to “read” non-verbal signals, record signs of fatigue, boredom or, conversely, involvement. An avatar can have a unique appearance, from an abstract symbol to a realistic three-dimensional model of a person, which enhances personalization and psychological attachment to the learner. Immersion in virtual worlds makes it possible to conduct “ immersive lessons,” where the student interacts with an AI mentor within a learning scenario.

The use of multimodal technologies ensures the transition from traditional knowledge transfer to the formation of an “educational experience” (learning experience), where learning is perceived as an event involving not only the rational, but also the emotional-sensory dimension.

In addition, multimodality enhances the adaptive potential of AI avatars: the system can switch to a more suitable interaction channel depending on the student’s preferences. Thus, a visual learner will prefer infographics and animation, an auditory learner will prefer a dialogue in a voice format, and a kinesthetic learner will prefer practical simulations in AR.

However, the integration of multimodal technologies also poses a number of challenges. These include high development costs, the need to protect biometric data (voice, face, movements), and the risk of excessive “gamification,” when the emotional effect begins to dominate the substantive part of education. Thus, multimodality turns AI avatars into full-fledged educational environments capable of engaging complex human cognitive and emotional mechanisms. This takes digital learning to a new level, where the boundary between virtual and real pedagogy becomes increasingly conditional.

The modern development of AI avatars cannot be considered outside the context of educational and technological platforms that are becoming their infrastructural basis. If the first experiments with digital mentors were highly specialized applications, today an ecosystem approach is increasingly being formed, which involves the integration of AI avatars into existing educational environments.

In practice, several directions can be distinguished: platforms like *Khan Academy* is already implementing AI mentors (for example, *Khanmigo*), capable of accompanying a student in the process of studying disciplines, providing explanations and correcting assignments. Large companies use digital mentors to train staff in the form of micro-courses , simulations and personalized development. Here, the AI avatar becomes part of the talent management and career development system. A number of countries are taking steps to create national educational platforms with elements of AI mentoring, which should ensure equal access to personalized learning throughout the education system. *Soul* type platforms *Machines* or solutions in the field of *Digital Humans* allow the creation of realistic three-dimensional avatars with emotional facial expressions and live animation, which is especially promising for VR/AR training.

The formation of ecosystems around AI avatars has several strategic implications: the ability to implement personalized mentoring for millions of students simultaneously; collecting and analyzing information on educational trajectories, which opens up new possibilities for diagnostics and predicting success; combining AI avatars with blockchain (for skills certification), big data (for predicting educational outcomes), and IoT (for integration with smart classrooms).

However, the formation of ecosystems also gives rise to the risks of monopolization. Large technology players with the resources to develop and implement AI avatars may take dominant positions, which will lead to a dependent position of educational institutions. In addition, the issue of regulating access to student data, which is becoming a key resource in digital education, remains unresolved. Thus, the platformization and ecosystem nature of the development of AI avatars form the basis for their mass distribution. It is the architecture of these solutions that determines whether AI mentors will be a tool for mass digital inclusion or will become a factor in strengthening global educational inequality.

One of the key advantages of introducing AI avatars into the educational process is their ability to provide personalized educational trajectories. If traditional pedagogy was built around the average model of the "average student," then a digital mentor, based on data on the cognitive characteristics, pace of learning, and emotional background of the student, is able to form a unique learning path for each.

AI avatars allow us to take into account a wide range of individual factors: defining basic knowledge and adapting the material to starting positions; slowing down or speeding up the delivery of information depending on the speed of assimilation; use of visual, auditory, textual or kinesthetic forms of presentation of material; selection of tasks and forms of interaction that increase interest and involvement; constant adjustment of the learning path depending on progress or difficulties that arise. Thus, the AI avatar acts as a digital tutor , accompanying the student throughout the educational process. It is able to identify gaps, offer additional resources, predict possible difficulties, and even form long-term learning strategies.

Personalization of trajectories also has strategic significance for educational systems as a whole. On the one hand, it improves the quality of knowledge acquisition, reduces the risk of students dropping out of the educational process, and strengthens their motivation. On the other hand, it allows for the formation of hybrid models of mass education that combine standards (the necessary minimum) and individual trajectories (the zone of personal development).

However, such a model requires balance. There is a risk of "algorithmic segregation," when students become locked into narrow trajectories, deprived of the opportunity to go beyond the usual scenarios. To avoid this, it is important to integrate pedagogical moderation mechanisms into the work of AI avatars , where a living teacher acts as a "horizon controller" — directing the student to more complex tasks and stimulating their development beyond automatic predictions.

In this sense, the AI avatar becomes not a replacement for the teacher, but a tool for expanding his or her capabilities, opening the way to one-on-one education, which has historically been considered the most effective, but has always been inaccessible on a mass scale.

Modern society places demands on graduates of educational systems that go far beyond subject knowledge. The focus is on the so-called 21st century skills - critical thinking, creativity, communication, collaboration , digital literacy and the ability to self-study. Traditional educational practices are far from always able to effectively develop these qualities, as they require an individualized approach and constant adaptation of educational tasks to real life situations.

AI avatars open up new opportunities for developing these competencies. Their key benefits include: digital mentors can ask clarifying questions, model alternative points of view and offer counterarguments, stimulating students to independent analysis and reflection ; using the generative capabilities of AI, avatars can help students generate ideas, create project prototypes and find non-standard solutions; the dialogue format of interaction with an AI avatar allows you to practice argumentation, conduct discussions and develop rhetorical skills in a safe environment; in group projects, an AI mentor can act as a moderator, distributing roles and monitoring the effectiveness of teamwork; Working with an AI avatar requires mastering new formats of interaction with digital systems, which organically forms the skill of using technology as a tool for solving educational and professional problems; the avatar can help the student track progress, record achievements and form a habit of regular self-development. AI avatars can thus act as a catalyst for the development of meta-skills needed to live and work in a rapidly changing society. Their value lies in their ability to create an environment of constant challenge and feedback, in which learning goes beyond rote learning and becomes a process of actively learning new ways of thinking and acting.

However, it is important to consider possible risks. There is a possibility that students will use AI avatars as a tool to replace their own efforts, which will lead to the formation of "passive users" instead of active creators. To avoid this, it is necessary to develop pedagogical scenarios where the AI avatar does not provide ready-made solutions, but stimulates the search for independent ones. In the long term, it is through the development of 21st century skills that AI avatars can become a tool not only for individual but also for social progress, preparing the next generation for the challenges of the digital age.

One of the most important arguments in favor of introducing AI avatars into the educational process is their ability to significantly increase the accessibility of education. If the traditional model of “one teacher — many students” is objectively limited by time, resources, and the quality of individual attention, then AI mentors are able to provide personal support to each student, regardless of the number of students in the class or geographic location.

The possibilities that AI avatars open up in this direction can be grouped as follows: Virtual tutors can work in different languages and take into account the cultural context, which allows integrating students from different regions into a single educational space; AI avatars have the potential to adapt educational materials for students with disabilities: visually impaired, hard of hearing or with cognitive difficulties. Multimodal technologies (speech synthesis, tactile interfaces, visualization) help compensate for perception limitations; the widespread use of digital tutors reduces barriers to access to high-quality educational resources, allowing for personalized learning even in conditions of a shortage of qualified teachers; AI avatars can accompany students 24/7, providing learning at a convenient time and pace, which is especially important for adult students and workers who combine study with professional activities.

Thus, AI mentors can become a tool for implementing the principle of “education for everyone,” which for many years remained a declaration, but rarely found practical implementation. Unlike mass online courses, where individualization is limited, avatars provide personal interaction, close to the format of tutoring, but available on a mass scale.

However, increased accessibility also comes with new challenges. There is a risk of increasing digital inequality, with only those with modern devices and a stable internet connection gaining access to AI avatars . In addition, “global platforms” may impose their own educational standards, which will lead to cultural unification and weakening of national educational traditions. AI avatars thus offer the opportunity to move from “mass homogenized learning” to mass personalization, making education truly inclusive. But for this prospect to be realized, systemic measures are needed at the level of educational policy aimed at overcoming digital barriers and preserving cultural diversity.

One of the most pressing challenges associated with the introduction of AI avatars into education is the problem of trust and the resulting dependency. Any educational system is built on the basis of trust in the source of knowledge, be it a teacher, a textbook, or a digital platform. In the case of AI mentors, this trust takes on a new form and new risks.

First, there is a phenomenon of trust transfer from a person to an algorithm. If a student regularly interacts with an avatar that provides answers, emotional support, and accompanies the educational trajectory, then over time he begins to perceive it not as a tool, but as an authority. This can lead to a weakening of critical perception of information, when any statement of a digital mentor is perceived as true.

Secondly, there is a risk of developing psychological and cognitive dependence. The constant readiness of the AI avatar to help, explain and support can cause the student to lose independence, initiative and ability to cope with uncertainty. As a result, the student may find themselves in a position of "digital guardianship", where every decision is filtered by the AI.

Thirdly, the problem of trust is also connected with the transparency of algorithms. Modern models of artificial intelligence remain "black boxes" in which it is difficult to track the basis on which a particular answer is built. This is critical for the educational process, since trust should be based not only on authority, but also on an understanding of the principles by which knowledge is formed.

Finally, the ethical dimension of trust must be taken into account. Educational institutions and states have a responsibility to ensure that the introduction of AI avatars does not undermine the humanistic foundation of pedagogy. Otherwise, trust in digital mentors can develop into digital manipulation, where the learner becomes the object of hidden influences - from commercial interests to political propaganda. Thus, the problem of trust and dependence requires the development of mechanisms for pedagogical mediation and digital ethics: transparency of algorithms and explainability of AI decisions; maintaining the leading role of the teacher in the development of critical thinking; implementation of digital hygiene systems that develop students' skills for independently selecting information.

The introduction of AI avatars into the educational process promises a significant increase in the availability and quality of education, but at the same time it exacerbates the problem of digital inequality. This concept refers to the uneven distribution of access to digital resources, skills and opportunities, which leads to the reproduction of the social and educational gap.

First of all, there is a technical barrier to consider. Effective use of AI tutors requires modern devices and a stable high-speed internet connection. In countries and regions with limited digital infrastructure, this becomes an insurmountable obstacle, effectively excluding students from educational innovation.

The second factor is economic inequality. Even with the technical base, access to high-quality AI avatars may remain paid, which will increase the gap between families with different income levels. The situation when some students receive individual support based on advanced technologies, while others are content with outdated methods, forms a new round of educational stratification.

The third aspect is digital literacy. Students and teachers who do not have the skills to interact with AI technologies are in a vulnerable position. Thus, digital inequality is expressed not only in access to resources, but also in the ability to use them.

Of particular concern is the risk of "two-speed education": elite schools and universities will be able to implement AI avatars as part of the educational ecosystem, while mass institutions will be forced to remain within the traditional model. This will lead to institutionalization of inequality and reduced social mobility.

To overcome the digital divide, a set of measures is needed: public investment in infrastructure and support for under-resourced schools; development of open educational platforms where basic versions of AI avatars will be available for free; improving the digital literacy of teachers and students through targeted programs; Ethical regulation of pricing policy in the field of educational technologies.

Thus, digital inequality is not a side issue, but a systemic challenge in the context of the introduction of AI avatars. If this challenge is not addressed, the technology that has the potential to expand access to education may turn into a tool for its further segregation.

One of the most critical issues associated with the introduction of AI avatars in education is the problem of protecting personal data and ensuring privacy. Unlike traditional digital tools, AI mentors operate based on deep analytics of large amounts of information: academic results, cognitive characteristics, emotional reactions, and even biometric data of students. This makes them unique in terms of the scale of information collection, but at the same time extremely vulnerable.

First of all, it is worth noting that AI avatars process personalized educational profiles, including academic performance history, individual preferences, learning styles, and motivational patterns. The second aspect concerns emotional and behavioral data. Modern multimodal technologies allow us to record facial expressions, voice timbre, reaction speed, and other indicators, which together form the so-called "digital personality portrait." The third dimension is the issue of privacy in the interaction process. Constant monitoring and analysis carried out by an AI avatar can create a feeling of total control in students, which reduces trust in the educational system and causes resistance to the introduction of technologies.

To minimize risks, it is necessary to develop a system of measures: development of strict regulations on the protection of educational data at the national and international levels; implementation of principles of transparency and explainability of algorithms, allowing to understand what data is collected and how it is used; the use of differential privacy and anonymization technologies that eliminate the possibility of direct identification of an individual; the formation of ethical codes for educational organizations and EdTech companies that regulate the boundaries of acceptable interference in the personal space of students. Thus, the issue of data protection and privacy goes beyond a technical task and becomes a fundamental condition for trust in AI avatars . Without a solution, any attempt to integrate digital mentors into education will be perceived as a threat, not an innovation. Only by maintaining a balance between personalization and privacy can AI avatars become a safe and effective tool for future pedagogy.

The integration of AI avatars into educational systems requires not only technological readiness, but also the development of a coordinated state policy aimed at regulating and supporting digital innovations. The experience of countries actively introducing artificial intelligence into education shows that the lack of a strategic approach leads to fragmentation of initiatives, risks of monopolization, and increased digital inequality.

First, national strategies must include infrastructure readiness: developing broadband internet, equipping schools with modern devices, creating data centers and cloud services capable of supporting large-scale AI platforms. Without basic digital infrastructure, the mass deployment of AI avatars turns into local experiments.

Secondly, the key area is training teaching staff. The teacher in the new paradigm does not disappear, but is transformed into a curator of educational trajectories, a moderator of digital mentors and an architect of the educational environment. This requires national programs for advanced training and retraining of teachers, including skills for interacting with AI avatars and managing blended learning models.

Third, the state strategy should include the development of ethical and legal norms governing the collection, storage and use of student data. This implies the creation of national standards for the protection of educational data, the introduction of principles of transparency and explainability of algorithms, and the formation of public control mechanisms.

Fourth, it is necessary to stimulate the development of our own national EdTech platforms. Relying solely on foreign solutions increases technological dependence and threatens the cultural identity of education. Local initiatives will allow adapting AI avatars to the linguistic, cultural and social characteristics of the country, forming educational ecosystems that correspond to national priorities.

Finally, it is important to consider the strategic mission of education as a factor of national competitiveness. The integration of AI avatars should be considered not only as a pedagogical innovation, but also as a tool for training personnel for the economy of the future, where the ability to interact with artificial intelligence will become a basic competency.

Thus, national educational strategies in the field of AI avatars implementation should be based on the principles of infrastructure readiness, pedagogical transformation, ethical protection and technological sovereignty. Only in this case, digital mentors will become a tool not for point innovations, but for systemic development of education.

The introduction of AI avatars into education does not mean the displacement of the teacher from the educational process, on the contrary, it requires a rethinking of his mission and functions. If previously the teacher was the main source of knowledge and controller of the assimilation of the material, then in the conditions of digital mentors he becomes the curator of educational trajectories and the architect of meanings, combining the capabilities of man and artificial intelligence.

There are several new roles for teachers in the era of AI avatars: the teacher accompanies the work of the AI avatar , adjusting its recommendations taking into account the cultural, social and personal context. He acts as a guarantor that learning will not be reduced to algorithmic forecasts and will retain a creative dimension; unlike algorithms, the teacher is able to form a space for dialogue, set value guidelines and resolve conflict situations. His task is not only to guide the learning process, but also to ensure a humanistic balance in the context of digitalization.

The teacher designs a hybrid space that combines traditional practices, digital tools, and the capabilities of AI avatars. This requires mastery of blended learning methods, digital pedagogy, and project-based approaches ; it is the teacher who must develop in students the ability to doubt, analyze, and ask questions — something that algorithms cannot yet fully reproduce. In the context of trust in digital mentors, it is the teacher who acts as a protector from “algorithmic dependence”; AI avatars are able to adapt knowledge to cognitive and emotional characteristics, but they cannot instill cultural values, national identity, and social responsibility. The teacher remains the key guide in this area.

Thus, the role of the teacher is not reduced, but diversified. He ceases to be a “single translator” and becomes the central figure of pedagogical symbiosis, where his tasks shift to the area of support, interpretation and humanistic understanding of education.

In the long term, this requires a revision of teacher training programs: from studying subject teaching methods to mastering digital pedagogy skills, managing educational data, interacting with AI, and developing ethical strategies. It is the new roles of the teacher that will ensure a harmonious combination of the human and the artificial, turning AI avatars not into competitors, but into allies of the pedagogy of the future.

One of the most significant effects of the introduction of AI avatars is their ability to internationalize the educational process. In the era of globalization, education is no longer limited to national borders: global competencies, the ability to work in multicultural environments, and the ability to use universal digital tools are becoming increasingly in demand.

AI avatars play a key role here due to a number of features: Modern artificial intelligence models can work in dozens of languages and take into account the specifics of the cultural context. This allows students from different countries to interact with digital mentors without language barriers and master materials in a comfortable form; AI avatars can connect students from different regions into a single educational network, where learning is based not only on the interaction "student-AI", but also on joint projects, discussions and cross-cultural tasks. Thus, a model of a "virtual international audience" is formed; work with international databases, scientific sources and educational resources that were previously available only to a limited circle. This enhances academic mobility and helps to equalize educational opportunities; interaction with AI mentors from different cultural contexts contributes to the development of tolerance, intercultural communication and global thinking - key competencies in the context of global integration.

However, internationalization through AI avatars is also associated with a number of risks. Firstly, there is a threat of cultural unification, when educational standards of global platforms displace national traditions and unique pedagogical practices. Secondly, there is a risk of increasing dependence on international corporations that control access to technology and data. Thirdly, the question remains open about the extent to which digital mentors are able to preserve local identity without dissolving it in the global flow. Internationalization through AI avatars thus opens up the prospect of education to form a global educational ecosystem where borders are erased and learning becomes truly universal. But at the same time, this requires developing strategies for cultural protection and diversity preservation, so that internationalization does not turn into homogenization. The prospects for the integration of AI avatars are outlined as a two-tier process: at the domestic level – creation of a sustainable national educational infrastructure and training of teaching staff; at the external level - participation in global educational networks while maintaining cultural diversity (table 1).

Table 1 - Prospects for integrating AI avatars into education

Direction	Main Contents	Key tasks	Potential risks
National Education Strategies	Formation of state policy for the introduction of AI avatars	Development of infrastructure (Internet, equipment) Preparation of the regulatory framework State support for schools and universities	Fragmentation of initiatives Dependence on external technology providers
New roles of the teacher	Transformation of teacher functions in the context of digital mentors	Moving from knowledge transfer to facilitation and mentoring Developing AI skills Developing critical thinking in students	Risk of reducing the authority of the teacher Insufficient training of personnel
Internationalization of education	Building Global Educational Ecosystems Based on AI Avatars	Multilingual and culturally responsive support Formation of "global classes" Access to international resources	Cultural unification Increasing dependence on global corporations

AI avatars can become a catalyst for educational transformation, capable of connecting the local and the global, the individual and the mass, the human and the digital. However, the success of this process is determined not only by technological progress, but also by the ability of society to develop ethical, cultural and strategic guidelines that will direct innovation in the direction of humanistic development of education.

The development of AI avatars as digital mentors indicates that education is entering a stage where the boundaries between humans and technology are becoming increasingly conditional. A new quality of pedagogical interaction is emerging — learning as a joint construction of experience in a dialogue between the individual and artificial intelligence. This is not mechanical automation, but an attempt to expand the horizons of human development through digital tools that can not only transmit knowledge, but also accompany the formation of the individual.

AI avatars demonstrate that education can cease to be a space of attention deficit and individualization. For the first time in history, it becomes possible to combine mass character with a personal approach, universality of knowledge with its deep adaptation, technological effectiveness with empathy . Thus, they open the way to the creation of a new pedagogical ecosystem, where the student ceases to be an object of influence and becomes a subject, shaping his development trajectory in partnership with AI.

At the same time, the future of this technology depends not so much on the speed of its implementation, but on the meaningfulness of its application. AI avatars can become a tool for developing critical thinking, global inclusion and the formation of 21st century skills, or they can turn into a mechanism of segregation, algorithmic dependence and cultural unification. The outcome is determined by what values will form the basis for their integration. Thus, the task of researchers, educators and politicians is not to unconditionally introduce AI avatars into education, but to determine the rules of their coexistence with humans, to create conditions under which a digital mentor will enhance the pedagogical process without replacing it. Only in this case, AI avatars will not become a threat, but a resource for updating the humanistic mission of education that meets the challenges of the 21st century.

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EMOTIONAL INTELLIGENCE IN MACHINES: CAN AI CULTIVATE EMPATHY?

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Abstract. *In the context of rapid digitalization and transformation of educational practices, there is a need to rethink the role of artificial intelligence in pedagogy. If in the first wave of digitalization, AI was considered primarily as a cognitive tool for automation and optimization of learning, then at present a new vector is being actualized - the study of its affective potential. Of particular importance is the question: is AI, deprived of its own emotional nature, capable of participating in the formation of such key competencies of the 21st century in humans as empathy, emotional regulation and social sensitivity?*

The article is devoted to the analysis of the concept of emotional intelligence of machines and consideration of AI not only as an intermediary in the transfer of knowledge, but also as an agent of the educational process. The novelty of the study lies in the integration of theories of emotional intelligence with modern developments in the field of affective computing, which allows us to propose an interdisciplinary model of "empathic AI pedagogy." This model assumes a transition from traditional cognitive digitalization to "affective education," where emotional AI becomes an accomplice in the development of the student's personality.

The article examines in detail the technological foundations of emotional AI: emotion recognition systems based on voice, facial expressions and behavioral signals; mechanisms for synthesizing empathically colored text and speech; multimodal architectures that combine cognitive and affective models of interaction. It is shown that the integration of such solutions into educational platforms opens up opportunities for supporting student motivation, reducing anxiety, developing empathy and developing soft skills.

The practical significance of the study is that it offers conceptual guidelines for state educational policy, training of teachers to work with emotional AI, and international cooperation in the development of standards for affective education.

Key words: *artificial intelligence, emotional intelligence, empathy, digital pedagogy, education, ethics.*

The modern educational system is undergoing a transformation caused not only by digitalization and the introduction of new technologies, but also by changes in the very nature of knowledge. In an era when cognitive resources are becoming easily accessible thanks to the Internet, digital platforms and artificial intelligence, educational institutions are losing their monopoly on the transmission of information. The task of developing personal and social competencies that determine a person's ability to interact with others, regulate their own emotions and empathize comes to the fore. These qualities are empathy, emotional stability, soft skills are becoming strategically important for successful adaptation in conditions of global instability and uncertainty.

However, traditional pedagogical models, focused primarily on the cognitive component of learning, are insufficient to solve this problem. The educational function of educational institutions is in crisis: teachers are overloaded with formal requirements, and educational practices are giving way to standardized educational results. In this situation, the question arises of finding new means and mediators capable of compensating for the deficit of emotional support and actualizing the value of empathy as a basic competence of the 21st century.

Artificial intelligence, long perceived as a purely rational tool for data analysis, is now demonstrating a qualitative shift towards affective technologies. The development of the affective direction computing has allowed systems not only to recognize human emotional states, but also to model empathic reactions. This opens up new horizons for pedagogy: a digital agent can become not just a “knowledge machine”, but also a conditional “emotional mentor” capable of reducing anxiety, motivating, and developing communication and social skills [1-5].

However, a fundamental dilemma arises: can AI, deprived of its own emotional nature, truly participate in the education of empathy? On the one hand, technologies for recognizing emotions and generating an empathically colored response make it possible to create the illusion of affective interaction, which is already used today in educational chatbots and digital tutors . On the other hand, there is a risk of replacing genuine interpersonal experience with simulation, which gives rise to new ethical and pedagogical challenges [5]. Thus, the relevance of the study is determined by the need to understand the pedagogical potential of emotional AI in the context of the educational function of educational institutions . The purpose of the article is to analyze the possibilities and limitations of integrating the emotional intelligence of machines into the educational process, to identify its impact on the formation of empathy in students and to outline the ethical framework for the use of such technologies.

The concept of emotional intelligence has become one of the key categories of psychology and pedagogy in the late 20th – early 21st centuries. Unlike traditional cognitive intelligence, associated with the ability to think logically, analyze, and solve problems, EI describes a person’s ability to understand their own emotions, regulate them, and perceive and interpret the emotional states of others. It is thanks to this concept that the emotional sphere of the individual has ceased to be considered secondary to the rational, which has opened up new horizons for pedagogical practices [1-4].

The theoretical basis for EI was laid by the works of Salovey P., Mayer J. D., who in the 1990s proposed a model that considered emotional intelligence as a set of cognitive abilities: recognizing emotions, using emotions to facilitate thinking, understanding emotions and regulating them. Their approach emphasized that emotions do not oppose rationality, but, on the contrary, can enhance cognitive processes, contributing to more balanced decisions and harmonious interactions [2,3].

Further development of the concept is associated with the work of Goleman D. D., who popularized the idea of EI and proposed a more applied model that included four dimensions: self-awareness, self-regulation , social awareness, and relationship management. In the pedagogical context, this model has received the greatest distribution, since it is directly related to the development of empathy, cooperation, and responsible behavior skills in students [1,4].

In education, the concept of EI has become a kind of “bridge” between the cognitive and affective dimensions of learning. Research shows that a high level of EI in students contributes not only to academic success, but also increases their resistance to stress, develops leadership skills and readiness for collaborative activities. Moreover, emotional intelligence is considered a metacompetence that determines the success of mastering other skills, including digital and professional ones.

Thus, in pedagogical theory, emotional intelligence has become the foundation for rethinking the role of emotions in education. If previously emotions were perceived as a "background" or "interference" with learning, today they are considered a central element of the educational process.

In this logic, the question arises: is artificial intelligence, operating with algorithms and data models, capable of acting as an intermediary in the development of EI in humans?

The history of artificial intelligence demonstrates a gradual transition from narrowly rational algorithms to systems capable of modeling and interpreting emotional states. The first developments in the mid-20th century focused exclusively on cognitive tasks: solving mathematical equations, processing logical expressions, and automating calculations. Classical AI was conceived as a machine of the mind, devoid of corporeality and emotionality.

At the first stage (1950–1970s), AI operated in the paradigm of so-called symbolic intelligence. Algorithms were built on logical rules, decision trees, and expert systems. In this logic, humans and machines were divided by rationality: if humans could make mistakes due to emotions, then machines were considered “pure” cognitive systems.

The second stage (1980–2000) is associated with the development of neural network technologies and machine learning. AI began to acquire the ability to learn from examples, recognize images and adapt to context. It was then that the first rudiments of affective signal analysis emerged — in speech recognition, facial expressions and intonations. But these technologies were considered more as auxiliary rather than as an independent direction.

A qualitative shift occurred with the emergence of the concept of affective computing proposed by Picard R. W. in 1997. It was based on the assumption that for full interaction with a person, a machine should be able to not only process rational signals, but also interpret emotional ones. This became the starting point for the development of systems that are able to “read” emotions based on physiological parameters (heart rate, facial expressions, speech tone) and respond accordingly [5].

The modern stage (2010s–2020s) is characterized by the emergence of emotional machines – complex systems that integrate machine learning algorithms, computer vision, natural language processing and biometric data. Such systems are capable of not only analyzing the emotional state of the interlocutor, but also generating a response close to empathic. Virtual assistants, chatbots, educational platforms increasingly include elements of emotional intelligence, modeling “human-oriented” interaction [6-10]. Thus, the evolution of AI reflects the transition from a "mind machine" to a "feeling machine". If emotions were initially considered an obstacle to cognitive processes, today they are becoming an object of modeling and control. This opens up a new research horizon: can AI that has learned to recognize and reproduce emotions become a full-fledged participant in the educational process and a mediator in the development of empathy in humans?

In traditional pedagogy, emotions have long been considered a side factor in the educational process: the teacher had to control them, and the student had to suppress them in order to concentrate on knowledge. However, modern research in the psychology of learning and neuropedagogy shows that without the involvement of the emotional sphere, the sustainable formation of knowledge and values is impossible. This is why emotional intelligence has become a key category of educational reforms in the late 20th and early 21st centuries.

In this context, emotional artificial intelligence opens up a new pedagogical perspective. It can act not only as a cognitive mediator providing access to information, but also as an affective partner creating an atmosphere of emotional safety and support. In the context of mass education, when the teacher has limited opportunities to work individually with each student, emotional digital agents can compensate for the deficit of attention and empathy.

Emotional AI can be considered as a tool of " affective pedagogy", in which technologies do not replace, but rather enhance the educational role of the educational institution. The key areas of such use are: supporting students in situations of anxiety, uncertainty or emotional burnout through empathically coloured digital interactions; modelling role-playing situations and simulations that allow students to practice empathy and interpersonal communication skills in a safe digital environment; developing soft skills through the integration of emotionally sensitive assistants into group and individual forms of training. However, it is important to emphasize that emotional AI in pedagogy cannot and should not be considered as a full-fledged replacement for live communication between a teacher and the student. Its task is to complement the educational process, expanding the space of opportunities for the formation of empathy and social-emotional competencies. Thus, the place of emotional AI in pedagogy can be defined as a link between cognitive digitalization and humanistic education. Its implementation marks the transition to a new stage - from information technologies of training to technologies of emotionally oriented education, where attention is paid not only to knowledge, but also to feelings, values and interpersonal relationships.

The development of emotional artificial intelligence is impossible without improving technologies capable of recording and interpreting human emotional states. Unlike traditional AI systems that work with cognitive signals (text, logic, knowledge), emotionally oriented platforms rely on affective markers expressed in voice, facial expressions, movements, and physiological reactions. Modern research highlights several key areas of emotion recognition [11-13]: voice and speech characteristics analysis. Algorithms record changes in timbre, pitch, volume, and tempo of speech, which allows one to distinguish states of joy, anxiety, fatigue, or irritation. In the educational environment, such technologies are integrated into digital assistants and online learning systems, allowing one to determine the emotional state of a student during an answer or discussion; computer vision and facial expression analysis. Computer vision technologies allow one to interpret facial microexpressions, smiles, frowns, and eye contact. These data together form a picture of the student's emotional state. In pedagogy , this approach can be used to monitor student engagement in a lecture or virtual classroom; movements and posture. Sensory systems record body position, gestures and motor activity. In educational practice, this can be used to detect signs of fatigue or loss of interest in a lesson, which allows for timely adjustments to teaching methods; physiological indicators. More advanced systems use sensors to analyze heart rate, skin conductivity, and breathing. Although the introduction of such technologies into mass education is still limited by ethical and technical barriers, they are actively being studied in the context of individualized learning and psychophysiological diagnostics.

Of particular importance is the multimodal approach, which involves combining various channels (voice, face, movements) into a single analysis system. This approach ensures a more accurate and reliable definition of emotional states, minimizing the risk of erroneous interpretations.

For pedagogy, emotion recognition technologies open up the possibility of creating dynamically adaptive educational environments, where a course or task is adjusted to the emotional state of the student. For example, when signs of fatigue are detected, the system can offer a break or a game element, and when anxiety is detected, it can provide support or a simplified explanation of the material.

However, the use of these technologies requires caution. On the one hand, they create conditions for individualization of learning, on the other hand, they generate risks of invading the student's personal space and manipulating emotional data. That is why the introduction of emotion recognition technologies should be accompanied by clear ethical frameworks and pedagogical control.

If emotion recognition technologies allow the system to "hear" and "see" a person's emotional states, then the synthesis of an empathic response forms the reverse side of the interaction — the ability of AI to generate a reaction that reflects care, support, and understanding. This direction makes artificial intelligence not just an analysis tool, but a full-fledged interlocutor capable of participating in an affective exchange.

Modern technologies are based on three key components: natural language processing (NLP). Systems are trained to generate text with emotional overtones, adapting it to the context. For example, AI responses can include words of support ("I understand that this was difficult," "you're doing better than you think"), and also take into account the tone of the dialogue; speech synthesis with emotional modulation. Voice generation algorithms (Text -to- Speech, TTS) allow you to vary the intonation, timbre and rhythm of speech. Thanks to this, the digital assistant can express sympathy or joy, making the interaction more "human"; multimodal reactions.

An empathic response can include visual elements: animations, digital avatars expressing emotions through facial expressions and gestures. These solutions are especially in demand in educational environments of virtual and augmented reality. In educational practice, the synthesis of an empathic response is capable of performing a number of significant functions: a learner receiving empathic feedback from an AI ("don't worry, mistakes are part of learning") reduces stress levels and maintains motivation; A digital agent can demonstrate examples of empathic dialogue, developing students' skills in correctly expressing emotions and interacting respectfully; students who regularly encounter empathically colored responses begin to adopt this style of communication, which contributes to the development of their own affective competencies.

Technologies for synthesizing empathic responses are moving toward personalization — building an individual communication style that takes into account the age, cultural background, and personal characteristics of the student. In the future, we can expect the emergence of emotional AI mentors that will not just teach, but support a person throughout their entire life, helping to develop skills of emotional self-regulation and empathy.

Modern research in artificial intelligence demonstrates that the isolated use of emotion recognition or empathic response synthesis technologies limits the quality of interaction. Truly effective affective interaction occurs when different channels of perception and response are combined into a single system. This approach is called multimodal integration.

Multimodal systems are able to simultaneously analyze voice, text, facial expressions, movements, and physiological parameters, combining this data into a holistic model of the user's emotional state. Likewise, they can generate a response through multiple channels—text, voice, visual images, animation. Thanks to this, AI not only "understands" but also "returns" emotions in a more natural way, as close as possible to human interaction [13-15].

Motivation and emotional well-being are key factors for successful learning. In traditional pedagogy, supporting students in situations of anxiety and uncertainty was the responsibility of the teacher, but in the context of mass education and digitalization, this task increasingly requires new tools. Emotional artificial intelligence (AI) opens up the possibility of systematically providing empathic support to students, reducing their emotional barriers and strengthening their internal motivation.

Regular interaction with an empathetically tuned AI forms in students the experience of constructive dialogue with their own emotions. Gradually, this experience is internalized, and the student begins to reproduce strategies of emotional self-support in everyday life. Thus, emotional AI becomes not only a temporary motivation tool, but also a factor in the formation of stable affective competencies.

Emotional AI is capable of creating virtual scenarios in which the learner encounters a variety of emotional situations. This can be implemented through: role-playing simulations; empathic feedback; social conflict modeling.

The optimal model seems to be a combination of digital and live interaction. Emotional AI can become a preparatory platform for the formation of empathic reactions, after which these skills are consolidated in real interpersonal communication with teachers, parents and peers. Thus, digital interaction does not replace, but complements traditional educational practices. Thus, emotional AI is capable of creating conditions for training empathy, but its influence is of instrumental support nature, rather than a full-fledged replacement for living experience. It can expand the possibilities of the educational process if it is integrated into educational practice in balance with humanistic principles of pedagogy.

In the modern educational and professional context, so-called "soft skills" are acquiring strategic importance. They are understood as a set of universal competencies, including communication, collaboration , critical thinking, leadership, emotional regulation and adaptability. Unlike "hard" knowledge, which is subject to standardized testing, soft skills are formed in the process of social interaction and are mediated by emotional experience. This is where emotional artificial intelligence (AI) opens up new horizons of pedagogical influence [16].

Digital assistants and chatbots equipped with affective modules can simulate various communication situations: from everyday dialogue to complex negotiations. Trainers get the opportunity to practice active listening, empathic response, and argumentation skills. Unlike a live interlocutor, AI is able to repeatedly reproduce the same situation, creating conditions for gradual skill honing.

Modern educational platforms with elements of emotional AI allow the formation of virtual project groups, where students learn to distribute roles, take into account the emotional states of participants and reach agreed decisions. Thus, even in a digital environment, cooperation and leadership competencies are developed, which is especially important for generations accustomed to remote forms of interaction.

An interesting direction is the use of emotional AI to foster a critical attitude towards digital interactions. By analyzing how “real” or “simulated” a machine’s empathy is, students develop skills in critical evaluation of information, ethical sensitivity, and an understanding of the limits of technology. Thus, emotional AI becomes a tool for targeted soft skills formation in the educational environment. Its potential lies in the combination of repeatability and adaptability of digital scenarios with the ability to cultivate emotional awareness and empathy, which makes it a key element in preparing an individual for life and work in the digital age.

An analysis of the pedagogical potential of emotional artificial intelligence allows us to state that its role in education goes far beyond the framework of assistive technologies. It forms a new dimension of the educational process, where attention is paid not only to the cognitive acquisition of knowledge, but also to the affective support of the individual.

First, emotional AI demonstrates high efficiency in supporting motivation and reducing anxiety by offering empathic feedback and adaptive interaction strategies. This is especially important in mass education, where the teacher’s attention cannot always be directed to each student.

Second, digital interaction with emotional AI opens up opportunities for developing empathy and training social skills through role-playing simulations, modeling conflict situations, and feedback colored with care and attention. Although this empathy remains imitative, it performs an important educational function – preparation for deeper interpersonal practices.

Thirdly, emotional AI is becoming an effective tool for soft development skills : communication, collaboration, emotional regulation and critical attitude to digital interactions. Its application allows to make training more holistic and focused on the formation of a personality capable of adapting to the challenges of the digital age.

At the same time, the results of the analysis show the need to maintain a balance: emotional AI should be considered as a supplement to pedagogical practice, not its replacement. Its value lies in expanding educational opportunities, but not in replacing live interpersonal contact. Thus, the pedagogical potential of emotional AI lies in the creation of an affectively enriched educational environment, where technologies become allies of the teacher in the formation of a harmonious, stable and socially sensitive personality.

The introduction of emotional artificial intelligence into the educational process opens up broad prospects, but at the same time threatens the fundamental values of pedagogy. Historically, education has always been viewed as a space for the humanistic development of personality, where the main goals were not only the transfer of knowledge, but also the formation of morality, responsibility, empathy and the ability to make free choices.

The integration of emotional artificial intelligence (AI) into the education system is impossible without a clear state policy and the development of standards regulating its use. This is not only about technical certification of software, but also about a broader set of legal, ethical and pedagogical frameworks that determine the place of affective technologies in the educational ecosystem.

Emotional data is one of the most sensitive types of information. Its processing requires much stricter protection than cognitive performance indicators. Otherwise, the risk of leaks, manipulation of emotions and commercial exploitation of students’ personal data increases. Public policy should provide for: creation of legal mechanisms for the protection of emotional data; development of standards for storing and processing information; implementation of mechanisms for monitoring the activities of companies developing emotional AI.

In order for emotional AI not to become just a tool for market decisions, it is necessary to include its use in the system of state educational standards. This implies: definition of pedagogical goals of using affective technologies (support of motivation, development of soft skills , development of empathy); development of methodological recommendations for schools and universities on the safe integration of emotional AI; implementation of ethical codes that limit the manipulative use of technologies.

Public policy must take into account ethical aspects: prohibition of the use of emotional data for advertising and political purposes; creation of ethics committees under the ministries of education and digital development; conducting independent assessments of technologies before their implementation in the educational process.

In the context of globalization, it is impossible to consider emotional AI exclusively within national borders. It is necessary to harmonize standards with international approaches developed by UNESCO, OECD and the Council of Europe. This will ensure a unified framework for protecting the rights of students, as well as create conditions for the exchange of best practices and joint research [9,10,14,15].

The development and implementation of state standards for emotional AI is of strategic importance: strengthens public trust in technology; creates conditions for safe digital pedagogy; increases the competitiveness of the national education system in the context of global competition. Thus, public policies and standards become the foundation for the formation of an “ethical architecture” for the use of emotional AI in education. Their task is to ensure that technologies are used for good, not harm, and that they enhance the humanistic mission of pedagogy, not replace it.

The integration of emotional artificial intelligence (AI) into educational practices extends far beyond national borders. As affective analysis and synthesis technologies are developed by global companies and research centers, their implementation in education requires international cooperation aimed at developing common ethical principles, pedagogical models, and legal standards.

Emotional AI operates on universal aspects of the human psyche, but its application depends on cultural, social and legal contexts. Different countries perceive different limits of acceptable technological intervention in the emotional sphere: what may be considered an innovation in one society is perceived as a threat in another. International cooperation allows us to smooth out these differences and develop a unified framework for the humanistic use of technology.

Leading global organizations are already setting benchmarks [9,10,14]: UNESCO is developing recommendations on the ethics of AI in education, emphasizing the priority of humanistic values. OECD explores impact of digitalization on development of future competencies, including soft skills skills and emotional intelligence. The Council of Europe focuses on protecting individual rights in the digital environment, including emotional autonomy. Combining these initiatives could form the basis for creating a global code of practice for the use of emotional AI in education.

A necessary step is the creation of research and educational consortia that bring together universities, schools, technology companies and government agencies. Such consortia can exchange scientific data and best teaching practices; test technologies in different cultural and age groups; to form open databases for the development of affective algorithms.

International cooperation should include training programs for teachers taking into account global standards for working with emotional AI; academic mobility of students and teachers participating in pilot projects; holding international conferences where the risks and prospects of affective pedagogy are discussed.

Global cooperation has not only scientific but also political significance. It helps prevent digital inequality between countries, where some gain access to emotional technologies and others are left out; to form an ethical ecosystem that limits the exploitation of emotions for commercial and ideological purposes; to strengthen the humanistic vector of development of education in the era of digital transformation. International cooperation is therefore a prerequisite for the safe and productive implementation of emotional AI in education. It creates a space where national initiatives are strengthened by global practices, and technologies become a tool not for dividing, but for uniting cultures and societies.

An analysis of the phenomenon of emotional artificial intelligence has shown that it is capable of transforming the very nature of the educational process, taking pedagogical practice beyond the cognitive acquisition of knowledge and including an affective dimension. If classical digitalization focused on automation and optimization of learning, then emotional AI opens the way to affective pedagogy, where the central object is emotional well-being and the development of empathy in students.

The theoretical foundations considered confirm that the emotional sphere is not a secondary, but an equivalent component of the educational experience. Technological solutions, including emotion recognition, synthesis of empathic response and multimodal integration, form the basis for building adaptive digital environments that can reduce anxiety, maintain motivation and develop soft skills. The pedagogical potential of emotional AI lies in the ability to develop empathy, emotional regulation and cooperation skills using virtual simulations, empathic feedback and digital soft trainers skills . The key condition for successful implementation is the ethical and pedagogical meaningfulness of technologies. Public policy should ensure the protection of emotional data, the development of standards and regulations, and include training teachers to work with emotional AI. International cooperation is necessary to form a unified framework for the humanistic use of affective technologies and overcome digital inequality.

Thus, the future of education can be imagined as a transition to the paradigm of "empathic AI pedagogy", where artificial intelligence acts not as a replacement, but as an ally in the formation of a harmonious, responsible and socially sensitive personality. Emotional AI becomes not only a cognitive, but also an affective mentor, strengthening the humanistic mission of educational institutions and society as a whole.

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SYNERGY «SCHOOL + UNIVERSITY»: NEW HORIZONS OF INTEGRATION OF EDUCATIONAL PROGRAMS

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Abstract. *Modern challenges associated with the digitalization of society, the formation of a knowledge economy and the growing demands for the universality of graduates' competencies call into question the effectiveness of the traditional model of separating school and university as two isolated educational environments. In conditions where the boundaries between levels of education are becoming increasingly conditional, there is a need to build synergetic trajectories that allow schoolchildren not only to acquire subject knowledge, but also to master the fundamental foundations of managerial, economic and philosophical culture.*

The article substantiates the concept of introducing modular courses in management, economics, philosophy and administration in a simplified form into the school curriculum using the pass/fail system, which eliminates the impact on academic performance. Such an organizational model allows minimizing stress traditionally associated with assessment procedures, and at the same time stimulates interest in self-determination, reflection and early professional orientation.

The scientific novelty of the study lies in the development of the "School-University 4.0" model, in which the integration of educational levels is understood not as a mechanical duplication of content, but as the creation of a cross-disciplinary environment for the formation of metacompetences - critical thinking, entrepreneurial outlook, the ability to manage projects and philosophical reflection. It is proposed to consider this model as a strategic tool for building "bridges" between general and higher education, reducing the "transition shock" and helping to prepare students for the intellectual and professional challenges of the 21st century.

In practical terms, the article reveals the prospects for using the credit system within the framework of integrative disciplines, demonstrates its advantages for educational motivation and social maturity of schoolchildren, and also examines international analogues of pre-college programs (Advanced Placement , International Baccalaureate , Foundation Year) with their adaptation to local conditions. Thus, the synergy of "school + university" is positioned not only as an innovative educational experiment, but also as a necessary step towards the formation of an educational ecosystem capable of preparing individuals of the future - flexible, creative and ready for interdisciplinary challenges.

Keywords: *synergy of education, pre-college , soft skills , metacompetences , pass/fail, school-university, philosophy of education.*

In the context of rapid digitalization and globalization, educational systems are faced with the need to rethink their structure and content. The traditional model, in which school and university exist as autonomous units, no longer meets the challenges of the 21st century. At the junction of eras, a new educational paradigm is being formed, where the key factors are not so much subject knowledge as the ability for interdisciplinary thinking, managing one's own development trajectory and adapting to rapidly changing socio-economic conditions.

School education today is focused primarily on mastering basic academic disciplines, while university requires applicants to be prepared for independent work, research, and strategic choice of professional specialization. The gap between these two stages manifests itself in the "transition shock" — the psychological and cognitive stress experienced by school graduates when faced with a new paradigm of academic freedom and a high degree of responsibility for learning outcomes.

Overcoming this gap is possible through the introduction of synergetic educational models that combine elements of the school and university programs. Of particular importance in this process are the meta-level disciplines - management, economics, philosophy, management fundamentals, which are integrated into high school not as a mandatory and assessment-laden block, but as a space for trials, self-determination and the formation of a broad worldview horizon.

The fundamental idea is that such courses should be modular and simplified and assessed on a pass/fail basis. Such a system removes the threat of a decline in academic performance and at the same time allows schoolchildren to "try on" the university culture of learning: mastering the conceptual apparatus, participating in discussions, and project work. This not only promotes the development of soft skills and critical thinking, but also allows you to build individual educational trajectories, where the choice of a future profession will be the result of conscious and conscious reflection, and not external pressure.

International experience confirms the potential of such models. Advanced programs Placement (USA), International Baccalaureate (Europe), Foundation Year (Great Britain and Australia) have already proven the effectiveness of the early introduction of university practices into school education. However, the proposed model "School-University 4.0" is distinguished by an innovative emphasis on reducing assessment pressure and turning interdisciplinary courses into a tool for developing metacompetences, rather than an additional source of workload [1]. Thus, the introduction of such modular disciplines opens up prospects for the formation of a new generation educational ecosystem, where school and university exist not as sequential, but as complementary stages, ensuring the continuity of personal and intellectual development.

The idea of continuity of education has deep historical and philosophical roots and has always been considered one of the key principles of building a holistic educational system. Even Jan Amos Komensky in his "Great Didactics" emphasized the need for a "natural transition" between stages of education, where each subsequent one does not cancel the previous one, but develops it and brings it to a new level of understanding. This principle became the basis for the formation of educational doctrines of the New Age, where education was thought of as a process of continuous and progressive development of the individual.

In the 19th–20th centuries, the concept of continuity was reinforced in the works of J. Dewey, J.-J. Rousseau, and later by L.S. Vygotsky, who pointed out the importance of the "zone of proximal development" as a pedagogical mechanism for the smooth transition of a student from the acquired level of knowledge to more complex forms of activity [3–5]. Thus, continuity in education is considered not only as an organizational principle, but also as a psychological and pedagogical law that ensures harmony between age stages, cognitive capabilities, and the requirements of the educational environment.

Modern concepts of sustainable development and knowledge economy have given this principle a new meaning. In the context of rapid changes, educational continuity should ensure not only academic consistency of programs, but also metacompetence coherence: the formation of skills in schoolchildren that will be in demand in the university and professional environment. At the same time, we are not talking about formal duplication of content, but about the creation of "through educational lines” that allow learning to be perceived as a continuous trajectory - from basic school to professional training and subsequent self-education [1].

In this logic, the integration of university course elements into school education can be seen as a modern embodiment of the principle of continuity. It forms a bridge between the two levels of the educational system and provides cognitive, cultural and social preparation for future challenges. Unlike the classical model, where the transition between school and university is often “fragmentary”, the proposed synergy allows for a softer and more conscious trajectory that eliminates the risks of an adaptation crisis.

Thus, the concept of continuity in education is currently being transformed from the idea of a smooth transition between stages into a strategy for the formation of a continuous educational ecosystem, where school and university education are not opposed, but interact, creating conditions for sustainable personal development.

In global educational practice, there has long been a tendency to "blur the boundaries" between secondary and higher education. Universities in a number of countries act not only as institutions of professional training, but also as partners in the process of forming an academic culture in high school students. This approach is implemented through pre-college programs aimed at providing students with the opportunity for early introduction to the university environment, mastering key concepts of future disciplines and developing research skills.

One of the most famous examples is the Advanced system Placement (AP) in the USA. It provides schoolchildren with access to university-level courses with subsequent credit for admission. The key result of participation in AP is not so much a quantitative increase in knowledge, but a qualitative change in thinking: students master the basics of academic discussion, project work and analytical work, which form the core of university culture [6-8].

In Europe, the most important analogue is the International Baccalaureate (IB Diploma) program. Programme**)**. It focuses not only on subject knowledge, but also on the development of critical thinking, intercultural communication and research activity. The IB system has become a universal “bridge” between school and university, especially in countries where mobility and international academic integration are in demand [9-13].

In the UK and Australia, so-called Foundations are common Year — preparatory courses at universities that allow schoolchildren to “immerse themselves” in the academic environment and master basic disciplines before starting full-time education. At the same time, the main task remains to reduce the adaptation barrier and develop stable skills in schoolchildren for working with large amounts of information, academic writing, and project research [14-16].

In Kazakhstan and a number of CIS countries, pre-university colleges and lyceums at universities are actively developing, creating conditions for early profiling . However, unlike Western models, they are often focused on formal strengthening of subject training, rather than on the formation of metacompetences, which limits their synergetic potential [1,17,18].

Comparative analysis shows that the most successful pre-college programs are based on three principles: A gentle introduction to the university environment through simplified courses, project work and academic internships. Minimizing assessment pressure - using a pass/fail format or a comprehensive portfolio assessment. Focus on meta-competencies – development of analytical thinking, research culture and knowledge management skills [1]. Thus, international experience demonstrates that the university as an early start space is becoming not a tool for “accelerating” learning, but a mechanism for preparing a mature, conscious and motivated student. For Kazakhstan and the post-Soviet space, this direction opens up the possibility of modernizing the education system by introducing hybrid forms of interaction between school and university, focused not only on the academic, but also on the personal and professional readiness of students [17,18].

The philosophy of education has traditionally viewed school and university as two qualitatively different stages of personality development. School acts as a space for socialization and basic personality development, where the foundations of worldview, values, and cognitive structures are laid. University, on the contrary, symbolizes the stage of personality development, its intellectual and professional autonomy. The synergy of these two levels presupposes the creation of a model where school and university cease to be isolated, but turn into interconnected links in a single educational cycle.

From the standpoint of the philosophy of education, school can be understood as an "anthropological matrix" where the individual receives his first ideas about the world, society and himself. Here, not only the transmission of knowledge is important, but also the development of abilities for critical understanding of reality. The university, on the contrary, embodies a space of intellectual freedom, where the individual goes beyond ready-made schemes and begins to construct his own research and professional trajectory.

In the synergetic model, education is conceived as a process of continuous self-development, where school and university form a dialectical unity: the former provides the basis for a holistic perception of the world, while the latter reveals potential in project, research and practical activities. That is why the introduction of university modules into school education should not be perceived as "accelerated maturation," but as a way to expand the horizon of students' self-identification.

From a philosophical point of view, the synergy of these stages reflects the principle of "horizontal integration of knowledge ", where the humanities, social and management disciplines cease to be an attribute of exclusively university education. Their simplified introduction into high school through the pass/fail format becomes a tool for preparing for future choice and the formation of a reflexive attitude to knowledge. Thus, the student's personality gradually emerges from the state of "an object of pedagogical influence" and begins to become a subject of his own educational path.

1. The synergetic philosophy of "school + university" is integrated into the global context of Illich's ideas I., Delors J., Freire P, who viewed education as a practice of freedom, creativity and critical reflection. In this logic, the university ceases to be the "beginning of adult life" and becomes its natural continuation, while the school turns from a "dressing room" into a full-fledged space for early personality development [8,12,19]. Thus, the philosophy of synergy demonstrates that only by combining two stages – school and university – is it possible to form a holistic, mature and innovatively thinking individual, capable of productive participation in the life of the knowledge society.

In the context of the transformation of education towards interdisciplinarity and a competence-based approach, disciplines traditionally related to the university level are becoming increasingly important: management, economics, philosophy and the basics of management. Their early introduction into the school curriculum in the format of modules does not pursue the goal of "academic deepening", but serves a strategic task - preparing students for a conscious perception of future university experience and the formation of metacompetences in demand in the digital age [1].

The modular principle is of key importance here. Unlike the linear subjects of the school curriculum, modules are built according to flexible logic: short blocks (6-8 lessons) focused on the practical application of knowledge and the development of skills. This approach removes the barriers of "overload" of the program and allows integrating new disciplines into the existing curriculum without compromising the basic subjects. Management in the school format can be presented as "management of everyday projects": organizing group work, time management, planning tasks. Students gain experience in structuring actions and making decisions - universal skills that go beyond specific professions. The economy is understood through the "microeconomics of everyday life" – understanding resources, the value of labor, the basics of financial literacy, and the logic of economic choice. This module forms the basic ability for economic thinking, which is necessary for orientation in a world of rapid change. Philosophy is taught in a practical way - as the development of critical and reflective thinking skills. This is not an academic history of philosophy, but the ability to ask questions, analyze arguments, and see alternatives. Thus, philosophy becomes an instrument of intellectual freedom and responsibility. Management can be integrated through the study of the "fundamentals of leadership and self-organization": teamwork, role distribution, decision-making under uncertainty. Here, the prerequisites for the formation of future managers, entrepreneurs, and leaders of public initiatives are laid.

The introduction of such modules into school practice should be accompanied by new pedagogical technologies: case method, game simulations, project assignments, debates. This will allow us to move away from the reproductive approach and focus on activity-based learning, where knowledge is born in the process of interaction, and not through memorization.

Thus, modular courses become an "entry point" into university culture, allowing schoolchildren to safely try out new formats of working with information and group dynamics. This not only reduces the future adaptation barrier, but also forms a generation of graduates ready to make a conscious choice of educational and professional trajectory.

One of the most controversial issues of introducing new subjects into the school curriculum is the problem of assessment pressure. The traditional grading system (from "2" to "5" or its analogues) historically served as a motivation and control function, but in modern conditions it is increasingly becoming a source of stress, demotivation and formal acquisition of knowledge. This is especially noticeable in cases where students have to master new and unfamiliar subjects that go beyond their basic educational experience.

The pass/fail format is being integrated into the educational process as a fundamentally different assessment model. It assumes a minimum threshold of requirements (for example, attending classes, participating in discussions, completing practical assignments), after which the student receives a pass. The absence of a traditional grading of grades eliminates situations of "race for points", turning learning into a space of experimentation and search, rather than coercion.

The advantages of this approach are obvious: students are not afraid of "getting a low grade", which stimulates creativity and boldness in statements; attention is focused on the process of acquiring knowledge, and not on the final grade on the report card; many foreign universities (especially in the USA and Scandinavia) use the pass /fail system in the first years for a smooth adaptation of students. Thus, its implementation in schools prepares for the future educational format; since management, economics and philosophy are not mandatory examination subjects at school, the pass/fail assessment allows them to be integrated without the risk of reducing overall academic performance; the student is assessed by involvement and ability to practically apply knowledge, and not by formal reproduction of the material.

In addition, the use of the “pass/fail” system corresponds to the trends of competency-based and humanistic education, where the key factors are not formal indicators, but the development of meta-competencies – the ability to think critically, work in a team, and make decisions.

Thus, the format of the credit system acts as an innovative tool for reducing academic pressure and, at the same time, a pedagogical strategy for supporting freedom of choice. In combination with the modular principle, it allows new disciplines to be transformed into a space for free search, while maintaining academic discipline and responsibility.

Modern educational systems are increasingly faced with the need to prepare graduates not only to pass exams and enter university, but also to live in conditions of uncertainty and rapid change in the socio-economic environment. In this regard, metacompetences are becoming a key reference point-supra-subject abilities that allow integrating knowledge, skills and personal qualities to solve complex problems [1].

Philosophy as a modular course opens up space for the formation of a culture of questions, analysis of arguments and verification of facts. In conditions of information overload, it is the ability to critically select, structure and interpret information that becomes the foundation of intellectual maturity. In a school environment, this can be realized through debates, essays, role-playing games and case studies that stimulate dialogic thinking.

Management and economics in the school format allow developing basic communication skills, teamwork and presentation of ideas. These skills - negotiation, reasoned expression of a position, teamwork - form the basis for future success both at university and in the professional environment. It is important that the development of soft skills at school reduces the risk of socio-psychological maladjustment of students in the first years of study at a university.

The course "Fundamentals of Management" is integrated into the educational process as a leadership laboratory. Students try themselves in the roles of organizers of group projects, facilitators of discussions or moderators of school events. Here, responsibility for the result, the ability to coordinate resources and strategic planning skills are formed-qualities that become the core of future management and entrepreneurial activity.

The synergy of management, economics and philosophy opens up opportunities for integrating knowledge at the intersection of the humanities and applied fields. This forms in schoolchildren an understanding of the interrelationship between disciplines and teaches them to see the complexity of social processes. This approach corresponds to the trends of STEAM education (Science, Technology, Engineering, Arts, Mathematics), where the emphasis is on interdisciplinary projects and practice-oriented learning.

One of the key challenges in integrating university modules into school education is the risk of overloading the curriculum. Modern schoolchildren are already faced with a highly intensive educational process: the expansion of the list of compulsory subjects, preparation for national exams, participation in Olympiads and extracurricular activities create a situation of constant cognitive stress. The introduction of additional disciplines, even in a simplified format, can be perceived by students and their parents as another source of pressure.

A study in the field of educational psychology [14] shows that excessive workload reduces not only motivation, but also the efficiency of knowledge acquisition: students tend to memorize superficially, avoid creative forms of activity, and demonstrate an increase in anxiety. For school education, this is fraught with the formation of a “saturation effect,” in which any new content is perceived as excessive and unnecessary.

However, the very idea of synergy between school and university does not imply a mechanical increase in teaching hours. On the contrary, modular courses should be built into the existing program according to the principle of flexible adaptation: use of the variable part of the curriculum; integration into project activities and elective courses; replacing excessive formal reproductive classes with activity-based formats (cases, debates, group projects). In addition, it is important to emphasize that the proposed courses are of a metacompetence nature, which means that their content may partially overlap with tasks already being solved within related disciplines. For example, the development of critical thinking is possible simultaneously in philosophy and literature classes, and project assignments on management can be integrated with computer science or social studies courses [1]. Thus, the key task of educational administrators is to ensure that new courses do not formally increase the workload, but transform it qualitatively, creating conditions for more conscious, active and interdisciplinary learning. Otherwise, the innovative idea risks becoming a source of resistance from students, parents and teachers, which will neutralize its strategic potential.

One of the most predictable and at the same time systemic barriers to the implementation of the synergetic model of "school + university" is resistance to the traditional assessment system. The very logic of domestic and post-Soviet education is historically based on quantitative indicators: grades, ratings, average scores, which are perceived as a universal and objective tool for measuring the success of a student. In this paradigm, the teacher, parent and government agencies rely on the grade as the main marker of the quality of education.

pass/fail format undermines the traditional foundations of this system. Resistance is strengthened by the fact that assessment in the traditional system performs not only an academic but also a social-normative function: the mark becomes an instrument of disciplinary control, a way of managing motivation and a form of social comparison. The rejection of the usual scales means the need to find new instruments for recording and recognizing academic achievements, which requires both methodological and organizational changes.

However, international experience (for example, the use of the pass /fail system in universities in the USA, Canada, and Finland) shows that abandoning strict point differentiation does not lead to a decrease in the quality of training. On the contrary, it encourages students to participate in the educational process for the sake of the experience itself and the development of competencies, and not for the sake of assessment. Moreover, studies demonstrate that the pass/fail system helps reduce anxiety and academic stress, while maintaining responsibility for meeting minimum requirements.

For Kazakhstan and the post-Soviet space, the implementation of such a model will require a gradual transition: parallel use of traditional assessment and the pass/fail format in different blocks of the program; development of transparent criteria for receiving credit (participation, completion of practical assignments, project activity); active work with parents and teachers to explain the goals and advantages of the new system. Thus, resistance to the traditional assessment system is a natural manifestation of institutional inertia. It can be overcome only through a systemic dialogue between the school, university, government structures and society. Otherwise, any innovation risks remaining a formal superstructure that does not change the essence of the educational process.

One of the most important advantages of integrating university modules into school education is smoothing the transition from school to higher education. For most graduates, this stage is accompanied by a phenomenon called "transition shock" in pedagogical literature. It manifests itself in a sharp change in the educational paradigm: from an environment where learning is based on detailed regulation and control by the teacher, the student enters a university where independence, the ability to self-manage and a proactive attitude towards knowledge are expected of him.

As a result, many first-year students face difficulties: inability to manage time and resources; lack of habit of independent reading and research work; stress from new formats (lectures, seminars, discussions, project assignments); cognitive and emotional overload. The introduction of modular courses in management, economics, philosophy and administration in schools can significantly soften this barrier. International studies (in particular, the practice of pre-college courses in the USA and Europe) show that such programs reduce the level of anxiety of first-year students, increase their academic success and accelerate socialization in the university environment. For Kazakhstan and the post-Soviet countries, this effect is of particular importance, since the gap between school and university is historically large: school remains more directive, while the university makes demands on autonomy.

Thus, the introduction of university modules in senior classes serves as a "soft springboard", allowing graduates not just to adapt, but to come to university with experience in academic communication, self-organization skills, and an understanding of the value of interdisciplinary knowledge. This not only reduces the percentage of unsuccessful students in the first years, but also contributes to the formation of a sustainable motivation for lifelong learning.

One of the central effects of the introduction of modular university courses into school education is a significant increase in academic motivation and the formation of a more conscious attitude among high school students towards the choice of a future profession.

The traditional school curriculum, focused on mastering basic subjects, is often perceived by students as being disconnected from real life and professional prospects. As a result, interest in learning decreases: knowledge is acquired formally, and the process of preparing for final exams becomes mechanical. The introduction of courses in management, economics, philosophy and administration changes the educational optics, creating space for a direct connection between knowledge and life.

International experience confirms this trend. In countries where pre-college programs are developed, the level of student satisfaction with their educational choice is significantly higher, and the percentage of students changing their course of study in the first years is lower. For Kazakhstan, this means a strategic step towards the formation of a conscious applicant who comes to the university not by chance, but with an understanding of his own interests and goals.

One of the most strategic effects of introducing university modules into school education is the opportunity to accelerate the formation of the “university of the future” model. In the classical paradigm, a university is thought of as a space where a person gets only after finishing school and successfully passing entrance exams. However, in the context of digitalization, global competition and the knowledge economy, a university is no longer exclusively an institution of higher education and is gradually turning into an ecosystem of continuous learning, to which a person connects much earlier and remains a part of it throughout his or her life.

The integration of management, economics, philosophy and administration courses into the school curriculum — even in a simplified format and on a pass/fail system — effectively turns the school into a " pre-university laboratory." Here, students receive not only basic knowledge, but also experience in mastering academic practices: participating in discussions, conducting project research, presenting results, and teamwork. These formats are integrated into the school ecosystem, creating an environment where students are both schoolchildren and potential students.

Thus, the university of the future is formed not as a closed institution, but as an open network, covering school, college, university and the system of additional education. In this model, the school plays the role of an "entry point" into the academic community, and the university is a space for deepening and developing already formed skills.

It is important to emphasize that such integration contributes to the formation of a new type of educational identity: the student begins to perceive himself not as an object of pedagogical influence, but as a subject of his own educational path, included in a broader ecosystem of knowledge. This creates the prerequisites for the formation of a lifelong culture learning (lifelong learning), where the university becomes not the final stage, but a permanent partner of the individual.

In addition, the synergy between school and university opens up opportunities for digital transformation of education: the use of online university courses (MOOC), blended learning formats, virtual laboratories and simulators. The school becomes a platform for testing these solutions, and the university becomes a center for their methodological support and development.

The introduction of modular courses in management, economics, philosophy and administration into the school curriculum requires not only methodological but also technological support. Here, artificial intelligence (AI) can play a key role, acting as a tool for personalization, adaptation and expansion of the educational experience. Unlike traditional methods, where the teacher is the main source of information, AI allows for the construction of a hybrid model in which the student gains access to multi-layered educational resources, interacts with digital mentors and forms an individual development trajectory [20]. The use of AI in modular courses serves a triple function: personalizes learning ; immersively simulates the university environment; provides the teacher with digital analytics .

Modern education is increasingly shifting from the transfer of subject knowledge to the formation of metacompetences — universal abilities that allow graduates to act effectively in conditions of uncertainty, digitalization, and global competition. In this process, artificial intelligence (AI) is becoming not just an automation tool, but a digital simulator of future experience that models situations that require critical analysis, creativity, communication, and leadership.

In the classical sense, a university is a "place" where you go after school. In the logic of the AI ecosystem, it becomes a process that begins at school, continues at the university, and is transformed into a lifelong system. learning. This university of the future unites schools, digital platforms, research centers and the labor market into a single smart network, where AI manages information flows, personalizes content and ensures the continuity of the educational trajectory.

Thus, the "university of the future" ceases to be an institution, but becomes a living AI ecosystem, which a student enters even before enrollment and remains a part of throughout his or her life. This not only reduces the transition barrier, but also forms a new type of educational culture, where learning is perceived as a continuous, personalized and interdisciplinary process.

The modern education system faces the need to bridge the gap between school and university. The traditional model, where these stages existed as isolated worlds, no longer meets the requirements of the knowledge economy and the digital age. The integration of modular courses in management, economics, philosophy and administration into senior grades of school in the pass/fail format is becoming not only a pedagogical innovation, but also a strategic tool for forming a holistic educational trajectory.

The synergy of "school + university" allows: smooth out the barrier of transition to a university and reduce the stress of adaptation; to form internal motivation and ensure a conscious choice of profession; develop key metacompetencies - critical thinking, soft skills , leadership and cross-disciplinarity; transform the school from a "university dressing room" into a laboratory of early experience, where individuals receive the first tools for independently constructing their educational and professional path.

Artificial intelligence is of particular importance in this model. It acts as a catalyst for synergy, providing personalization of learning, support for the pass/fail system, development of metacompetencies, and the formation of the university ecosystem of the future as a distributed digital network. At the same time, it is AI that is capable of turning education into a process of continuous and adaptive growth, where the school becomes the entry point, and the university is a space for disclosure and deepening, while maintaining a single digital identity of the student.

However, the implementation of such solutions requires attention to ethical and organizational challenges: data protection, overcoming digital inequality, training teachers and preserving the humanistic dimension of education. Only in the balance of technologies and values is sustainable transformation possible, capable of ensuring the competitiveness and cultural maturity of future generations.

Thus, the synergy of school, university and artificial intelligence forms a new paradigm of education, where learning ceases to be linear and fragmented. It becomes continuous, integrated and future-oriented, creating a generation of individuals who are ready not only to adapt to changes, but also to actively initiate them.

Project "Synergy school No. 11 - KarIU Temirtau"

General concept

Creation of a pilot program integrating senior classes of School No. 11 and Karaganda Industrial University (KaRIU). The goal is to build a bridge between secondary and higher education through modular courses in economics, management, philosophy, administration and digital technologies. The training is based on the "pass/fail" principle to relieve the stress of grades and focus on the development of metacompetencies .

Project objectives

The goal of the project "Synergy School No. 11 - KarIU Temirtau" is to create an integrated educational model that ensures a smooth transition of students from school to university level of preparation through the introduction of modular courses in management, economics, philosophy and administration using digital technologies and artificial intelligence.

The project aims to:

1. Reducing the adaptation barrier between school and university by introducing schoolchildren to academic practices and digital learning tools early on.

2. Formation of new generation meta-competencies - critical thinking, communication, leadership, project approach, digital literacy - which will become the foundation for successful mastering of university programs.

3. Increasing student motivation through the integration of practice-oriented modules related to real economic, managerial and social situations.

4. To prepare conscious applicants to KarIU who make their choice of profession not by chance, but based on personal interests, abilities and prior experience of participating in university projects.

5. Development of a new pedagogical model at the intersection of school and university, where teachers and lecturers of KarIU act as mentors and facilitators , and artificial intelligence ensures personalization and transparency of learning.

6. Creation of an educational ecosystem in Temirtau, where schools, universities and industrial enterprises act as interconnected links in the training of personnel for the region.

Thus, the goal of the project goes beyond simple preparation for admission: it forms a sustainable system of educational continuity, where the school becomes the entry point into the university culture, and KUU becomes the center of personal development and professional orientation already at the senior stages of school education.

Implementation format

The project "Synergy School No. 11 - KarIU Temirtau" is implemented in the format of a pilot integrated educational program based on a combination of school and university practices. Its key principle is modularity, variability and personalization of training with the active use of artificial intelligence technologies.

The main forms of implementation include:

1. **Modular courses**

Courses in management, economics, philosophy and administration in grades 10–11.

They are built according to block -modular logic (6–8 weeks), which allows them to be integrated into the curriculum without overload.

The assessment system is **pass** /fail, stress-free and focused on participation and engagement.

2. **Team teaching**

Lessons are taught in a collaborative format between school teachers and KarIU instructors.

University teachers give introductory lectures and master classes, school teachers help to adapt the material.

A unified educational community is being formed, where students feel like they are part of the university culture.

3. **University internships for schoolchildren**

Excursions and laboratory classes at KarIU (virtual and in-person).

Participation of schoolchildren in scientific and practical conferences, debates and hackathons organized by the university.

Project groups of “schoolchildren + students” to solve real cases (for example, on urban infrastructure, ecology or digital services).

4. **Digitalization and AI**

Using chatbots and intelligent tutors for consultations and knowledge testing.

Personalized learning through adaptive platforms: the system selects tasks depending on the level of preparation.

Formation of a student's digital portfolio, which accompanies him from the 10th grade and is taken into account when entering KarIU .

5. **Extracurricular formats**

School and university clubs of interest (economics, philosophy, management, engineering).

Case studies and business games (for example, “School Startup”, “Mini-City of the Future”).

Summer schools and winter camps at KarIU for schoolchildren with an emphasis on project work.

6. **Hybrid learning**

Some modules are implemented online (lectures by KarIU , recordings of webinars).

Some are offline, with an emphasis on collaborative activities.

A unified digital educational environment is being formed, accessible to both school students and KarIU students .

7. **Industry Connection**

Connecting Temirtau industrial partners to the project (JSC Qarmet, machine-building enterprises).

Joint mini-projects of schoolchildren and students based on requests from enterprises.

Primary professional experience for schoolchildren through participation in practice-oriented tasks.

Thus, the implementation form is built as a multi-level interaction model: the school gets access to university resources and AI tools, KAIU gets motivated applicants, and the region gets trained young specialists with experience in project work even before entering the university.

Stages of implementation

Phase I (2025–2026): Preparatory

Joint development of modules by school No. 11 and KarIU .

Advanced training for school teachers (courses at KarIU).

Creation of a pilot AI assistant to support students and schoolchildren.

Phase II (2026–2027): pilot

Launch of modules in 10th grade.

Conducting the first joint classes at the KarIU .

Formation of digital portfolios of students.

Phase III (2027–2028): Expansion

Connecting 11th graders.

Creation of school and student project teams.

Conducting a regional scientific and practical conference "School and University without Borders".

Stage IV (from 2028): integration

Automatic accounting of school credits upon admission to KarIU.

Creation of the Center for Continuity of Education "School- KarIU".

Connecting other schools in Temirtau to the model.

Expected results

The implementation of the project will achieve significant educational, organizational and socio-economic effects at the level of the school, university and the city of Temirtau.

1. For schoolchildren

Reducing the adaptation barrier when transferring to university: graduates of school No. 11 will come to KarIU with experience of working in university formats (lectures, seminars, project assignments).

Formation of meta-competencies (critical thinking, teamwork, leadership, digital literacy) that complement subject knowledge.

Increased motivation for learning: schoolchildren will see a direct connection between knowledge and future professions.

Conscious choice of educational trajectory: reducing the number of cases when students change their specialty after the first year.

A digital portfolio of each graduate, containing achievements and projects, useful for admission and career start.

2. For school No. 11

Strengthening the status of an innovative school in the region implementing a pre-university training model.

Improving the quality of the educational process through the introduction of new disciplines and technologies.

Improving the image among parents and applicants: the school will be perceived as a launching pad for admission to KGIU.

Methodological development of teachers: teachers will gain experience working in a team with university professors and master new teaching roles (facilitator, mentor, coach).

3. For KAIU Temirtau

An influx of motivated applicants who are already familiar with the university environment and ready for independent study.

Reducing the percentage of maladjustment and academic failure among first-year students.

Formation of an educational brand: KGIU will become a center of innovation and digital practices, open to the school and the city.

Integration into the regional ecosystem: the university will be perceived not as a “separate institution”, but as an active participant in the school and city community.

4. For the city and region

Connection between education and industry: school and student projects will solve practical problems of the city (infrastructure, ecology, digitalization).

Building social capital: creating a new generation of citizens with critical thinking and leadership skills.

Reducing the outflow of young people: applicants will see prospects in KarIU and Temirtau, which will strengthen the local personnel base.

Creating a model that can be scaled up to other schools and universities in the region.

Thus, the project "Synergy School No. 11 – KarIU Temirtau" will have a multi-level effect: from improving the quality of school education and the competitiveness of KarIU to strengthening the regional system of personnel training.

Development Prospects

The project has significant potential for expansion and institutionalization, going beyond the local initiative of School No. 11 and KarIU. Its further development can be implemented in several strategic directions:

1. Scaling to the city and region

Connecting other schools in Temirtau to the project and forming a network of partner schools of KarIU .

Creation of a "school-university cluster" in the Karaganda region, where KarIU acts as a methodological and digital integration center.

Conducting annual city educational forums "School + University", where projects of schoolchildren and students are presented.

2. Integration with industrial enterprises

Involvement of industrial partners of the region (Qarmet, mechanical engineering enterprises, IT companies) in the organization of practice-oriented cases.

Creation of " mini-orders" for school and student teams, where real production tasks are adapted to the level of 10-11 grades.

Formation of a system of "early dual education": schoolchildren become familiar not only with the university, but also with the industry.

3. Digital transformation

Development of the AI platform: transition from a chatbot to a smart educational assistant that accompanies schoolchildren and students throughout their entire journey.

Creation of a single digital portfolio database, which is automatically integrated into the KGIU system upon admission.

Implementation of virtual laboratories and simulators for modular courses (economic games, engineering simulations, management simulators).

4. Academic institutionalization

Development of the official program "Pre-college KarIU", approved by the Ministry of Science and Higher Education of the Republic of Kazakhstan.

Inclusion of modules in the system of elective disciplines in senior schools.

Preparation of joint publications and methodological materials (school + KarIU) for the exchange of experience at the level of Kazakhstan.

5. International cooperation

Connecting the Kar IU and schools in the region to the Erasmus + and UNESCO Education 2030 programs, where the integration of schools and universities is one of the priorities.

Creation of network projects with foreign universities (online courses, joint hackathons).

Formation of "virtual classes" where Temirtau schoolchildren will be able to work in a team with foreign students.

6. Long-term effect

Preparing a new generation of applicants focused on engineering, economics and management professions.

Reducing the educational and social gap between school and university.

Transformation of KarIU into a regional center for innovation in education, forming a personnel base for the industrial development of Temirtau and the region.

Thus, the project's prospects are to transform a local initiative into a systemic solution for the region, and in the future – into a model that can be scaled up at the national level as a "Kazakhstani pre-college integration format".

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Abstract. *The modern educational environment is entering a phase when basic academic disciplines are no longer sufficient to form generations capable of not only adapting but also managing global change processes. In the context of the rapid development of bioengineering, agricultural technology, genetic engineering, energy of the future and programming, there is a need to create flexible educational modules that will allow schoolchildren of the early pre-university level to touch the technologies of tomorrow. The elective module "Future Technologies" within the Synergy "School + University" program is an innovative format for integrating research, engineering and digital education into the school-university trajectory. Unlike the basic modules focused on metacompetences (critical thinking, soft skills, leadership), this module is optional and is designed for motivated schoolchildren ready for research. This makes it a kind of "educational laboratory" - a space for trying out ideas, modeling technologies and creating prototypes. The scientific novelty of the module lies in the fact that for the first time it offers a comprehensive solution for early career guidance in STEM areas in the logic of "school + university". The methodological innovation consists of a combination of project work, mentoring of students in technical specialties and digital support (online simulations, chatbots, digital portfolios, artificial intelligence for progress analysis). This creates conditions for personalized learning, where each student gets the opportunity to build their own research trajectory.*

Keywords: *synergy school + university; elective module; bioengineering; hydroponics; genetic engineering; energy of the future; programming; research projects; educational innovations.*

The modern education system faces a double challenge: on the one hand, it is necessary to provide schoolchildren with fundamental knowledge, and on the other hand, to form readiness for life and work in the conditions of accelerated scientific and technological revolution. The development of bioengineering, genetic engineering, sustainable agricultural technologies, renewable energy and programming changes the idea of what competencies will be in demand in the coming decades. In this situation, traditional school programs are insufficient to prepare young people for the knowledge economy and innovative society [4,9-12,16-21,23-26].

The Synergy "School + University" program was developed as a response to the gap between school and university education. At the first stages, it focused on the formation of metacompetencies (critical thinking, leadership, financial literacy, soft skills), then expanded by introducing innovative modules such as Mini-MBA and student mentoring. These elements allowed us to create a solid foundation that ensures successful adaptation of schoolchildren to the university environment and the development of management and social skills. [4-7,9-12,16-20]. The next logical step is to create an optional, selective module "Future Technologies" aimed at schoolchildren with a clear interest in STEM areas. Its peculiarity is that it is not mandatory for all participants, but works as an individual educational trajectory for motivated students who want to explore promising areas of science and technology. This format allows for a balance between mass synergetic training and in-depth research training.

Within the framework of this module, schoolchildren have the opportunity to: get in touch with bio- and genetic engineering through adapted simulations and discussions about the ethics of science; get acquainted with hydroponics and agricultural technologies as a model of sustainable development and a “green economy”; explore the energy of the future, modeling solutions for regional and global energy; master the basics of programming, which is becoming a universal tool for work in any field of science and business [21-26].

Of particular importance in this case is the participation of student mentors from technical and natural science fields, who accompany schoolchildren in research projects, explain complex terms in accessible language, and help to structure project assignments. This ensures intergenerational continuity and turns the module into a platform for interaction between schoolchildren and students on an equal footing.

Thus, the introduction of the optional module “Future Technologies” expands the educational architecture of “Synergy”, combining fundamental metacompetences, management skills (Mini-MBA) and mentoring with a focus on the latest technological trends. This makes the program more flexible and innovative, providing Kazakhstan with the training of future researchers, engineers and entrepreneurs capable of solving the problems of sustainable development and global competition [4,6,7,9-12].

Bio and genetic engineering are one of the most dynamically developing areas of science, which shapes the future of medicine, agriculture and ecology. For the school-university model Synergy "school + university", the integration of these areas into the educational trajectory has a dual meaning: on the one hand, it introduces schoolchildren to current scientific achievements, and on the other, it forms their ethical and critical view of the use of technologies capable of radically changing nature and man [21,23].

Educational objectives of the block. To provide schoolchildren with basic knowledge of the principles of molecular biology and genetics in an adapted form. To introduce the possibilities and limitations of genome editing technologies. To form an understanding that biotechnology is not only a tool, but also an ethical challenge for humanity. To develop research thinking through modeling virtual experiments [21,23].

Training formats: virtual laboratories; project assignments; mentoring of biology students [21,23].

Expected effects. For schoolchildren: development of scientific interest, formation of critical thinking, familiarization with current world research, increased motivation to enroll in biotechnology and medical specialties. For student mentors: strengthening pedagogical competencies, the ability to adapt complex material for a younger audience, development of soft skills in scientific communication. For the university and the region: training potential applicants in the field of bioengineering and medicine, formation of the image of an educational environment open to innovations [4,7,9-12,21,23].

Bio- and genetic engineering block into the elective module “Future Technologies” allows schoolchildren not only to become familiar with advanced scientific trends, but also to develop a critical and value-based attitude towards them. This turns learning into a process of not passive assimilation of facts, but active reflection on how technologies affect people, society and the planet [21,23].

Hydroponics is one of the most promising technologies in the field of agriculture, which allows growing plants without using soil, using nutrient solutions instead. In the context of global climate change, population growth and limited natural resources, hydroponic systems are becoming a key area of sustainable agriculture. The introduction of this block into the elective module "Future Technologies" gives schoolchildren a unique opportunity to come into contact with a practice that is at the intersection of biology, engineering and ecology [21-23].

Educational objectives of the block. To introduce schoolchildren to the principles of hydroponics and modern methods of agricultural technology. To show the advantages of sustainable farming: water savings, reduced use of fertilizers and pesticides, the possibility of growing in urban conditions. To develop students' design and experimental work skills through the creation of mini-installations. To cultivate environmental responsibility and understanding of the role of innovative technologies in ensuring food security [4.9-12.22].

Training formats: workshop “Mini-hydroponic installation”; research project; team assignments with mentors; discussions on sustainable development [22]:

Expected effects. For schoolchildren: practical experience in design, understanding of the principles of sustainable agriculture, increased interest in biology and engineering. For student mentors: development of research project facilitation skills, consolidation of knowledge in the field of agricultural technology, ability to explain complex processes in simple language. For the university and the region: formation of a personnel reserve for the agro-industrial complex, popularization of innovative agricultural technologies among young people. [4,9-12,21,23].

Hydroponics in the educational module "Technologies of the Future" becomes not only an object of study, but also a tool for developing engineering and research thinking. This block teaches schoolchildren to see the relationship between science and life, showing that solutions to global problems (hunger, ecology, sustainable development) begin with simple experiments and local projects [22].

Future energy is a strategic direction that determines the sustainability and competitiveness of humanity in the 21st century. The world is experiencing a transition from traditional hydrocarbon sources to renewable energy and new technological solutions - solar and wind power plants, thermonuclear reactors, smart grids, energy storage technologies and hydrogen energy. Including this block in the optional module "Future Technologies" allows schoolchildren not only to get acquainted with modern trends, but also to see the connection between global challenges and local opportunities in their region [8,13,23-25].

Educational objectives of the block. To give schoolchildren an idea of the principles of operation of renewable energy sources. To show the role of future energy in solving the problems of climate change and sustainable development. To develop an understanding of the concept of "smart grids" and digital management of energy systems. To develop skills in modeling energy solutions through design and digital tools [23-25].

Training formats: interactive simulations; mini- projects; mentoring of students of technical fields; discussion clubs. Expected effects. For schoolchildren: understanding of the global energy agenda, skills in resource analysis and design of energy solutions, development of ecological and engineering thinking. For student mentors: experience in popularizing energy technologies, ability to work with models and digital simulations, development of facilitation skills. For universities and the region: formation of interest in engineering and energy specialties, preparation of motivated applicants, support of strategic initiatives on “green energy” in Kazakhstan [8,13,23-25].

The "Energy of the Future" block shows schoolchildren that energy is not only "large power plants", but also a space for innovation, where digitalization, environmental friendliness and engineering solutions are intertwined. It forms in schoolchildren the idea that the future of energy is associated with sustainable development, digital technologies and global responsibility, which means that each of them can contribute to building an environmentally safe world [4,9-12,23-25].

Programming today is not only a tool for working in the IT sphere, but also a universal language of the modern world, which is “spoken” by science, engineering, economics and social practices. Knowledge of it allows creating digital products, managing systems, analyzing data and modeling processes. For schoolchildren of the optional module “Technologies of the Future”, programming becomes a key connecting element, allowing to combine blocks on bioengineering, hydroponics and energy into a single digital educational environment [21-26].

Educational objectives of the block. To introduce schoolchildren to basic programming languages (Python, JavaScript) and their application. To develop an understanding that programming is not only “code”, but also the logic of problem solving. To demonstrate the capabilities of digital technologies for modeling, analysis and visualization in projects on biology, agricultural technology and energy. To develop skills in working with algorithms, digital platforms and the simplest elements of artificial intelligence. [21,23-26].

Training formats: interactive workshops; mini- projects; coding marathons (mini-hackathons):

Expected effects. For schoolchildren: development of algorithmic and critical thinking; experience of integrating digital tools into interdisciplinary projects; increased confidence in working with IT technologies and awareness of their versatility. For student mentors: consolidation of programming skills through teaching; development of soft skills - the ability to explain code "in simple terms"; expansion of the portfolio through participation in mentoring digital projects. For universities and the region: preparation of schoolchildren for applicant trajectories in IT and engineering specialties; formation of an ecosystem of digital literacy among young people; contribution to the implementation of the national agenda for the digitalization of Kazakhstan [7,24,25,26].

Programming and digital technologies become the core of the module’s interdisciplinary nature: they link together biological, engineering and energy projects, turning ideas into working digital solutions. For schoolchildren, this is not only mastering the “language of the future,” but also understanding that through code they can influence reality — from a school project to global innovations [4,9-12,21,23-26].

The elective module *"Future Technologies"* is conceived as an optional educational track within the *Synergy "school + university" program*. Its difference from the basic blocks is that it is not aimed at all participants, but at motivated schoolchildren who are ready to go beyond the standard curriculum and try themselves in research and engineering practices. This format creates conditions for the formation of individual educational trajectories, and also ensures a balance between mass training and targeted support for talents.

The principle of optionality is a key feature of the elective module "Technologies of the Future", which distinguishes it from the basic mandatory blocks of the Synergy program "school + university". Unlike courses aimed at developing universal metacompetencies, this module is built on the basis of motivation and internal interest of schoolchildren. Its value lies in the fact that it includes precisely those students who strive to go beyond the standard school curriculum and immerse themselves in research activities related to advanced technologies [6,7].

Voluntary participation. Participation in the module is carried out at the student’s personal choice and does not affect his basic academic workload. This model removes the stress associated with compulsory subjects and turns the learning process into a positive educational adventure rather than an additional source of stress. Voluntariness increases internal motivation: students come to the module with a desire to learn, and not because of external pressure.

Selection mechanisms. The optional nature of the module implies minimal selection, based not on academic achievement, but on demonstrated interest: motivational essays (“Why do I want to participate in the “Future Technologies” module?”); creative tasks (mini-research or small project in the STEM direction); interviews with mentors, where the student can talk about his expectations and interests. Thus, the module includes students who are ready for exploration and experimentation, regardless of whether they are “excellent” or “average” students in the traditional grading system.

Individual trajectories. Electiveness opens up the possibility of flexibly constructing individual educational trajectories. For example:

a student can choose only one block (for example, “Programming”) and focus on it; another - go through all four areas (bioengineering, hydroponics, energy, programming) and create their own interdisciplinary project; students can work both individually and in teams, depending on the format of the tasks [21,22-26].

Significance for the pedagogical model. Voluntary participation in the module serves several purposes at once: Selection by interest: the most motivated students are involved. Development of subjectivity : schoolchildren make conscious choices, which increases the sense of responsibility for the result. Mentoring effectiveness: student mentors work with a group of students interested in development, which means the interaction becomes more productive.

The optional nature of the "Technologies of the Future" module turns it into a space of conscious choice and research freedom, where students study not because they "have to," but because they are truly interested. This is what creates an atmosphere of enthusiasm, creativity, and innovation that distinguishes this module from traditional compulsory courses and strengthens the general model of Synergy "school + university" [4,9-12].

Project logic is the central methodological principle of the *"Future Technologies" module.* Unlike the traditional learning model, where students acquire knowledge primarily in the form of lectures, tests and assignments, here the educational process is built around practical tasks, research initiatives and collective design of solutions. This approach not only makes learning more applied, but also prepares students for the real challenges of the university and professional environment.

Basic principles of project logic. From task to solution: training is built not from theory to practice, but vice versa: students receive a problem (case, research challenge, engineering task) that needs to be solved; theory is mastered to the extent that it is necessary for the implementation of the project. Interdisciplinarity: projects combine knowledge from different fields: biology + programming (digital model of a hydroponic installation), physics + ecology (mini solar battery), ethics + genetic engineering (discussion on genome modification); students learn to synthesize knowledge, which is especially important in the era of complex problems. Teamwork: projects are carried out in small groups (4-6 people), where the following roles are distributed: leader, analyst, programmer, presenter, mediator; role rotation allows each student to try themselves in different positions, developing soft skills. Public defense of the result: each project ends with a presentation - a mini-pitch session, where students present their product, argue their solutions and answer questions; This builds confidence in public speaking and the ability to work with feedback [7,21- 26].

Examples of project formats. Research mini-project: "How to change the composition of the nutrient solution to increase the yield of a hydroponic system?" Engineering prototype: a model of a "smart home" using solar panels and sensors. Social and ethical case: a discussion about the use of CRISPR technologies in medicine and their moral boundaries. Digital solution: developing an application for monitoring plant growth or calculating the efficiency of an energy system [1,22].

The role of student mentors in project logic: help schoolchildren structure a project (from idea to implementation); provide advice on complex issues, explaining professional terms in accessible language; facilitators of team discussions, keeping the focus on the goal.

Educational effects. For schoolchildren: development of critical and engineering thinking, ability to work in conditions of uncertainty, formation of communication skills. For student mentors: practicing project management and pedagogical facilitation techniques . For the university: creating a base for future research laboratories and start-ups with the participation of motivated applicants.

Project logic transforms the optional module "Future Technologies" into a laboratory of practical experience, where schoolchildren learn not only to assimilate knowledge, but to apply it to create specific solutions. This approach forms the thinking of the participants as a researcher and a practitioner at the same time, which corresponds to the challenges of the digital age and the principles of innovative education [4,9-12,16-20].

An important feature of the selective module *"Technologies of the Future"* is the active participation of university students in the role of mentors, tutors and facilitators . Unlike teachers, who often perform the function of knowledge translators and controllers of material assimilation, student mentors become partners of schoolchildren in the research process, which strengthens the horizontal "peer-to-peer" model and gives educational interaction the dynamics of trust and openness.

Functions of student mentors. Educational support: explaining complex scientific and technical concepts in an accessible language; assistance in mastering digital tools (simulators, laboratories, software environments); consulting schoolchildren when completing mini-projects. Facilitation of teamwork: organizing project discussions and distributing roles in groups; supporting the rotation process of leaders and participants; supporting teams in resolving conflict situations. Motivation and inspiration: demonstrating personal experience: how the student chose the direction, what projects he or she implemented; forming an image of the "near future" — schoolchildren see that in a few years they can be in the same position; creating an atmosphere of trust and partnership, unavailable in the classic "teacher-student" interaction. Developing schoolchildren's soft skills: training communication skills through dialogues and discussions; developing empathy and the ability to argue a position; supporting in public speaking (rehearsals of pitch sessions, feedback on presentations) [7].

The effects of mentoring on the students themselves. Leadership and pedagogical empathy: students learn to lead and listen to their junior colleagues. Reinforcing professional knowledge: by explaining complex material in simple terms, mentors learn it more deeply themselves. Developing facilitation skills: experience in moderating discussions and managing group dynamics. Creating a digital portfolio: participation in mentoring is recorded in the system, increasing the academic and professional value of the student [5,6].

Systemic role for the university a. The university receives not only motivated applicants among schoolchildren, but also a new generation of student leaders who undergo practical training in pedagogical and mentoring interaction. This turns the university into a platform for multi-level educational interaction, where students not only study, but also become active subjects of the educational process.

Student mentors in the *Future Technologies module* act as catalysts for educational synergy, connecting university knowledge and schoolchildren's motivation. Their participation makes learning less formal, more lively and closer to real practice. Mentoring becomes not only a support tool, but also a social technology for the formation of a culture of mutual assistance and continuity of generations.

Digital support for the elective module *"Future Technologies"* organically continues the architecture already tested in the previous stages of the *Synergy " school + university" program.* If in the basic level modules digital tools were used primarily for communication and progress recording (online platforms, chat bots, electronic portfolios), and in the Mini -MBA - for simulating business situations and public presentations, then in the new elective the digital environment acquires a research and engineering character, allowing schoolchildren to model real technological processes.

Key areas of digital integration. Virtual labs and simulations: develop the practice laid down in the Mini-MBA (business games, cases), but transfer it to the STEM sphere: schoolchildren can work with digital models of hydroponic systems, power plants or biological processes; create a safe space for experiments, where mistakes become part of the educational process, and not a reason for sanctions; provide access to experience that is impossible in a school lab (for example, modeling thermonuclear reactions or genome editing). Digital portfolio as an extended analogue of the MBA CV: continues the line laid down in the Mini-MBA, where each participant recorded their achievements in management and project tasks; in the "Future Technologies" module, the portfolio already records research and engineering practices: code solutions, mini-projects, prototypes of installations, participation in discussions on the ethics of technology; becomes an individual educational "ecosystem" reflecting the dynamics of the growth of the student's competencies. Chatbots and digital assistants: inherit the support function tested in the early Synergy modules: chatbots remind about tasks, help distribute roles in the project, record activity in teamwork; are supplemented with intelligent modules - a chatbot can simulate a negotiation situation, check the logic of argumentation or generate additional tasks. Artificial intelligence as a pedagogical partner: if in Mini-MBA AI acted as a simulator of business scenarios, then here it becomes a universal tool for STEM education: it simulates biological processes, analyzes energy calculations, evaluates the correctness of the program code; acts as an intelligent facilitator: suggests weak points in the project, offers development scenarios and generates feedback in real time. Hybrid implementation model: digital infrastructure makes the module accessible to schoolchildren from different regions of Kazakhstan; project teams can work in a mixed format: offline experiments in schools are combined with online work on the university platform; This strengthens the principle of "synergy through the network", allowing to expand the audience without losing the quality of educational interaction [1,16-25].

Educational effects of digital support. For schoolchildren: the opportunity to "try on" the role of a researcher and engineer, working with professional digital tools; increased digital literacy and confidence in STEM areas. For student mentors: developing digital facilitation skills, teaching practices through online tools, and experience integrating AI into educational processes. For universities: creating a basis for further integration of optional modules into the pre-university training system; expanding the digital infrastructure for future programs.

Digital support in the Future Technologies module is not just a technical supplement, but an innovative educational framework that ensures continuity with all previous stages of the Synergy School + University program. It combines the experience of a digital portfolio, case methods and AI simulations tested in the Mini-MBA and mentoring practices with new STEM areas, turning training into an interdisciplinary study where schoolchildren and students create the future together [1,4,9-12].

Unlike the basic modules *Synergy " school + university"* and Mini -MBA, where the "pass/fail" principle was used as a tool to relieve pressure and focus on participation, in the selective module *"Technologies of the Future"* the assessment logic requires even greater flexibility and individualization. Since participation in the module is optional, it should not turn into a source of stress control or strict certification. On the contrary, the value here is to record the educational path of each participant, emphasizing their contribution, achievements and progress.

Basic principles of evaluation. Voluntary recording of results: participation in the module does not require mandatory exams or formalized results; Students themselves choose the form in which to demonstrate their achievements: a project, a digital portfolio, an essay, a research note, or a public presentation. Multi-format: The results are recorded in different formats: digital portfolio with project records; demonstration of a prototype or simulation; participation in a mini- hackathon or research discussion; software product development;

Each format is valuable and is assessed not by strict criteria, but through quality feedback. Loyal and supportive nature: the emphasis is not on comparing participants with each other, but on individual progress; The criterion for success is not the result in absolute numbers, but the interest shown, participation and steps forward compared to one's own starting level. Mentoring feedback: the key element of the system is feedback from student mentors and teachers; Feedback is structured in the format of "strengths – growth areas – possible steps for development," which turns assessment into a tool for reflection rather than pressure. Self-assessment and peer assessment: students learn to analyze their own contributions and those of their team, creating a culture of open and constructive assessment; This enhances reflexivity and develops the ability to receive and give feedback.

Digital recording. All achievements are integrated into a digital portfolio, which acts not as a "report card" but as a living map of the educational path. The platform allows you to track: participation in blocks (bioengineering, hydroponics, energy, programming); completed projects and their results; feedback from mentors and self-assessment of participants; dynamics of competence development [21-26].

The assessment system in *the Future Technologies module* differs from the previous stages of Synergy by being even more individualized and flexible. There is no point in traditional assessments or ratings: the value lies in giving students space for experimentation, mistakes, and growth. Each participation is already a result, and the outcome is not a "grade in a journal," but skills, experience, and a digital portfolio that record progress and form a sense of authorship in the student's educational trajectory.

The implementation scenario of the optional module *"Future Technologies"* is based on the principles of flexibility, project-based approach and intergenerational mentoring. Unlike the basic program and Mini -MBA, where the educational structure is more strictly regulated, here the emphasis is on freedom of choice and variability, which allows each student to build an individual research trajectory.

Stage 1. Selection and orientation of participants.

The module starts with a motivational stage: schoolchildren submit an application in free form (essay, video presentation, mini-project), where they justify their interest in the selected topics. Introductory meetings are held with student mentors and teachers, where the objectives, structure and possibilities of the module are explained. Each student gets access to a digital platform where their educational trajectory is recorded.

Stage 2. Immersion in thematic blocks.

The module lasts one academic year and is divided into four blocks (by quarters or trimesters): Bio and genetic engineering — introduction to genetics and ethical discussions. Hydroponics and agrotechnology — creation of mini- experiments on growing plants. Energy of the future — modeling of renewable sources and smart-grid solutions. Programming and digital technologies — development of applications and simulations to support projects. Each block ends with an intermediate project: a mini-research, prototype or public defense. Students can choose one block in depth or participate in all for a broad coverage [21-26].

Stage 3. Interdisciplinary teams.

Flexible teams of schoolchildren and student mentors are formed to work on projects. In a team, schoolchildren try out different roles (leader, analyst, programmer, presenter). Role rotation builds flexible leadership and collaboration skills.

Stage 4. Digital recording and support.

All results are recorded in a digital portfolio, which becomes the main assessment tool. AI assistants offer recommendations (“develop public speaking skills,” “deepen programming knowledge”). Chatbots help schoolchildren manage deadlines and teamwork [24–26].

Stage 5. Final integration and presentation.

The academic year ends with a final pitch session, where teams present their projects, ranging from biotech concepts to energy simulators and digital solutions. The jury includes university professors, senior students, and representatives of local innovation companies. The best projects may receive support for continuation in university laboratories or business incubators [4,9-12,21,23-25].

Stage 6. Post-modular support.

Participants retain access to their digital portfolio and AI recommendations. For motivated schoolchildren, tracks of in-depth cooperation with the university are opened: participation in summer schools, internships, research circles. The university gets the opportunity for early recruitment of talented applicants.

The implementation scenario of the module "Technologies of the Future" sets a flexible, multi-level and interdisciplinary learning path, where schoolchildren do not just study new technologies, but try themselves in the role of researchers and designers. This format strengthens the continuity of the previous stages of "Synergy" (meta-competences, Mini-MBA, mentoring) and brings the program to a level where education becomes a tool for the formation of a generation of creators and innovators for Kazakhstan. [6,7,16-20].

Examples of projects in the module "Technologies of the Future" . One of the key features of the optional module is the focus on practice-oriented projects that schoolchildren develop in a team with student mentors. These projects act as "mini-laboratories of the future", where teenagers try themselves in the roles of researchers, engineers, programmers and entrepreneurs.

Bio and genetic engineering. The Virtual CRISPR Lab project: schoolchildren use digital simulation to “edit” plant DNA to increase its resistance to drought. Essay-discussion “The Ethics of Genome Editing”: teamwork on the pros and cons of using genetic engineering in medicine. Mini-study “GMO: Myths and Reality”: schoolchildren conduct a survey at school and analyze public opinion on genetically modified products [21, 23].

Hydroponics and agricultural technologies. The School Farm on the Windowsill project: the team constructs a simple hydroponic installation and monitors the growth of plants in different solutions. Comparative experiment "Traditional soil and hydroponics": schoolchildren record the growth rate and quality of plants, analyzing the data obtained in a digital portfolio. The City of the Future: Green Roofs and Vertical Farms initiative: development of a model of a sustainable microdistrict using hydroponic technologies [22].

Energy of the Future. The Solar Station for School project: calculating the school's energy needs and modeling the installation of solar panels. Simulation of the Energy Crisis: schoolchildren, as a team of power engineers, make decisions about the distribution of resources in the event of power outages. The Smart Home Energy study: the team designs a digital lighting and heating control system to save energy [23-25] .

Programming and digital technologies. Mini-hackathon "Digital School Assistant": creating a simple chatbot for a lesson schedule or FAQ for schoolchildren. Software simulator "Plant growth": schoolchildren model how plant growth conditions change depending on the composition of the nutrient solution. Data visualization "Energy of the Future": developing an interactive map showing the share of renewable sources in the energy sector of different countries [23-26].

Interdisciplinary projects. "Green City 2035": integration of bioengineering, hydroponics, energy and programming into a single sustainable city project. "School Startup": a team develops a startup idea (for example, a vertical farm for the city or an application for monitoring energy consumption) and presents it at a pitch session. "Ethical Forum": an intergenerational discussion of schoolchildren and students about which technologies of the future carry risks and which ones bring new opportunities [21-26].

The projects of the *"Future Technologies" module* provide schoolchildren with real-life experience, where they learn not only to learn new things, but also to apply them. Each task is open-ended: it is not so much the "correct answer" that is important, but a reasoned solution, creativity, and teamwork. Thus, the projects become not an academic obligation, but a space for the formation of the students' research identity.

Hypothetical case (KarIU + school No. 11, Temirtau). The integration of the optional module "Technologies of the Future" into the educational model Synergy "school + university" logically continues the trajectory we have set. If at the first stage the emphasis was on mentoring students as a social bridge, at the second - on the structural integration of the school and university through digital technologies, at the third - on Mini-MBA as the managerial core of the program, then the optional "Technologies of the Future" forms the research dimension of synergy, allowing schoolchildren to immerse themselves in the practice of STEM areas [1].

Participant selection and preparation. Schoolchildren: participation is voluntary, which corresponds to the optionality logic inherent in the new model. Selection is based not on academic performance, but on motivation and interest in research activities. Student mentors: senior students of KarIU from the fields of biotechnology, energy, IT and agricultural engineering are involved. Their role continues the “peer to peer” line tested in previous modules, but with an emphasis on scientific and engineering support. Teachers: act as coordinators and moderators, ensuring a balance between the accessibility of the material and academic depth [21,23-25].

Implementation of educational blocks. The elective is divided into four blocks, each of which strengthens and develops the Mini-MBA practices and the mentoring model already mastered by schoolchildren: Bio and genetic engineering — expands the philosophical and ethical component previously laid down in the basic modules. Hydroponics and agricultural technology — relies on the logic of project practices and forms the skills of sustainable thinking. Energy of the future — links school projects with the global agenda (ESG, green economy), which continues the ideas of strategic thinking of the Mini-MBA. Programming and digital technologies — integrates the digital platform and AI practices laid down in the second stage of "Synergy" into the STEM context. Each block ends with a mini-project, which is recorded in the digital portfolio and can be used as a "step" for entering a university or participating in regional competitions [8,13,21-26].

Integration and final presentation. Teams of schoolchildren and students prepare interdisciplinary projects: "Green Class of the Future", "Smart School Greenhouse", "Digital Assistant for Energy Management". The final pitch session repeats the Mini-MBA practice, but is transferred to the STEM plane, where research hypotheses, engineering prototypes and digital solutions are evaluated. The jury includes representatives of KGIU, schools and regional enterprises, which makes the module a platform not only for educational, but also for innovative and social testing of ideas [4,9-12].

Expected results. For schoolchildren: consolidation of project and research work skills, confidence in STEM areas, experience in public communication. For students: development of mentoring competence and the ability to facilitate scientific and engineering projects. For the university: attracting motivated applicants and expanding the pre-university preparation model. For the region: forming the core of a youth community ready to solve the problems of sustainable development and the digital economy. The case of "Kariu + school No. 11, Temirtau" demonstrates that the optional module "Technologies of the Future" is the fourth logical stage of the evolution of the Synergy program "school + university". It combines the experience of mentoring, digital architecture, management practices of Mini-MBA and brings synergy into the sphere of research and engineering solutions, preparing schoolchildren for the challenges of the 21st century [1].

Effects for schoolchildren. Formation of a research identity: teenagers not only acquire knowledge, but try themselves in the roles of scientists, engineers, and programmers. Mastering practical STEM competencies that cannot be obtained within the standard school curriculum. Developing knowledge integration skills: combining biology, engineering, programming, and ethics in interdisciplinary projects. Increasing motivation to enter university and a conscious choice of a future professional trajectory [21–26].

Effects for student mentors. Deepening professional knowledge through teaching practice and supporting school projects. Developing the facilitation and teaching skills needed by future leaders and managers. Enrich your digital portfolio with experience working with interdisciplinary teams. Increasing the role of students at the university as active subjects of the educational process, and not just recipients of knowledge.

Effects for universities. Creation of a channel for early recruitment of talented applicants who are already familiar with the university environment and project-based learning methods. Formation of the image of the university as a center of innovative education that works proactively. Strengthening ties with regional schools and building a sustainable “school-university-community” model. Development of the infrastructure of digital and research practices that can be scaled to other educational programs of the university [4.9-12.16-20].

Effects for the region and society. Preparing a younger generation with an engineering and research mindset, ready to engage in sustainable development projects and digitalization of the economy. Creating an ecosystem of “small innovations” where school projects can be transformed into startups and social initiatives. Strengthening the social capital of the region: a culture of mentoring, horizontal cooperation and intergenerational continuity. Potential integration of the optional module into the national strategy for modernizing education in Kazakhstan, which makes it significant not only at the school or university level, but also at the state level [4.8-13.16-20].

The module "Technologies of the Future" becomes the next evolutionary stage of the Synergy "school + university" program, taking it beyond adaptation and management competencies to the formation of a research and innovation culture of the new generation. Its effects go beyond classical pedagogy: schoolchildren become researchers, students - mentors, universities - innovation centers, and the region - a platform for the formation of the personnel reserve of the 21st century. Thus, the prospects of the module are associated not only with improving the quality of education, but also with the creation of a model of the socio-technological future of Kazakhstan, where the synergy of generations and the integration of school and university become the basis for sustainable development [4.9-12.16-20].

The optional module "Future Technologies" is not just an additional element in the structure of the Synergy "school + university" program, but its qualitative expansion and entry into a new level. If the first four stages of the model's evolution laid the foundation - from mentoring and digital integration to Mini-MBA management practices and regional testing in Temirtau - then this module opens up a research and innovation dimension, turning school-university synergy into a full-fledged laboratory of the future [4,9-12].

This is where its strategic novelty lies: Firstly, the module elevates the educational model from the level of adaptation and management competencies to the level of technological creativity. Schoolchildren become not only consumers of knowledge, but also its co-authors, trying themselves in the roles of researchers, engineers, programmers and inventors. Secondly, the elective introduces a component of variability and flexibility into the program, removing the burden of mandatory assessment procedures and providing students with freedom of choice, independence and responsibility for their own development. Thirdly, the module strengthens intergenerational synergy: student mentors, who previously helped schoolchildren adapt, are now involved in supporting research projects, becoming a bridge between university science and the school environment. Fourthly, the digital support of the module takes the educational process beyond the classroom, creating an ecosystem where students gain access to virtual laboratories, simulations and AI assistants, and their achievements are recorded in a digital portfolio - an analogue of a professional resume [8,13].

Development prospects. The module develops interdisciplinary thinking, critical analysis and digital literacy skills in schoolchildren, ensuring readiness for STEM-focused university programs. KarIU and other universities have the opportunity to build a long-term trajectory with future applicants who come not as "passive students", but as active researchers with their own portfolio of projects. The elective strengthens the culture of mentoring and peer-to-peer cooperation, builds trust between generations and makes the university a significant social partner for the school and the region. The first rudiments of research initiatives, startups and prototypes appear through school and student projects, which can be integrated into university laboratories and business incubators. The inclusion of elective modules such as "Technologies of the Future" in the educational strategy of Kazakhstan can become part of the state program for school modernization and training of personnel for the digital economy and "green energy" [8,13,23-25].

The optional module “Technologies of the Future” secures the status of a full-fledged multi-level educational ecosystem for the Synergy “school + university” program, where a student goes through the following path: from soft adaptation (mentoring); through digital integration and modular learning logic; to management thinking (Mini-MBA); regional testing (Temirtau cases); and, finally, to research and innovation experience, which forms not just “future students”, but future creators of technologies and leaders of the 21st century [1,4,9-12].

Thus, “Technologies of the Future” are becoming not an elective in the traditional sense, but the culmination of a synergetic program, its strategic expansion and a guide to the future. It is this module that opens new horizons for the school, university and society of Kazakhstan, setting the foundation for a national system of early training of researchers, engineers and entrepreneurs of the digital era [8,13].

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SYNERGY "SCHOOL + UNIVERSITY": CAPSTONE - CAREER GUIDANCE MODULE AS A TRANSITION TO HIGHER EDUCATION

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Abstract. *The Capstone module "Career Guidance and Professions of the Future" is conceived as the final stage of the Synergy educational program "school + university", combining all the accumulated experience of pupils and students into a single trajectory of a conscious choice of profession. Unlike the basic modules aimed at forming metacompetencies, Mini -MBA, providing management training, or electives such as "Technologies of the Future", focused on research practices, this module has a strategic navigation function: it helps graduates not only decide on the direction of further education, but also correlate it with the prospects of the labor market in 2035-2050.*

The novelty of the approach is that career guidance is viewed not as a formal procedure (tests, consultations), but as a practice-oriented immersion into professional worlds through VR/AR simulations, artificial intelligence, competency maps of the future and job practices. shadowing ("following a professional"). This format allows schoolchildren to live a "rehearsal of a profession", see its pros and cons, and correlate personal interests and skills with the demands of the global economy.

Keywords: *capstone module; career guidance; professions of the future; school + university synergy; digital portfolio; educational trajectories.*

The modern education system faces a challenge: how to help schoolchildren not only acquire knowledge and metacompetences, but also make an informed choice of profession that corresponds to their interests and the challenges of the global economy of the future. Traditional forms of career guidance, limited to tests and consultations, are insufficient in the context of rapid changes in the labor market, where professions disappear and appear faster than schoolchildren manage to go from high school to university [1].

Previous studies on the Synergy "school + university" program identified key stages in the formation of an educational ecosystem: student mentoring as a social bridge, digital integration of school and university, Mini -MBA as a management core, and optional STEM modules. Each of these steps allowed students to expand their horizons, prepare them for teamwork, and develop soft skills, research activities and basic management practices. However, before entering the university, there remains a critical task - the transition from general preparation to personalized professional choice.

It is to solve this problem that the capstone module of career guidance is being developed, which becomes the final stage of the Synergy program. Its mission is to transform the accumulated experience (project portfolio, management training, STEM initiatives) into a tool for conscious choice of profession and educational trajectory. Here, schoolchildren get the opportunity to “try on” the professions of the future through VR/AR simulations, job shadowing with students and young professionals, digital analytics of competencies using artificial intelligence.

Thus, the introduction of the capstone module allows to close the gap between school and university not only at the level of academic or social adaptation, but also at the level of the graduate's life strategy. He becomes not just an applicant choosing a faculty, but a subject aware of his professional mission and understanding how his personal competencies relate to the demands of society and the economy of the future.

In the global educational tradition, capstone modules play the role of the final stage of training, integrating the knowledge, skills and experience acquired by students throughout the course. In universities in the USA, Canada, Great Britain and Australia , capstone - projects have long been a mandatory part of bachelor's and master's degrees. Their goal is not only to test the level of training of graduates, but also to give them the opportunity to demonstrate their ability to solve problems in a complex manner in conditions as close to reality as possible [2].

Features of capstone practices in foreign universities: capstone combines several areas: from economics and management to engineering and social sciences. Students learn to see the relationship between different disciplines; the project is developed based on a real case of a company, social organization or research laboratory. This makes capstone a bridge between academia and practice; tasks are completed in groups, which allows for the development of soft skills: communication, leadership, time management, critical thinking; the result is a public presentation of the project with the participation of experts - teachers, employers, representatives of public organizations.

Capstone programs, projects occupy a special place. There they act as management simulations: students analyze complex business cases, model strategic decisions and evaluate their consequences. This format proves the graduates' readiness to manage companies and organizations.

Transferring the capstone model to the school-university level opens up fundamentally new horizons. Here, the capstone module can perform the function of final career guidance: integrate the results of all previous modules of the *Synergy program*; allow students to undergo a “job rehearsal” through simulations, mentoring and reflection; make the transition to university education more meaningful and strategic.

Thus, the world experience of capstone practices shows that they are an effective tool for integrating knowledge and preparing for the next stage of life. In the context of Kazakhstan and the Synergy program "school + university", capstone becomes not just an academic result, but an educational bridge to future professions, setting a vector for schoolchildren for professional and personal self-determination.

Career guidance has always been an important element of the educational system, but in the digital age it is acquiring new strategic significance. If previously the choice of profession was based on a relatively stable structure of the labor market and a limited set of “traditional” career paths, today the situation has changed dramatically: professions become obsolete within 5-10 years, new spheres appear, and globalization and digitalization erase the boundaries between industries [3,4].

Key challenges that determine the relevance of career guidance [3,4]:

Labor market dynamics. According to WEF forecasts, by 2030, more than 40% of existing professions will undergo transformation or disappear. For schoolchildren, this means the need to prepare for careers that do not yet exist in their usual form [5].

Growing interdisciplinarity. Future professions combine different fields of knowledge - bioinformatics, cognitive sciences, programming, energy. Classical career guidance according to the "humanities/techie" scheme is losing its relevance [1,3,4].

The need for digital skills. Regardless of the chosen profession, mastery of digital tools and understanding of the logic of working with data are becoming a prerequisite [6].

Social and ethical dilemmas. Digitalization and automation give rise to questions of employment, responsibility of AI, sustainable development. Career guidance should prepare schoolchildren for an informed choice, taking into account these challenges.

Evolution of career guidance [1]:

The classic stage: ability tests, consultations with a psychologist, excursions to enterprises.

stage: online platforms, automated career guidance tests, profession databases [1,6].

Modern stage: use of VR/AR simulations, AI analysis of student portfolios, digital maps of future professions [6,7].

Significance for the Synergy program "school + university". Capstone - the career guidance module is built into this modern context. It allows: combine the student's accumulated experience (Mini -MBA, STEM projects, mentoring) with the forecast of the professions of the future; form an individual educational trajectory through a digital portfolio [2,5,20]; use AI to match a student's personal competencies with relevant and promising professions; shift the focus from choosing a faculty "by tradition" to choosing a profession based on strategic forecasting. Thus, career guidance in the digital age ceases to be an auxiliary function and turns into a key tool for managing the student's future. The Capstone module allows institutionalizing this transition, providing school graduates with a conscious entry into university. and into the world of professions that will be in demand in 2035–2050.

Capstone - the career guidance module in the Synergy "school + university" program plays the role of a closing link that connects school education with the university trajectory. Its value lies in the fact that it is not considered as a "separate course", but as a system for integrating all the educational experience accumulated by the student during participation in the previous modules of the program.

capstone functions. Capstone helps schoolchildren systematize the knowledge obtained at different stages (Mini-MBA, STEM modules, "Technologies of the Future") and see their interconnection. Graduates learn to think interdisciplinary: to combine humanities and technical knowledge, soft skills and hard skills . The final project within the capstone is transformed into a "compressed model" of the future educational trajectory Capstone becomes a space for "professional rehearsal": students test their own interests and abilities through VR/AR simulations, shadowing and digital portfolios [6-8]. The choice of profession ceases to be abstract - it becomes the result of real trials and reflection. The university receives not a random applicant, but a future student with a conscious professional choice. Capstone creates a culture of responsibility for one's choices and an understanding of their long-term consequences. Students gain experience interacting with mentors, teachers and employers, which expands their social capital. The inclusion of the university and regional partners in capstone makes career guidance a collective process, rather than an individual problem of the student [1,2,8].

If mentoring addresses, the issue of social adaptation, digital integration addresses the issue of technological support, Mini-MBA addresses the issue of managerial thinking, and STEM modules address the issue of research experience, then capstone becomes a bridge from school preparation to university and professional choice. It does not simply complete a cycle, but opens a new dimension, where the student begins to act as a subject of his educational and professional trajectory. Thus, the capstone module transforms linear learning into spiral development: the experience accumulated in the school program is rethought and "melted" into a choice of the future. This allows the graduate to enter the university not as a "freshman-newbie", but as a young researcher and future professional, aware of his mission and place in the system of the economy and society.

In the classical education system, the university enters the life of a young person only after finishing school, when the applicant has already made a choice of direction. However, experience shows that this choice is often random, forced or superficial. The Capstone module of career guidance in the Synergy program " school + university" offers a different solution: the university becomes not only a point of admission, but also an active navigator of educational and career trajectories even at the senior school stage.

The university takes on the role of a guide to the world of professions, demonstrating to schoolchildren a variety of areas - from engineering and biotechnology to creative industries and the digital economy. University structures (career centers, research laboratories, business incubators) become a “window into the future” for schoolchildren. Thus, the university acts as a career compass, correcting the student’s choice based on an analysis of his competencies and interests.

Formats for including the university in career guidance. Demonstration sites where schoolchildren get acquainted with professions through practice: mini-experiments, engineering tasks, business simulations. Example: "a day in a bioengineering lab" or "an MBA management session for high school seniors." University professors give open lectures, demonstrating how fundamental knowledge is transformed into professional competencies. This helps schoolchildren develop an understanding of the real content of university disciplines. Involving employers through the university. The university acts as an intermediary between the school and the labour market, attracting companies and organisations to conduct career guidance events. This makes capstone not only an academic but also a socio-economic project.

Effects of the university role. For schoolchildren: access to information about professions, real experience of interaction with the university environment, reduced risk of making the wrong choice. For the university: an influx of motivated applicants ready for active learning and involvement in research projects. For the region: formation of a personnel reserve focused on strategic areas of the economy and society. Thus, the university in the capstone module ceases to be the “final entry point” and becomes a systemic career navigator, creating a stable understanding of the professions and trajectories of the future in schoolchildren.

If the university in the capstone module performs the function of a strategic navigator, then the school becomes a space for initial trials and experiments, where the student can safely test different roles and areas of activity. In the digital age, the school ceases to be just a provider of knowledge - it turns into a laboratory of self-determination, where educational practices prepare students for a conscious choice of profession.

School as a platform for "professional rehearsals". Within the framework of capstone steps, the school can organize mini-projects that simulate real professional situations: creating a school startup, a research experiment, a social project. Such formats allow students to try themselves in different roles: researcher, manager, analyst, teacher, engineer. Mistakes in this space are not critical: they are perceived as part of the educational experience, not as a failure.

Early choice through cross-disciplinary assignments. The school can integrate interdisciplinary projects that cross subject boundaries. Examples: project "Green energy for my city" (physics + ecology + economics), "Programming for social assistance" (computer science + sociology), "Ethics of genetic experiments" (biology + philosophy). Such tasks show that the professions of the future are born at the intersection of disciplines.

Support through teachers and school tutors. Teachers become not just transmitters of knowledge, but facilitators of choice, helping students analyze their interests and record their experience in a digital portfolio. It is important to create a culture in the school that values not only academic achievement, but also trying new things.

Effects of the school role. For students: the opportunity to "try on" different professions, feel their strengths and weaknesses, and develop an initial trajectory. For the school: strengthening its role as the first step in the “school-university-profession” chain, increasing its attractiveness in the eyes of parents and society. For the university: schoolchildren come to capstone with a conscious experience of trials, and not from a blank slate. Thus, the school in the capstone module turns into an experimental environment for early professional choice, creating a foundation for subsequent navigation at the university. It becomes a place where a teenager begins not only to study, but also to design his future.

The peculiarity of the capstone module is that it preserves and strengthens the logic laid down in the first articles of the Synergy series "school + university" - the idea of mentoring students as a "bridge" between generations. If at the early stages mentors helped schoolchildren adapt to the university culture and master soft skills, then within the framework of capstone their mission is transformed: they become guides into the world of professions, giving schoolchildren the opportunity to look at the future through the practice of "job shadowing [7].

The essence of job shadowing. A schoolchild "follows a student" for a certain period of time (day or week), observing his or her educational, research, and project activities. This format allows graduates to see the university from the inside: lectures, laboratory classes, project sessions, student initiatives. Students share their personal experiences of choosing a profession, difficulties of adaptation, participation in projects and internships.

The role of student mentors. They help students understand how real university life differs from their perceptions. They share insights: what is important for a successful start, what skills are really in demand, how to build an individual educational trajectory. Students are closer to schoolchildren in age and thinking style, so their experience is perceived as more authentic and accessible for imitation. They demonstrate that the university is not an abstract structure, but a living environment of growth and opportunity. The participation of students from different fields allows schoolchildren to see the diversity of professional tracks. It is important that mentors can show not only the "ready-made profession", but also its transformation in the digital age.

Digital support job shadowing [7]. Using online platforms, students record their observations in a digital portfolio. Mentors and students jointly create "career maps" where they highlight skills that are actually in demand. AI analytics helps to generalize shadowing experience and link it to competency maps for 2035–2050.

Job implementation shadowing. For schoolchildren: fear of university and choice of profession disappears, clarity about one's own interests appears. For students: develops the ability for pedagogical facilitation and leadership, forms soft skills skill "mentoring". For the university: a system of early involvement of applicants is being created, which reduces the risk of dropping out in the first years. For the region: a culture of continuity and horizontal support between generations is being formed. In this way, student mentors become an integral part of the capstone module, transforming career guidance from a formal consultation into a living process of shared experience, where the student learns to see himself as part of an academic and professional community.

The digital portfolio has become a key element of the Synergy cycle "school + university". In the context of the capstone module, it plays a special role: it becomes a navigator of professional choice, integrating the student's academic experience, the results of the Mini -MBA, participation in the electives "Technologies of the Future" and the experience of interacting with student mentors.

Digital portfolio functions in the capstone module. The student's projects are recorded: research, management, social, STEM initiatives. The results of shadowing sessions and VR/AR simulations of professions are displayed. Achievements in soft are taken into account skills. Artificial intelligence analyzes the accumulated data array and identifies the student's strengths and weaknesses. Based on the analysis, recommendations are formed on the educational trajectory and professions that are most relevant to the individual profile. The student can trace the dynamics of his development over the years of participation in the *Synergy program*. Capstone becomes a moment to take stock: what has been mastered, what needs improvement, what is of interest. The university receives a structured graduate profile, which facilitates distribution among faculties, educational tracks or research laboratories. The portfolio can be used as a "mini-CV" for admission to programs, grants and competitions.

Advantages of a digital portfolio: a single resource reflects the entire educational and personal path of a student; results do not depend on subjective marks, but record real participation and achievements; AI recommendations are based on individual progress, not average norms; a digital portfolio is linked to foresight maps of professions for 2035–2050, allowing for the prediction of development trajectories.

Thus, the digital portfolio in the capstone module turns into an educational compass, showing the graduate the directions in which his personal potential best matches the needs of society and the economy of the future.

Flexible assessment system in capstone –module. Unlike the basic courses of Synergy and the Mini -MBA module, where it is advisable to use the “pass/fail” system to relieve the excessive pressure of traditional grades, in the capstone module of career guidance the priority is not recording the result, but supporting the individual educational trajectory of the graduate. Here it is more important not to “assess”, but to help to understand and “collect” your path before moving to university [1,2,8,9].

Effects of a flexible approach a. For schoolchildren: no pressure from grades, emphasis on self-development and awareness. For mentors and teachers: the opportunity to focus on support and consultation rather than formal grading. For the university: a more complete understanding of the applicant as an individual with experience and plans, and not just as a bearer of “UNT scores or a certificate.” Thus, the flexible assessment system in the capstone module makes it not an examination barrier, but a pedagogical platform for conscious choice, where the process of reflection, depth of analysis and the ability to self-navigate are valued.

The Capstone module of career guidance is not an isolated element, but rather a logical conclusion and culmination of the entire Synergy educational program " school + university". It synthesizes the results of all previous steps - mentoring, digital integration, management Mini -MBA, electives on "Future Technologies" - and translates them into the plane of a conscious choice of profession.

Place of capstone in the architecture of "Synergy". Basic level: Mentoring students, soft skills, pedagogical facilitation. Intermediate level (management and research): Mini -MBA, STEM and elective modules. Capstone level (transitional): career guidance, development of an individual educational trajectory, choice of profession. Thus, the capstone completes the trajectory, transforming the student from a “student of the program” into a subject of educational and professional strategy.

Regional cases as a scaling model. Examples like the partnership between KarIU and school No. 11 in Temirtau are becoming a platform for testing capstone [8]. This allows us to develop a model that can then be scaled to other regions of Kazakhstan.

Hypothetical case (KarIU + school № 11, Temirtau). The initial phase of the capstone program is virtual immersion in professions, designed for the first week. Its task is to provide schoolchildren with a wide range of professional "tests" through digital simulations and interactive scenarios, so that they can then more consciously choose areas for in-depth study in the second and third weeks.

Implementation format. A VR/AR platform with a set of simulations is being created at the university, each of which models a real work process in various fields - from engineering and medicine to bioengineering, energy of the future and IT. Each student goes through at least 4-5 professional simulations, recording their decisions, choice of strategies and results. The result of the week is a “map of interests”: a set of areas in which the student demonstrated the greatest involvement and competence.

Examples of virtual scenarios in. Power engineer: resource allocation in the city's "smart grid". Programmer: developing a prototype of a chatbot with AI elements. Bioengineer: modeling the process of growing tissues in the laboratory. Medical specialist: digital diagnostics and decision making with the help of AI assistant. Entrepreneur: Simulation of defending a startup in front of investors.

Digital recording and analytics. All student actions are recorded in a digital portfolio, which is automatically updated. The AI system generates a report: strengths, preferred roles (analyst, leader, creator , researcher), areas for development. This data becomes the starting point for the next stage - job shadowing and practical training of professions.

First week effects. For schoolchildren: a safe and varied experience of “trying on professions” in a risk-free environment. For student mentors: the opportunity to accompany students, discuss simulation results with them, and help interpret the experience. For the university: a clear idea of the interests and inclinations of future applicants. Thus, virtual immersion in professions becomes the starting phase of the capstone module, setting the direction for further in-depth study and career guidance choice [1,3,4].

The second week of the capstone program is dedicated to live interaction of schoolchildren with students and young professionals in the job format shadowing ("following a mentor") and practical training of professions. This stage allows the transition from virtual simulations to real observation and testing in the university and professional environment [2,7].

The essence of the format. Each schoolchild is assigned to a student mentor or a young specialist in a certain field. During the week, the students observe the educational and research activities of the mentor, participate in individual tasks and discuss what they have seen. Mentors explain which competencies are really in demand and help students relate the results of VR immersion to real professional practice.

Program components: Attendance at lectures, laboratory and project sessions at the university. Participation in mini-research groups with students. Discussion of what was seen and reflection in the digital portfolio. Mini-tasks from mentors: create an algorithm, calculate an energy model, conduct an experiment, prepare a mini-presentation. Work in small teams of schoolchildren and students with role rotation (leader, analyst, presenter). Evening reflective Q&A sessions between students and student mentors. The pros and cons of the profession, real challenges and prospects of the industry are discussed.

Digital recording and support. The digital portfolio reflects: the chosen field, practical assignments, the student's conclusions about the profession. The AI system analyzes the dynamics of interests: whether they coincide with the results of the first week of VR immersion or have changed under the influence of live experience.

Effects of the second week. For schoolchildren: understanding the real content of the profession, adjusting their own expectations, strengthening or revising their choice. For students: soft development mentoring skills, development of pedagogical empathy. For the university: strengthening its image as a partner in career guidance, forming a sustainable “school-university” system. For the region: formation of a base of applicants consciously focused on strategic areas of development. Thus, the second week of the capstone module becomes a stage of conscious immersion in real practices, where students not only observe, but also participate, turning abstract interests into a concrete experience of choice.

The final stage of the capstone module is the third week, when schoolchildren move from trials and observations to independent formation of their own educational and professional trajectory. This stage is project-based and ends with a public defense in the format of " Pitch of my future".

Structure of the third week. Formation of an individual project: Based on the experience of virtual simulations (first week) and job shadowing (second week) each student prepares an individual development plan: choice of profession, justification of direction, competency map [10]. The project records both professional goals (“Who do I want to become?”) and educational steps (“Which university program should I choose?”, “What skills do I need to develop additionally?”). Group projects "Professions 2035-2050": Schoolchildren unite into small teams to develop futurological mini-studies: "Energyman of the Future", " Bioengineer 2040", "Teacher of the Digital Age", "Lawyer in the World of AI ". Teams create short presentations or videos where they demonstrate their vision of the development of the profession. Pitch session "My Future". Each participant is given 5-7 minutes to publicly defend their educational trajectory in front of a committee (teachers, student mentors, employer representatives). It is important not only to explain what the student wants to become, but also to justify the choice, based on their experience in the capstone module. After the presentation, the student receives feedback from experts and recommendations for further development.

The role of a digital portfolio. The portfolio includes: the final project, a recording of the pitch session, recommendations from mentors and experts. The AI system records the competencies demonstrated in the presentation: argumentation, structured thinking, communication. Thus, the portfolio becomes the graduate’s educational passport, ready for entering university.

Educational effects. For schoolchildren: formation of a conscious professional choice, confidence in public self-presentation, skills of argumentation and strategic thinking. For student mentors: experience in supporting schoolchildren to achieve results, development of leadership and pedagogical facilitation. For the university: an influx of applicants with ready-made educational trajectories and a high level of motivation. For the region: the emergence of graduates focused on key professions of the future, with a readiness for leadership and innovation. " Pitch of my future" becomes the final point of the capstone module, where the student turns from a passive observer into an active subject of choice. This is not an exam, but a ceremonial presentation of one's own life and education strategy, which sets a confident start to the university stage.

Effects for schoolchildren. For schoolchildren, participation in the capstone module becomes not just the end of their school journey, but a turning point in understanding themselves and their future. Unlike traditional forms of career guidance (tests, consultations, excursions), capstone creates a deep immersion in the reality of professions, combining digital simulations, live mentoring and public defense of their own plans.

Academic effects. Schoolchildren learn to connect disparate modules of the Synergy program (Mini -MBA, STEM, Technologies of the Future) into a single educational picture; capstone shows that real professions require a synthesis of humanitarian, technical and managerial competencies; growth of reflection skills, dynamics of personal and academic growth.

Psychological effects. Thanks job shadowing and mentoring eliminate the fear of the “unknown”; students understand that they are capable of independently formulating goals and defending their own projects; each graduate leaves the program not just with a certificate, but with the awareness of themselves as future professionals.

Social effects. The format of " Pitch of my future" trains self-presentation, a skill that will be in demand at the university and in the labor market; schoolchildren interact with students, teachers, employers, receiving their first professional contacts; through joint projects, teenagers understand the importance of teamwork and mutual support.

Strategic effects: Graduates do not choose a faculty "blindly", but make a choice based on experience, analysis and reflection. Capston allows every student to leave school with a “map of the future” – an understanding of what steps need to be taken at university and beyond; Through digital simulations and futurological projects, schoolchildren prepare for the realities of 2035–2050. Thus, the capstone module for schoolchildren becomes an educational lift and a personal springboard, which not only completes the school stage, but also opens a new one - university and professional - at a qualitatively different level of maturity.

Effects for students. In the capstone module, students occupy a special place: they become mentors, facilitators and mediators between the school and university environments. This experience not only strengthens the Synergy program "school + university", but also forms a new level of professional and personal maturity in students.

Academic effects. By explaining complex topics to schoolchildren in simple terms, students absorb the material more deeply and practice their ability to translate pedagogically; working in the capstone module, they encounter tasks that go beyond their specialty, which develops flexibility of thinking; students learn to accompany schoolchildren in their work on mini-projects, acting as research assistants.

Psychological effects: By acting as mentors, students understand the value of their own experience and see that they are able to influence others; They learn to notice the difficulties of schoolchildren, support them and create an atmosphere of trust; for the first time, the student feels like not just a student, but a bearer of knowledge and experience that can be shared.

Social effects. Students practice dialogue with teenagers, teachers and employers; mentoring requires the ability to motivate, coordinate and inspire a team; students become part of a community that values mutual assistance and continuity between generations.

Strategic effects. Mentoring experience becomes a good school for future leaders, teachers, researchers and managers; participation in capstone is recorded in the student’s digital portfolio, which strengthens his/her CV and distinguishes him/her from graduates; communication, facilitation, working with uncertainty and the ability to manage the educational process are becoming key competencies of the 21st century. Thus, the capstone module opens up a double perspective for students: on the one hand, they help schoolchildren take a step into the future, and on the other hand, they themselves gain unique experience that makes them in demand at the university, in the labor market and in the professional community.

Effects for the university. The Capstone module in the Synergy program " school + university" opens up new horizons for universities to interact with schools and applicants. It turns the university not only into an educational organization accepting students after exams, but also into an active participant in the formation of professional identity at the school stage.

Academic effects. Schoolchildren come to the university already familiar with its infrastructure, disciplines and scientific culture; capstone involves schoolchildren in mini-research and laboratory projects, which forms an interest in science and applied developments; motivated and consciously oriented applicants enter the university, which reduces the risk of academic failure and dropout.

Social effects. The university is perceived not as a “distant goal”, but as a close and accessible partner in the educational trajectory of schoolchildren; the university becomes a center that unites schools, students, parents and employers; capstone enables the university to speak to young people in the language of projects, digital tools and futurological scenarios [2, 6, 8].

Economic and strategic effects. Participation in capstone strengthens the university's position in the educational market, making it attractive to applicants and their parents; capstone can be integrated into state and regional programs for the development of human resources; the university gets the opportunity to see talented schoolchildren in advance and direct them to key specialties for the region and the country.

Innovative effects. Integration of digital solutions: VR/AR, artificial intelligence and digital portfolios become part of the university ecosystem; teachers begin to work not only with students, but also with schoolchildren, acting as facilitators and mentors; capstone - Start-up sessions and business simulations create an innovative environment around the university. Thus, the capstone module transforms the university from a “reception point” into an active architect of educational trajectories, strengthening its scientific, social and strategic mission. This allows the university to become the center of a regional educational ecosystem uniting schools, business and society [6,7,10].

Effects for the region. The Capstone module in the Synergy program " school + university" goes beyond individual schools and universities, becoming a strategic resource for the development of the region. Its effects are manifested not only in the educational sphere, but also in the socio-economic and cultural space.

Social effects. The practice of “seniors helping juniors” is being formed, where students and teachers become mentors for schoolchildren. This strengthens horizontal connections and the value of mutual assistance; schoolchildren from different social strata receive equal access to modern career guidance tools; teenagers see opportunities for self-realization in local universities and companies, which reduces the risk of “brain drain”.

Economic effects. Capstone prepares young people who, already at the school stage, are oriented towards professions that are in demand in the region (energy, metallurgy, digital technologies, medicine, education); schoolchildren and students are involved in startup projects that can become the basis for future small businesses and innovative enterprises; regional companies get the opportunity to participate in capstone as partners, offering cases and tasks, as well as identifying potential employees.

K cultural and educational effects. Participation in the capstone module strengthens the reputation of schools and universities as innovative platforms; the school, university, business and local authorities begin to work as a single ecosystem; schoolchildren perceive themselves as part of a community that works for the future of their city or region.

Strategic effects. Capstone allows the region to integrate into the agenda of "professions of the future" and digital transformation; by training competent graduates, the region receives a personnel base for modernization of the economy and social sphere; the region becomes an example for other territories, demonstrating how educational programs can be a driver of development. Thus, the capstone module functions as a social and economic accelerator for the region, connecting schools, universities, business and society into a single strategy for training future leaders and specialists.

Capstone - module in the Synergy system "School + University" is a logical culmination of a holistic educational trajectory built within the four previously described areas: student mentoring, modular integration ("School-University 4.0"), the Mini-MBA management block and electives on future technologies. If the first stages formed social coherence, academic continuity, management thinking and research initiative, then capstone turns this complex into a conscious professional choice of the graduate.

The main difference between capstone and traditional career guidance practices is its depth and multi-layered nature. This is not a test of interests or a one-time excursion, but a three-week immersion program, including virtual simulations of professions, job shadowing with student mentors, workshops and final defense in the format of " Pitch of my future". This approach allows the graduate not only to see, but also to live through different professional scenarios, compare them with their competencies and interests, recorded in the digital portfolio.

The Capstone module performs several strategic functions: ensures the transition from the accumulation of knowledge to its integration and application in conditions of uncertainty; reduces anxiety before university, builds confidence and readiness for self-determination; strengthens the culture of mentoring, collaboration and continuity; trains personnel focused on the professions of the future and the strategic challenges of the digital economy [6]. Thus, the capstone module becomes not just the final step of the Synergy program "school + university", but its innovative semantic core, where the student is finally transformed from an "object of learning" into a subject of his own development. This model creates the prerequisites for the formation of a new generation of graduates who come to the university not by chance and not by inertia, but with a clear map of the future - educational, professional and personal [8].

Capstone can be considered a universal tool for modernizing career guidance in Kazakhstan: it connects schools, universities and regional communities into a single ecosystem, where each step of a graduate is not a random choice, but the result of a conscious strategy. That is why this model is capable of going beyond local experiments and becoming the basis of a national system of early career navigation that meets the challenges of the 21st century [8].

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RISK MANAGEMENT IN PROJECTS ON TECHNICAL INSPECTION OF THE RELIABILITY AND STABILITY OF BUILDINGS AND STRUCTURES - DATA VISUALIZATION USING VOSVIEWER

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Annotation.*The article discusses modern approaches to risk management in projects involving technical surveys of the reliability and sustainability of buildings and structures. The focus is on identifying key risk factors that affect the safe operation of facilities. The VOSviewer tool was used to analyze and visualize scientific publications and the relationships between them. This technology allows data to be structured and research clusters and trends in risk management to be identified. The results obtained can be used to improve the effectiveness of decision-making in the implementation of technical inspection projects.*

Keywords: *risk management, technical inspection, reliability of buildings and structures, sustainability, data visualization, VOSviewer, risk management.*

Risk management is a critical component in projects related to the technical inspection of the reliability and stability of buildings and structures [1]. This part aimed to analyze and develop effective approaches for identifying, assessing, and mitigating potential risks that may impact the safety and durability of construction projects. We employed a comprehensive review of scientific publications to identify dominant keywords and clusters, providing valuable insights into the prevailing themes, challenges, and emerging trends in this field. The visualization using VOSviewer highlights key research directions and their interconnections, supporting the development of more resilient strategies for project implementation.

We exported metadata from 39,680 publications from the Web of Science (WoS) database using the following query: "TITLE: ("risk management" OR "project risk management" OR "construction risk management" OR "risk assessment" OR "risk analysis" OR "risk mitigation" OR "technical inspection" OR "building reliability" OR "structural reliability" OR "stability of buildings" OR "structural stability" OR "safety of structures" OR "infrastructure risk management" OR "engineering risk assessment" OR "construction safety" OR "building inspection" OR "structural inspection" OR "reliability analysis" OR "structural monitoring" OR "failure analysis"), timespan: 2020–2024. Indexes: SCI - EXPANDED, SSCI, CPCI - S, ESCI. The construction of a network of co-occurrence of keywords and their clustering was carried out using the VOSviewer 1.6.15 program [2].

The minimum occurrence of keywords selected for consideration was four. The total number of keywords in the 39,680 publications considered (authors and Keywords Plus generated by WoS) is 4,334. The number of keywords that appear at least 4 times is 240, and further analysis was carried out on them.

During the analysis, the spellings of keywords were not translated into Russian in order to preserve their original meanings. To reduce the number of clusters into which keywords (KW) are aggregated, an additional restriction has been introduced: at least 100 KW per cluster.

Table 1 presents the risk management in projects on technical inspection of the reliability and stability of buildings and structures. The visualization with VOSviewer demonstrates how different research works and publications are linked together, showing patterns and connections in this field. It provides a broader picture of how studies contribute to developing safer practices, improving inspection processes, and supporting effective project management in construction.

Table 1- 40 most frequently occurring keywords in a sample of 39,680 metadata

Keyword	**N-kw**	**Keyword**	**N-kw**	**Keyword**	**N-kw**	**Keyword**	**N - kw**
reliability analysis	68	risk mitigation	41	probability	25	active learning	18
management	68	small failure probabilities	39	algorithm	25	kriging model	17
structural reliability	66	framework	33	machine learning	25	surrogate model	17
risk management	59	impact	31	learning-function	22	information	17
risk assessment	57	subset simulation	30	failure probability	21	response-surface method	15
structural reliability analysis	56	safety	30	failure	21	cost	15
performance	48	systems	29	models	20	strategies	14
uncertainty	46	simulation	28	behavior	20	monte carlo simulation	14
system	44	reliability	28	construction	19	response-surface	13
optimization	43	construction safety	27	high dimensions	19	importance sampling	13

Notes: keyword is the name of the term; N-kw is the occurrence of the term.

The dominant keywords are related to the topic, its reliability analysis, management, structural reliability, risk management, risk assessment, structural reliability analysis, performance, uncertainty, system, optimization, risk mitigation, small failure probabilities, framework, impact, subset simulation, safety, systems, simulation, reliability, and construction safety.

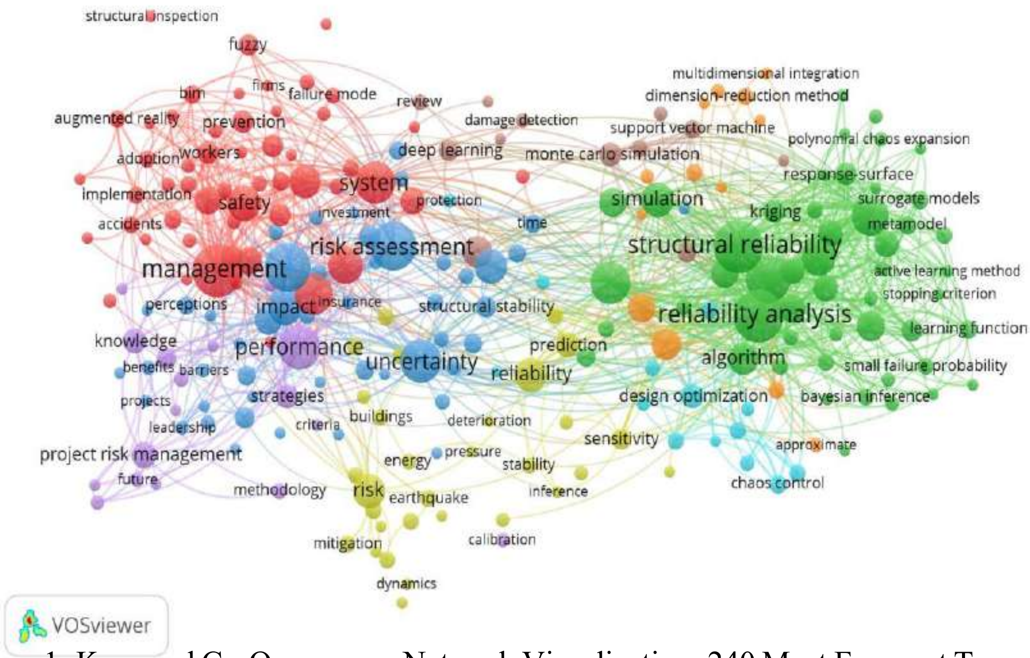

Figure 1- Keyword Co-Occurrence Network Visualization: 240 Most Frequent Terms in 39,680 Publications

If we consider separately the keywords of the authors themselves, then with a total number of 2,855 KW, 92 KW occur at least four times, while the total number of keywords plus (Keywords Plus) generated by the WoS platform is 1,724, and those encountered more than four times are 133.

Table 2- Comparison of the 30 most common keywords used by publication authors and WoS platform keywords

Author Keywords	**N-kw**	**Keywords Plus**	**N-kw**
reliability analysis	68	monte carlo simulation	14
structural reliability	66	importance sampling	13
risk management	59	safety	12
risk assessment	57	kriging	12
structural reliability analysis	56	project management	11
risk mitigation	41	deep learning	11
construction safety	26	uncertainty	10
machine learning	25	construction	10
risk	23	optimization	9
reliability	22	learning function	9
failure probability	20	small failure probability	8

active learning	18	bayesian inference	7
surrogate model	17	review	6
project risk management	17	bayesian active learning	4
kriging model	15	stopping criterion	4

The above table 2 presents the result of a comparison of the 30 most common keywords of publication authors and keywords of the WoS platform. It shows that authors often use more general terms to classify their publications: reliability analysis, structural reliability, risk management, risk assessment, structural reliability analysis, risk mitigation, construction safety, machine learning, risk, reliability, failure probability, active learning, surrogate model, project risk management, and kriging model.

The Web of Science (WoS) platform also generates a list of “Keywords Plus” based on the analysis of the full texts of publications. These terms often describe the topic from a broader perspective than the authors' original keywords. In this case, the dominant terms include management, small failure, probabilities, system, performance, framework, uncertainty, optimization, algorithm, subset simulation, impact, learning-function, high dimensions, simulation, failure, probability, systems, information, strategies, and knowledge, which collectively provide a deeper insight into the implementation of the themes addressed by the authors' keywords [3].

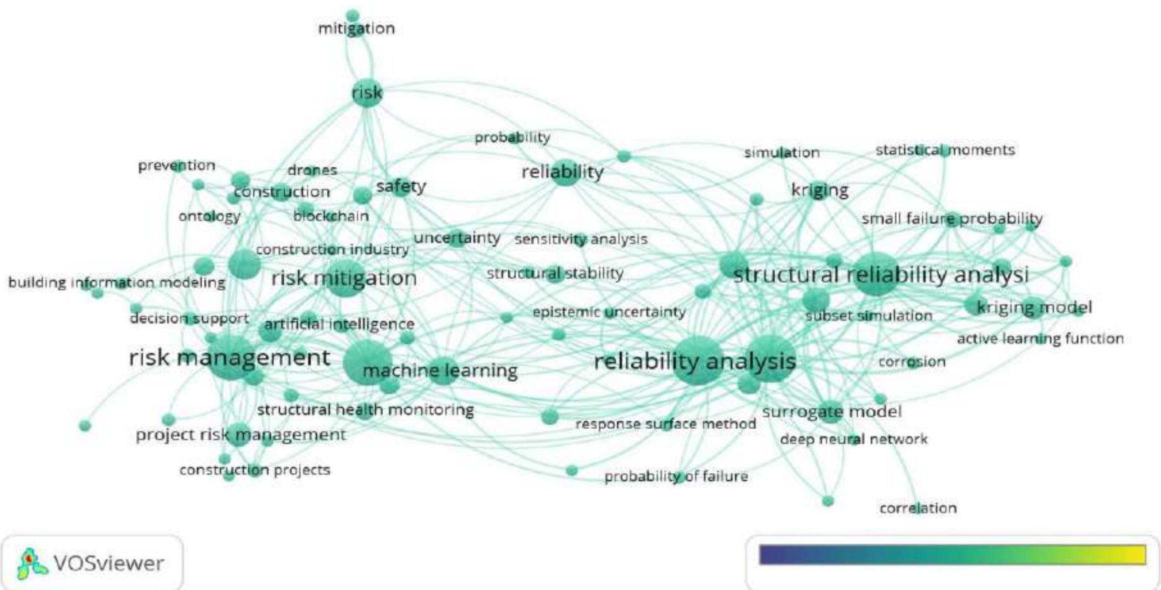

Figure 2- Overlay Visualization of 30 Most Common Keywords: Author-Assigned vs. WoS-Generated Terms

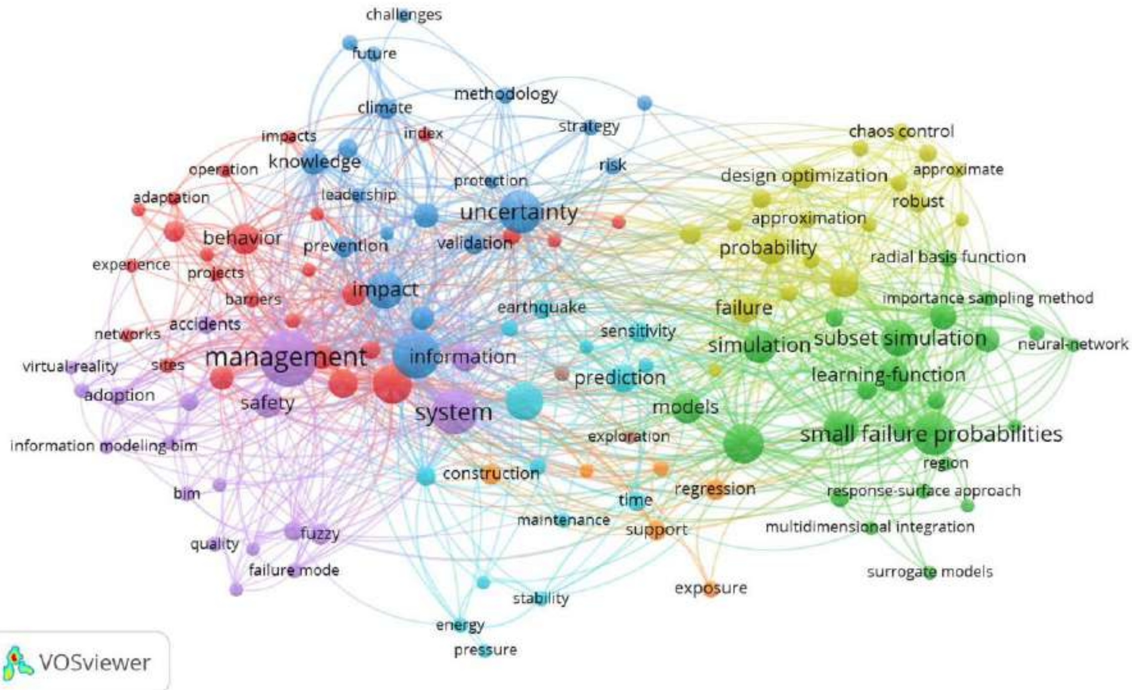

Figure 3- Keywords Plus Co-Occurrence Network Visualization: 133 Most Frequent in 39,680 Publications

This is also reflected in the clustering of author keywords, WoS platform keywords and the sum of these keywords. Clustering is based on the co-occurrence of keywords in a publication; the clustering algorithm is described in detail in the VOSviewer 1.6.15 user manual. Identification of the dominant keywords in each cluster allows us to reduce bias in the further collection of scientific publications on a narrower issue, for example, to compile a systematic review. A well-known problem of narrow specialists: they see their topic well, overestimate the importance of key terms close to them and tend to underestimate other people's topics. At the same time, a significant part of innovations is implemented at the intersection of research areas.

Risk management is increasingly recognized as a fundamental component in projects related to the technical inspection of the reliability and stability of buildings and structures. Construction projects are often exposed to complex risks, including structural failures, design errors, environmental factors, and operational uncertainties. Therefore, identifying, assessing, and mitigating risks is critical to ensure the safety, durability, and resilience of infrastructure. This analysis provides a detailed overview of the current state of research in this area, using bibliometric visualization through VOSviewer to highlight dominant keywords, clusters, and research directions. The purpose of this review is to provide insights into the prevailing themes, challenges, and opportunities in risk management for construction projects, while also identifying potential areas for future research.

The bibliometric analysis revealed a number of dominant keywords, including reliability analysis, structural reliability, risk assessment, risk mitigation, uncertainty, optimization, construction safety, performance, and machine learning. These terms represent both traditional approaches in engineering risk analysis and new technological trends shaping the field. For example, reliability analysis and structural monitoring have long been central to understanding the performance of buildings under different stressors. However, the rise of artificial intelligence and machine learning reflects the industry's shift toward more predictive and data-driven methodologies [4]. The visualization also revealed how clusters of research are interconnected, illustrating the interdisciplinary nature of risk management, where knowledge from engineering, project management, and data science converge.

One of the most important developments in the field is the increasing reliance on advanced simulation techniques to quantify risks. Traditional methods such as deterministic modeling often fail to capture the inherent uncertainties in construction projects. Advanced probabilistic methods, such as Monte Carlo simulation, subset simulation, and importance sampling, allow researchers and practitioners to evaluate the probability of failure under various conditions [5]. These methods have been particularly useful in situations involving rare events, such as structural collapse or extreme weather impacts, where failure probabilities are very small but have catastrophic consequences. By combining simulation with surrogate models and optimization algorithms, risk assessments can be performed more efficiently and with greater accuracy.

In parallel with these methods, machine learning and artificial intelligence (AI) are becoming integral to risk management in construction. Machine learning models can process vast amounts of structural, environmental, and operational data to detect early warning signs of failure. They can also be trained to improve decision-making processes in real time, reducing human error and improving safety outcomes [4]. Techniques such as deep learning and Bayesian inference are particularly promising, as they allow for adaptive learning from past project data, enabling continuous improvement of risk management frameworks.

Beyond technical innovations, safety and sustainability have emerged as major research priorities. The analysis highlighted that terms such as construction safety and environmental performance frequently appear alongside risk-related terms. This indicates a shift in focus from merely preventing accidents to creating long-term resilience and sustainability in construction projects. Effective risk management strategies now integrate environmental and social dimensions, ensuring that infrastructure not only meets safety standards but also contributes to sustainable urban development [6]. The integration of sustainable inspection methods, such as the use of drones for building monitoring or hybrid-electric equipment in construction, illustrates how risk management is evolving to address modern challenges.

Another key insight from this study is the value of systematic reviews and clustering of research keywords in advancing the field. Bibliometric methods help scholars and practitioners identify underexplored areas and emerging trends. For example, clusters around active learning, Bayesian inference, and digital inspection technologies represent cutting-edge directions that can significantly improve inspection reliability and efficiency [7]. Systematic reviews also reduce the bias that occurs when researchers focus narrowly on familiar concepts, thereby encouraging innovation across disciplines. Many of the most impactful advances in risk management are occurring at the intersection of engineering, data science, and management science.

From a broader perspective, this study reinforces the importance of interdisciplinary approaches to project risk management. Effective risk mitigation cannot be achieved by engineering solutions alone. It requires collaboration between structural engineers, project managers, data analysts, and policymakers. For example, the adoption of ISO 31000 (2018) risk management guidelines provides organizations with a comprehensive framework for integrating risk considerations into decision-making processes at every stage of a project [8]. Similarly, the use of digital inspection technologies such as sensors, Building Information Modeling (BIM), and Internet of Things (IoT) devices offers real-time monitoring of building performance, thereby reducing risks associated with undetected failures [9].

Finally, this study emphasizes that risk management in technical inspection is not only about preventing losses but also about creating opportunities for innovation and resilience. By incorporating advanced analytics, smart monitoring, and sustainable practices, organizations can enhance project outcomes, improve safety standards, and ensure the long-term stability of infrastructure. Moreover, the integration of risk management with sustainability goals highlights the role of construction projects in addressing broader societal challenges, such as climate change and urbanization [10].

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DIGITAL TRANSFORMATION OF SALES IN THE TELECOM SECTOR DEVELOPMENT AND IMPLEMENTATION OF CRM SYSTEMS USING FREEDOM MOBILE AS AN EXAMPLE DATA VISUALIZATION USING VOSVIEWER

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Annotation. *This research examines the digital transformation of sales in the telecommunications sector through the development and implementation of CRM systems, using Freedom Mobile as a case study. The study highlights the strategic importance of customer relationship management in increasing sales efficiency, improving customer experience, and supporting sustainable business growth in a competitive digital environment. Special emphasis is placed on the application of VOSviewerfor data visualization, which allows for the identification of key scientific trends, research clusters, and interconnections in the field of digital transformation and CRM. The findings demonstrate the practical significance of CRM adoption for telecom companies, showing how technological innovation fosters customer-oriented strategies and strengthens competitive advantages.*

Keywords.*Digital transformation; telecommunications sector; CRM systems; sales management; Freedom Mobile; customer experience; VOSviewer; data visualization.*

The digital transformation of sales plays a crucial role in reshaping the telecom sector, where customer-centric approaches and advanced technologies determine long-term success. One of the most effective tools in this transformation is the implementation of Customer Relationship Management (CRM) systems, which enable telecom companies to optimize customer data management, personalize services, and enhance overall sales efficiency [1]. This part focuses on Freedom Mobile as an example, examining how CRM solutions contribute to improving customer engagement, retention, and revenue generation. To gain deeper insights, we conducted a comprehensive review of scientific publications, identifying dominant keywords and clusters. The findings provide valuable perspectives on current research trends and practical strategies in the digitalization of telecom sales.

We exported metadata from 10,884 publications from the Web of Science (WoS) database using the following query: "TITLE: ("digital transformation" OR "digitalization" OR "ICT transformation" OR "digital sales" OR "sales digitalization" OR "telecom sales" OR "telecommunication sector" OR "telecom industry" OR "CRM" OR "customer relationship management" OR "CRM systems" OR "CRM implementation" OR "sales technology" OR "digital CRM" OR "CRM in telecom" OR "sales transformation" OR "customer engagement" OR "digital business strategy" OR "Freedom Mobile"), timespan: 2020–2024. Indexes: SCI - EXPANDED, SSCI, CPCI - S, ESCI. The construction of a network of co-occurrence of keywords and their clustering was carried out using the VOSviewer 1.6.15 program [2].

The minimum occurrence of keywords selected for consideration was four. The total number of keywords in the 10,884 publications considered (authors and Keywords Plus generated by WoS) is 3,539. The number of keywords that appear at least 4 times is 359, and further analysis was carried out on them.

During the analysis, the spellings of keywords were not translated into Russian in order to preserve their original meanings. To reduce the number of clusters into which keywords (KW) are aggregated, an additional restriction has been introduced: at least 100 KW per cluster.

Table 1 presents the digital transformation of sales in the telecom sector, with particular attention to the development and implementation of CRM systems using Freedom Mobile as an example. The visualization with VOSviewer illustrates how research and practical applications are interconnected, revealing patterns and connections in this area. It provides a comprehensive view of how studies contribute to advancing customer management practices, optimizing sales performance, and strengthening digital transformation strategies within the telecom industry.

Table 1- 40 most frequently occurring keywords in a sample of 10,884 metadata

Keyword	**N-kw**	**Keyword**	**N-kw**	**Keyword**	**N-kw**	**Keyword**	**N - kw**
digital transformation	226	brand engagement	67	scale development	42	artificial intelligence	33
customer engagement	179	behavior	67	service quality	41	information	33
impact	152	loyalty	66	information-technology	40	value co-creation	33
social media	117	framework	55	big data	39	business	31
customer relationship management	102	antecedents	53	adoption	38	systems	30
innovation	98	digitalization	53	word-of-mouth	36	consequences	27
satisfaction	94	consumer engagement	47	strategy	36	firm performance	26
performance	94	management	46	quality	35	actor engagement	25
model	83	dynamic capabilities	45	co-creation	35	capabilities	24
technology	70	experience	42	trust	34	online	23

Notes: keyword is the name of the term; N-kw is the occurrence of the term.

The dominant keywords are related to the topic, its digital transformation, customer engagement, adoption, impact, quality, social media, customer relationship management, innovation, satisfaction, performance, model, technology, brand engagement, behavior, loyalty, framework, antecedents, digitalization, consumer engagement, management, dynamic capabilities, experience.

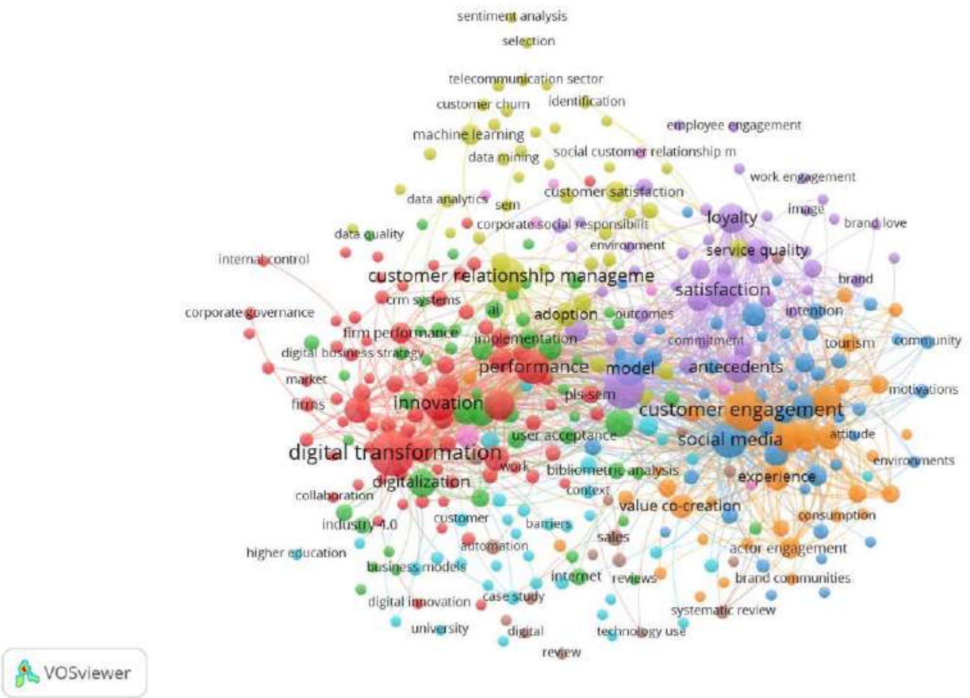

Figure 1- Keyword Co-Occurrence Network Visualization: 359 Most Frequent Terms in 10,884 Publications

If we consider separately the keywords of the authors themselves, then with a total number of 2,631 KW, 130 KW occur at least four times, while the total number of keywords plus (Keywords Plus) generated by the WoS platform is 1,239, and those encountered more than four times are 229.

Table 2- Comparison of the 30 most common keywords used by publication authors and WoS platform keywords

Author Keywords	**N-kw**	**Keywords Plus**	**N-kw**
digital transformation	226	irm performance	12
customer engagement	178	digital technologies	12
customer relationship management	93	digital economy	12
social media	58	marketing	11
digitalization	53	digitization	11
crm	52	digital marketing	10
artificial intelligence	33	big data	10
machine learning	24	loyalty	10

customer satisfaction	23	systematic review	9
customer loyalty	18	brand engagement	8
customer experience	15	technology	8
service quality	14	relationship marketing	7
innovation	14	augmented reality	7
bibliometric analysis	14	digital technology	7
trust	12	e-crm	6

The above table 2 presents the result of a comparison of the 30 most common keywords of publication authors and keywords of the WoS platform. It shows that authors often use more general terms to classify their publications: digital transformation, digitization, customer engagement, customer relationship management, big data, social media, digitalization, crm, artificial intelligence, machine learning, customer satisfaction, customer loyalty, customer experience, service quality, innovation, bibliometric analysis, and trust.

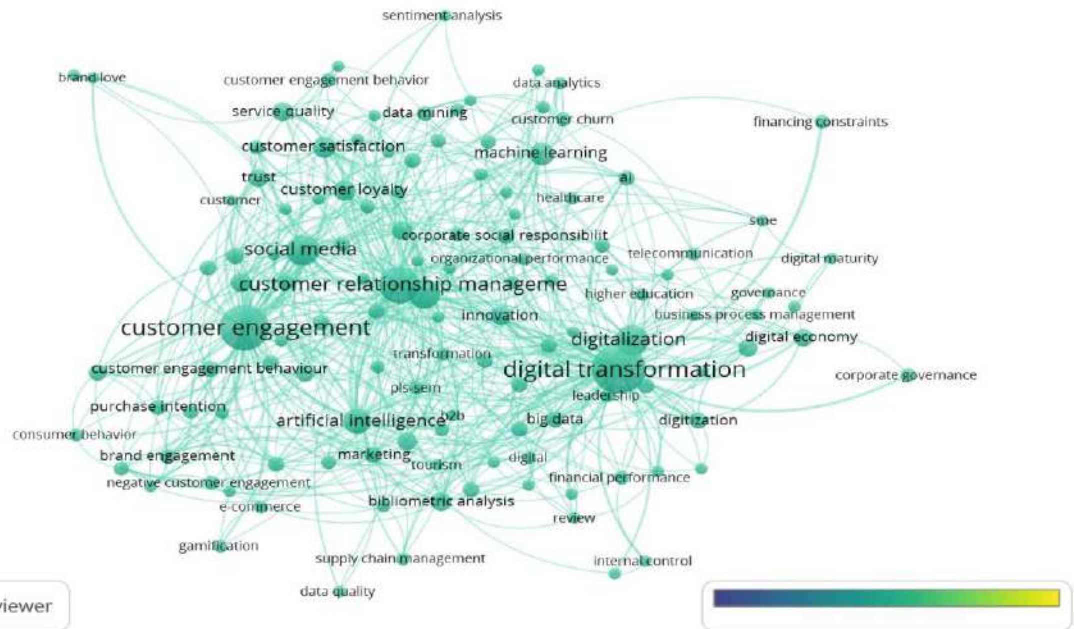

Figure 2- Overlay Visualization of 30 Most Common Keywords: Author-Assigned vs. WoS-Generated Terms

The Web of Science (WoS) platform also generates a list of “Keywords Plus” based on the analysis of the full texts of publications. These terms often describe the topic from a broader perspective than the authors' original keywords. In this case, the dominant terms include: impact, satisfaction, performance, model, innovation, behavior, social media, brand engagement, antecedents, loyalty, technology, consumer engagement, experience, framework, scale development, word-of-mouth, co-creation, dynamic, capabilities, information-technology, adoption, which collectively provide a deeper insight into the implementation of the themes addressed by the authors' keywords [3].

This is also reflected in the clustering of author keywords, WoS platform keywords and the sum of these keywords. Clustering is based on the co-occurrence of keywords in a publication; the clustering algorithm is described in detail in the VOSviewer 1.6.15 user manual. Identification of the dominant keywords in each cluster allows us to reduce bias in the further collection of scientific publications on a narrower issue, for example, to compile a systematic review. A well-known problem of narrow specialists: they see their topic well, overestimate the importance of key terms close to them and tend to underestimate other people's topics. At the same time, a significant part of innovations is implemented at the intersection of research areas.

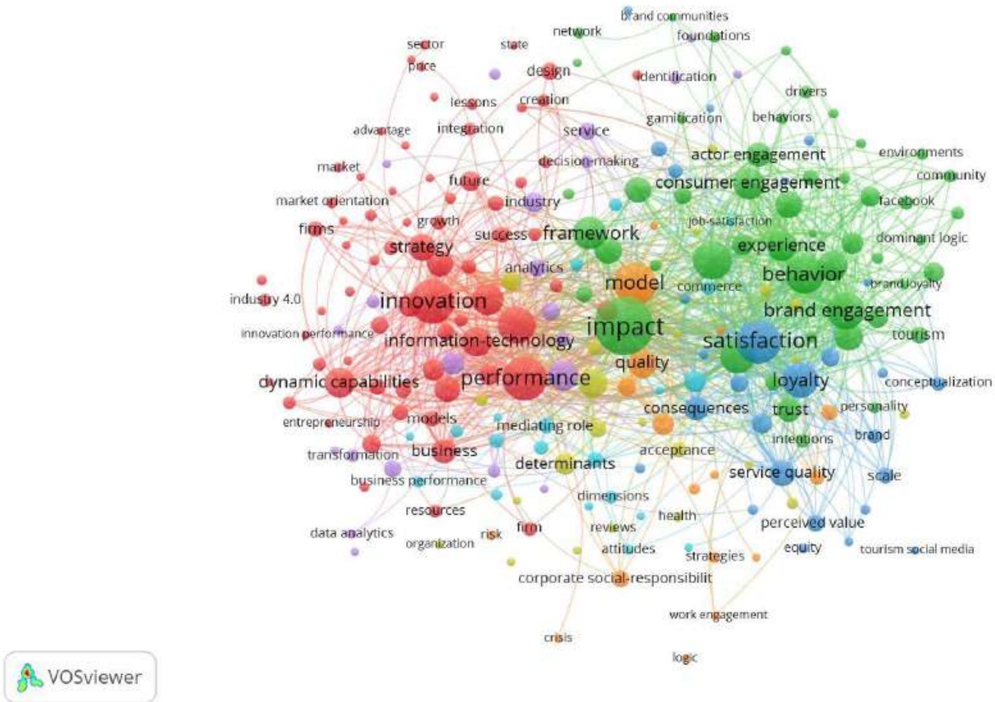

Figure 3 - Keywords Plus Co-Occurrence Network Visualization: 229 Most Frequent in 10,884 Publications

This analysis provides a comprehensive review of the digital transformation of sales in the telecom sector, with a specific focus on the development and implementation of Customer Relationship Management (CRM) systems using Freedom Mobile as an example. The study emphasizes that digital transformation is reshaping the telecom industry, where success increasingly depends on data-driven strategies, personalized customer experiences, and advanced technological integration [4]. CRM systems play a pivotal role in this transformation, enabling telecom operators to effectively collect, store, and analyze customer data, enhance loyalty programs, and improve overall sales performance.

To gain deeper insights, we conducted a bibliometric analysis of 10,884 publications indexed in the Web of Science database, applying VOSviewer for keyword co-occurrence visualization [5]. The clustering of dominant keywords revealed several interconnected research domains. The first cluster focused on digital transformation and customer engagement, highlighting the importance of interactive and customer-centric sales models. The second cluster concentrated on CRM systems and innovation, reflecting how technology adoption improves service quality and organizational agility. The third cluster captured big data, artificial intelligence, and machine learning, showcasing the rising role of advanced analytics in predicting consumer behavior and optimizing resource allocation. A final cluster highlighted social media and trust, demonstrating how digital platforms strengthen or undermine long-term customer relationships [6].

Our findings indicate that the implementation of CRM solutions in the telecom sector extends beyond technology, it represents a cultural and strategic shift. For example, Freedom Mobile's adoption of digital CRM practices illustrates how customer profiling, predictive analytics, and automation tools can directly increase retention rates and revenue generation [7]. Furthermore, integrating big data and AI into CRM systems supports more precise segmentation, targeted marketing, and proactive service delivery, which are crucial for competitiveness in saturated telecom markets [8].

The study also shows that digital transformation in telecom is highly interdisciplinary, requiring a combination of management science, information technology, and marketing expertise. Effective digital strategies must not only integrate CRM systems but also align them with broader digital business strategies, emphasizing sustainability, scalability, and long-term adaptability [9]. Additionally, the importance of transparency, data security, and customer trust emerged as critical enablers of CRM adoption, particularly as telecom companies expand their engagement with customers through social media and omnichannel platforms [10].

Overall, this research contributes to a deeper understanding of the interaction between CRM, sales transformation, and digital technologies in the telecom sector. It provides valuable insights for both academics and practitioners, supporting the design of systematic reviews and practical roadmaps for telecom operators seeking to optimize sales performance, strengthen customer loyalty, and sustain digital competitiveness in a rapidly evolving marketplace.

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СОЗДАНИЕ ЭФФЕКТИВНЫХ УСЛОВИЙ ДЛЯ РАЗВИТИЯ ПРОЦЕССОВ ЦИФРОВИЗАЦИИ СОЦИАЛЬНО-ЭКОНОМИЧЕСКОЙ СФЕРЕ РЕСПУБЛИКИ КАЗАХСТАН

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Современное общество в условиях глобализации мировой экономики характеризуется очередным этапом внедрения информационных компьютерных технологий во все сферы жизни, которые меняют уклад жизни людей и составляют фундамент и материальную базу для перехода к информационному обществу, обществу с высоким социально-экономическим, политическим и культурным развитием.

В мире повсеместно наблюдаются такие тенденции, как: трансформация всех общественных институтов и сфер человеческой деятельности под воздействием ИКТ; прогресс во всех сферах разработки, производства и внедрения современных технологий; стремление к формированию развитой информационной среды, адекватной задачам социально-экономического развития страны; обеспечение равноправного гарантированного доступа населения к информационным ресурсам; подготовка граждан, общественных институтов, бизнеса и органов государственной власти всех уровней к жизни в условиях информационного общества.

В большинстве передовых стран мира, таких как, например, Канада, Корея, Сингапур, США, разработаны и реализуются стратегии или комплексные программы информационного развития как общества в целом, так и отдельных сфер деятельности.

В отличие от других способов инновации, цифровизация опирается на одновременное развитие многих технологий, среди которых: телекоммуникационные сети (мобильные или стационарные), компьютерные технологии (компьютеры, ноутбуки, беспроводные планшеты), программная инженерия (операционные системы, машинное обучение, искусственный интеллект), а также последствия их использования (общие платформы для разработки приложений, электронная доставка госуслуг, электронная коммерция, социальные сети, а также доступность информации на форумах, блогах и порталах).

Внедрение таких технологий ведет к массивным, взрывным изменениям, подобно тому, что было после распространения паровых машин, электричества и железных дорог по всему Земному шару, так что изменились и экономика, и общество [1].

Внедрение цифровых технологий в нашу жизнь, с одной стороны, очевидно, с другой - ее влияние на социальную и экономическую ситуацию в обществе пока неясно и пока нет ясного понимания, что внесет повсеместное внедрение цифровых технологий в жизнь общества.

Цифровые трансформации позволяют автоматизировать многие операции в производстве и распространении продукции, так что возрастает эффективность производства и сокращаются транзакционные расходы. С другой стороны, цифровизация открывает новые возможности для бизнеса, оказывая влияние на подбор кадров и методы их работы. Предоставление услуг государственными органами способствует доступу большего числа людей к системам здравоохранения и образования и в то же время улучшает каналы связи между населением и управляющими органами. Наконец, цифровая трансформация оказывает влияние на поведение людей и их взаимоотношения, способствуя социализации людей и облегчению их коммуникаций.

В связи с этим в обществе появились надежды на то, что с помощью цифровых технологий можно решить такие сложные социальные проблемы, как снижение уровня безработицы, борьба с бедностью, деградация окружающей среды.

По данным многих исследователей, попытки государств использовать преимущества цифровых технологий сосредоточиваются на развитии соответствующих отраслей промышленности [2; 3]. К.А. Семячков указывает, что в целом государства принимают однотипные меры, среди которых наиболее популярны: развитие инфраструктуры, представляющей основу для формирования новых моделей ведения бизнеса и построения научных и социальных сетей; снижение барьеров в отраслях цифровой экономики; повышение уровня владения цифровыми технологиями, обучение и переквалификация специалистов; обеспечение доверия к надежности и безопасности цифровой инфраструктуры, оценка рисков; развитие цифрового сектора экономики [4].

Однако следует отметить, что цифровая трансформация может также принести потенциально негативный эффект, например, привести к сокращению числа рабочих мест и разорению компаний, и уходу их из бизнеса, к кибер-преступности и к социальной аномии (этим словом обозначается разрушение традиционных устоев, крах человеческих личностей).

По мере развития информационных технологий исследователи отмечают изменения в их воздействии на производство и на общество в целом. Социологи отмечают, что в воздействии цифровой трансформации на общество проявляются приливы и отливы, некоторая волнообразность, которая зависит, прежде всего, от технологического прогресса и распространения инноваций [5].

Цифровая трансформация Республики Казахстан к 2025 году является ключевым элементом государственной политики, направленной на формирование эффективной модели цифрового государства. В последние годы предпринимается целенаправленная работа по модернизации государственного управления, экономики и социальной сферы посредством внедрения цифровых технологий.

Базовым документом в данной сфере выступает Концепция цифровой трансформации Республики Казахстан на 2023–2029 годы, в которой определены стратегические цели и ожидаемые результаты на среднесрочный период. В числе целевых ориентиров к 2025 году обозначены: обеспечение 60 % государственных услуг в формате «за 5 минут», оцифровка 60 % внутренних процессов госорганов, рост экспорта ИТ-продуктов до 210 млрд тенге, подготовка 35 тысяч ИТ-специалистов, а также достижение 80 % охвата населения по показателю цифровой гигиены [6].

Кроме того, в Стратегическом плане развития Казахстана до 2025 года подчёркивается важность цифровизации как системного фактора устойчивого роста. Среди ключевых задач — увеличение доли онлайн-экономики до 2,3 % ВВП, повышение расходов на НИОКР до 1 % ВВП и рост доходов от интеллектуальной собственности до 25 %. Также обозначена цель вхождения Казахстана в топ-25 стран мира по уровню цифрового развития согласно индексу ООН [7].

По состоянию на 2025 год достигнуты существенные результаты. Так, в 2024 году Казахстан занял 24-е место в Индексе развития электронного правительства ООН, опередив ряд развитых государств, включая Германию и Китай. Более 92 % государственных услуг предоставляются онлайн, а совокупное число пользователей портала eGov и мобильного приложения превысило 14,7 млн человек, из которых более 11 млн являются активными пользователями [8].

Особое внимание уделяется развитию искусственного интеллекта (ИИ). В 2024 году была принята концепция развития ИИ до 2029 года, в рамках которой в 2025 году запущен первый национальный суперкомпьютер — крупнейший в Центральной Азии. Он стал основой для создания общедоступной AI-платформы, предоставляющей ресурсы для университетов, научных институтов и технологических стартапов. Параллельно ведётся работа по разработке закона об ИИ и созданию консультативного совета при Президенте [9].

Важным шагом стало внедрение платформенной модели цифровизации посредством запуска национальной технологической платформы QazTech, которая позволяет сокращать срок разработки и внедрения цифровых решений с 2–3 лет до 6 месяцев. Платформа стандартизирует архитектуру, обеспечивает информационную безопасность и даёт возможность более гибкого взаимодействия между государственными структурами [10].

В рамках обеспечения цифровой инфраструктуры в 2025 году к широкополосному интернету подключаются 328 удалённых населённых пунктов с применением спутниковых технологий. Планируется, что к 2027 году уровень мобильного охвата достигнет 99 %, а к 2030 году будет запущено 10 дата-центров уровня Tier III. Общий объём инвестиций в ИКТ-инфраструктуру превысит 1,3 трлн тенге [11].

Для укрепления цифрового суверенитета государство реализует переход на использование отечественного программного обеспечения. С 2025 года национальный мессенджер Aitu внедряется во всех государственных и силовых структурах как приоритетное средство внутренней коммуникации [12].

Казахстан к 2025 году демонстрирует высокую степень цифровой зрелости. Последовательное выполнение стратегических программ, активное внедрение ИИ, развитие цифровой инфраструктуры и платформенных решений, а также цифровизация госуслуг создают условия для формирования эффективной цифровой экономики и устойчивого технологического развития страны в долгосрочной перспективе.

Цифровая трансформация в Казахстане реализуется в рамках стратегической программы, ориентированной на формирование устойчивой цифровой экономики и современного, эффективного государства. Программа строится на пяти ключевых направлениях, каждое из которых решает как текущие задачи, так и обеспечивает долгосрочный технологический суверенитет страны.

1. Цифровизация отраслей экономики направлена на внедрение сквозных и прорывных технологий — таких как IoT, большие данные, машинное обучение, роботизация — в ключевые сектора: промышленность, сельское хозяйство, транспорт и энергетику. Это соответствует международной концепции Индустрия 4.0 и предполагает резкое повышение производительности труда, снижение транзакционных издержек, а также рост инвестиционной привлекательности и капитализации предприятий. Внедрение цифровых двойников, автоматизированного управления и интеллектуальной логистики способствует укреплению конкурентоспособности казахстанской экономики.

2. Переход на цифровое государство отражает системные изменения в подходе к государственному управлению. Проактивные госуслуги, развитие Open API, отказ от бумажного документооборота и повсеместное внедрение цифровых удостоверений личности трансформируют государство в сервисную платформу. В центре этой трансформации — гражданин, который получает доступ к услугам в цифровой среде быстро, безопасно и без необходимости физического взаимодействия. Это позволяет повысить уровень доверия к государству, снизить коррупционные риски и повысить институциональную прозрачность.

3. Реализация цифрового Шёлкового пути направлена на развитие надёжной, высокоскоростной и защищённой цифровой инфраструктуры. Казахстан, расположенный между Европой и Азией, выступает важным транзитным узлом, и усиление его роли как цифрового моста позволяет интегрироваться в глобальные каналы обмена данными. Строительство магистральных линий передачи данных, развитие дата-центров и киберустойчивой инфраструктуры создаёт предпосылки для экспорта цифровых услуг и хостинга региональных ИТ-решений.

4. Развитие человеческого капитала охватывает повышение цифровой грамотности населения, внедрение программ ИКТ-образования в школах и вузах, а также культивирование креативного и предпринимательского мышления. Особое внимание уделяется подготовке кадров для ИТ-сектора, инженерных и аналитических профессий. Современная цифровая экономика требует не только технической подготовки, но и гибких навыков — критического мышления, способности к междисциплинарному взаимодействию и адаптации к постоянным технологическим изменениям.

5. Создание инновационной экосистемы представляет собой формирование среды, благоприятной для технологического предпринимательства и венчурных инвестиций. Ядром этой экосистемы выступает международный технопарк Astana Hub, предоставляющий стартапам доступ к инфраструктуре, менторской поддержке и налоговым льготам. Также развиваются механизмы поддержки R&D, создание венчурных фондов, акселераторов и инкубаторов. Это позволяет не только стимулировать внутренние инновации, но и привлекать зарубежные ИТ-компании и таланты.

Данные направления формируют целостную архитектуру цифровой трансформации Казахстана — от экономики и государства до человека и инновационного пространства. Их реализация закладывает прочный фундамент для построения конкурентоспособной, устойчивой и инклюзивной цифровой нации. В таблице 1 показано сравнение мировой практики с Казахстаном.

Таблица – Сравнение мировой практики с Казахстаном

Направление	Мировая практика (примеры)	Казахстан — статус на 2025 год
Цифровые ID и идентификация	Эстония (ID-карта), Сингапур (SingPass)	eGov ID, платформа eGov и eGov Mobile, охват ~14,7 млн пользователей
Количество онлайн-услуг	Эстония 99 %, ОАЭ 99 %, Сингапур 90 %	Более 92 % госуслуг доступны онлайн; 1200+ сервисов через eGov
Платформенная модель	Австралия, Дания, Украина, СНГ модели	QazTech — единая цифровая технология, снижение сроков внедрения до 6 месяцев
Инфраструктура и охват	Эстония 24/7 онлайн, Сингапур массовая автоматизация	Подключение 328 удалённых пунктов, масштабные ИКТ-инвестиции
ИИ и аналитика	Дания — интеграция AI, Австралия — выгоды от данных	Концепция ИИ до 2029, суперкомпьютер, AI-платформа на старте
Управление инвестициями	Австралия — Benefit Management Policy, BuyICT	Казахстан пока без формального механизма оценки эффективности
Участие граждан	Дания (Borgerforslag), Сингапур high trust	Развитие eGov, но инструменты вовлечения граждан можно усилить
Платежные решения	Шри-Ланка (GovPay), Индия (Aadhaar ecosystem)	В стране используется e-gov платежи, но специализированных платформ пока нет
Оценка и индексирование	OECD показывают лидеров как СК, Дания, Великобритания	Казахстан участвует, но позиция не на уровне лидеров OECD

Анализ мировой практики цифровых преобразований показывает, что ведущие страны добились устойчивых результатов благодаря системному подходу к цифровому управлению, высокой степени вовлечённости граждан и эффективному использованию данных. Казахстан в этом контексте демонстрирует уверенное развитие и стремление к интеграции в глобальное цифровое пространство, но сохраняется ряд направлений, где возможны качественные улучшения.

В сфере цифровой идентификации Казахстану удалось охватить значительное количество граждан через платформу eGov ID и мобильное приложение eGov Mobile. Однако, по сравнению с передовыми решениями таких стран, как Эстония (где цифровая ID полностью заменяет бумажные документы и используется для голосования, здравоохранения и бизнеса) или Сингапур (где цифровая идентичность интегрирована в повседневные процессы и дополняется биометрическими технологиями), казахстанская система требует дальнейшего развития, в том числе в вопросах универсальности и правовой интеграции.

По доступности онлайн-услуг Казахстан приближается к лидерам: более 92 % государственных сервисов доступны в цифровом формате. Это сопоставимо с ОАЭ, Эстонией и Сингапуром, где этот показатель достигает 99 %. Однако в части проактивности (предоставление услуг до обращения гражданина) Казахстану ещё предстоит реализовать полноценные механизмы персонализированной цифровой помощи на базе ИИ и больших данных.

Развитие платформенной модели управления, представленное запуском QazTech, является значительным шагом вперёд. Эта модель позволяет существенно сократить сроки внедрения ИТ-решений, обеспечивая масштабируемость и стандартизацию процессов — подход, схожий с тем, что применяется в Австралии, Великобритании и Украине. Подобная архитектура создает предпосылки для устойчивого и гибкого цифрового развития.

В вопросах инфраструктурного охвата Казахстан последовательно расширяет доступ к широкополосному интернету в отдалённых населённых пунктах, применяя спутниковые технологии и масштабные инвестиции в ИКТ. Однако важно дополнительно учитывать опыт стран с высокой плотностью цифрового покрытия (например, Сингапура или Южной Кореи), где параллельно развиваются цифровые навыки населения и создаются интеллектуальные сервисы в реальном времени.

Отдельного внимания заслуживает развитие искусственного интеллекта**.** Казахстан — одна из немногих стран СНГ, имеющая концепцию по ИИ, собственный суперкомпьютер и платформу для исследовательской деятельности. Это приближает страну к таким государствам, как Дания или Южная Корея, где ИИ интегрируется в государственные процессы, включая принятие решений, аналитику и планирование.

Тем не менее, в сфере управления цифровыми инвестициями Казахстану пока не хватает институционализированной системы оценки эффективности цифровых проектов (по примеру Австралии и её политики Benefit Management). Это ограничивает возможности для стратегической приоритизации и контроля возврата инвестиций.

Низкая вовлечённость граждан в цифровые процессы также является уязвимостью. Тогда как Дания, Эстония и Украина активно используют цифровые платформы обратной связи, электронные петиции и вовлечение в государственные инициативы, Казахстан только начинает формировать такие механизмы.

Отсутствие специализированной государственной платёжной платформы также отличает Казахстан от стран, где такие решения (GovPay в Шри-Ланке, IndiaStack в Индии) обеспечивают прозрачность, борьбу с коррупцией и эффективность фискального администрирования.

Наконец, в контексте международной индексации, Казахстан делает заметные шаги, участвуя в рейтингах ООН, однако пока не входит в группу стран-лидеров по индексу OECD или Digital Nations. Это может стать ориентиром для дальнейшего совершенствования государственной цифровой политики.

Казахстан демонстрирует динамичное и комплексное развитие цифрового сектора, успешно реализуя ключевые проекты в области электронного правительства, инфраструктуры и ИИ. В то же время сравнение с международной практикой показывает необходимость углубления реформ в области цифровой идентификации, оценки инвестиций, проактивного обслуживания и гражданского участия. Опора на лучшие мировые практики позволит Казахстану выйти на новый уровень цифровой зрелости и устойчивости в условиях глобальной технологической трансформации.

Цифровая трансформация сегодня стала неотъемлемой частью национальной стратегии устойчивого развития Казахстана. Однако для её успешной реализации необходимо не только наличие технологий, но и создание комплексных, благоприятных условий, охватывающих законодательную, институциональную, инфраструктурную и культурную среды. Именно эти условия формируют основу, на которой возможен качественный скачок в цифровом развитии.

В первую очередь, развитие цифровой инфраструктуры - один из важнейших факторов ускорения цифровизации. Наличие стабильного широкополосного интернета, развитие мобильных сетей и внедрение новых технологий, таких как 5G, позволяют обеспечить равный доступ к цифровым услугам по всей территории страны, включая отдалённые и сельские районы. В этом направлении Казахстан уже предпринимает шаги: реализуются масштабные проекты по подключению более 300 сельских населённых пунктов, запускаются национальные дата-центры и платформы, такие как QazTech.

Также важнейшим условием выступает наличие гибкой и современной нормативно-правовой базы. Для цифровой трансформации необходимо устранение регуляторных барьеров и создание прозрачных, стимулирующих механизмов, которые позволяют внедрять инновационные решения без излишнего административного давления. Казахстан в последние годы активизировал работу по цифровому законодательству, включая разработку нормативной базы по искусственному интеллекту и кибербезопасности, однако по оценке OECD, стране ещё предстоит усилить конкуренцию на телекоммуникационном рынке и модернизировать институциональные подходы к регулированию ИКТ.

Создание благоприятной среды невозможно без формирования цифровой культуры и цифровых навыков среди населения и бизнеса. Сегодня только около 11 % предприятий Казахстана активно используют цифровые технологии. Это свидетельствует о необходимости дальнейшего стимулирования цифровизации малого и среднего бизнеса, повышения уровня цифровой грамотности, а также популяризации новых моделей ведения бизнеса - от e-commerce до автоматизированных производств.

Ключевую роль играет поддержка инновационной экосистемы. В этом направлении Казахстан развивает технопарки, такие как Astana Hub, предоставляет налоговые льготы и инфраструктурную поддержку стартапам. Однако для масштабного эффекта необходимо усилить механизмы доступа к финансированию, интеграции с глобальными рынками и сопровождения цифровых проектов на всех стадиях развития.

Наконец, цифровая трансформация напрямую влияет на качество жизни граждан. Современные государственные цифровые сервисы позволяют упростить доступ к образованию, здравоохранению, социальным и финансовым услугам. Благодаря национальной платформе eGov и мобильным приложениям, более 92 % госуслуг уже предоставляются онлайн, что значительно снижает бюрократическую нагрузку и повышает прозрачность.

Таким образом, создание благоприятных условий для цифровой трансформации - это не просто вспомогательная мера, а необходимая основа, от которой зависит успех цифрового развития. Это включает не только технологии, но и устойчивую инфраструктуру, гибкое законодательство, поддержку предпринимательства, развитие человеческого капитала и институциональную готовность. Без этих факторов цифровая трансформация рискует остаться точечным явлением, а не системным механизмом повышения конкурентоспособности Казахстана и качества жизни его граждан.

Цифровизация в Казахстане переходит от стадии внедрения базовых электронных решений к построению целостной цифровой экосистемы. На фоне глобальной технологической конкуренции и региональных вызовов, страна стремится не только догонять, но и в отдельных направлениях — опережать общемировые тренды. В этом контексте перспективы цифрового развития РК можно охарактеризовать через несколько ключевых направлений.

Переход к «цифровому-by-default» Государственные и бизнес-процессы всё активнее переходят в цифровой формат. Перспективно — развитие проактивных услуг (услуг без запроса), расширение использования цифровых удостоверений, биометрии и автоматизированных решений в госуправлении. Это позволит окончательно отказаться от бумажного документооборота, усилить прозрачность и доверие между государством и гражданами.

Углубление индустриальной цифровизации (Индустрия 4.0) Внедрение умных производств, цифровых двойников, предиктивной аналитики и IIoT (Интернет вещей в промышленности) создаёт возможности для качественного роста производительности труда и снижения затрат. Сектора с наибольшим потенциалом — горнорудная отрасль, сельское хозяйство, энергетика и транспорт.

Развитие искусственного интеллекта (ИИ). С учётом утверждённой до 2029 года Концепции по развитию ИИ, Казахстан имеет возможность занять региональную нишу в этой сфере. При наличии национальной AI-платформы, суперкомпьютера и набора специализированных данных, перспективно масштабировать ИИ в госуслугах, медицине, образовании и экономическом прогнозировании.

Экспорт цифровых решений и сервисов. На фоне усиления роли Казахстана как «цифрового моста» между Европой и Азией, ожидается рост экспорта ИТ-услуг, программного обеспечения и цифровых решений. Astana Hub уже формирует стартап-экосистему с глобальными амбициями, и при условии создания благоприятных правил для инвесторов и разработчиков, экспорт цифровых технологий может стать драйвером ВВП.

Развитие человеческого капитала и цифровой инклюзии Цифровая грамотность и ИКТ-компетенции становятся обязательными не только для молодёжи, но и для всего трудоспособного населения. Перспективно внедрение онлайн-образования нового поколения, программ переподготовки, а также усиление STEAM-направлений в школах. Важно также обеспечить цифровое равенство - доступ к ИКТ в сельских и уязвимых сообществах.

Устойчивое и безопасное цифровое пространство Рост цифровизации требует усиления кибербезопасности, цифрового суверенитета и устойчивости к внешним угрозам. Казахстану предстоит продолжить разработку и внедрение стандартов цифровой этики, цифровых прав и защиты данных, особенно в контексте развития ИИ и больших данных.

Перспективы цифровизации в Казахстане обнадеживают: сформированы стратегические ориентиры, развиваются институты, создана нормативная база. Однако дальнейший успех зависит от системной реализации проектов, подготовки кадров, стимулирования инноваций и международной интеграции. В условиях глобальной цифровой конкуренции Казахстан имеет шанс не только сократить цифровой разрыв, но и стать технологическим лидером в регионе Центральной Азии.

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ПРАКТИКА ПРИМЕНЕНИЯ ЦИФРОВЫХ АНАЛИТИЧЕСКИХ РЕШЕНИЙ В УПРАВЛЕНИИ ЛИКВИДНОСТЬЮ ПРЕДПРИЯТИЯ

КАЛИМОЛДИНОВА ДИЛЬНАЗ КАЙРАТОВНА
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Аннотация: *В статье рассмотрены практические аспекты применения цифровых аналитических решений в системе управления ликвидностью предприятия. Раскрываются современные подходы к управлению ликвидностью, основанные на использовании бизнес-аналитики, искусственного интеллекта и связанных цифровых технологий. Проведен анализ отечественного и зарубежного опыта, отражающий преимущества внедрения данных инструментов для повышения точности прогнозирования денежных потоков и эффективности управления оборотным капиталом. Авторами обобщены ключевые тенденции (включая рост доли компаний, использующих цифровые решения), а также обозначены проблемы и риски, сопутствующие цифровизации финансового анализа. Представлены сравнительные характеристики традиционных и цифровых подходов к управлению ликвидностью, а также приведены примеры результатов их применения. Отмечается специфика влияния цифровизации на оценку ликвидности и платежеспособности. В заключение сформулированы выводы о влиянии цифровых аналитических решений на финансовую устойчивость компании и рекомендации по их эффективному использованию.*

Ключевые слова: *ликвидность; управление ликвидностью; цифровая аналитика; финансовый анализ; бизнес-аналитика; искусственный интеллект; денежные потоки*

Введение. Управление ликвидностью предприятия представляет собой деятельность по обеспечению платежеспособности организации путем поддержания достаточного объема денежных средств и других легко реализуемых активов для своевременного выполнения финансовых обязательств. Иными словами, ликвидность отражает способность компании генерировать необходимый денежный поток для покрытия текущих платежей, что является непременным условием ее финансовой устойчивости [1, с. 213]. В классической теории финансового менеджмента управление ликвидностью относится к сфере управления оборотным капиталом и краткосрочной финансовой политике предприятия. Оно требует балансирования между риском и доходностью: поддержание более высокого уровня ликвидных средств снижает риск неплатежеспособности, но одновременно может приводить к уменьшению прибыли из-за отвлечения ресурсов от инвестирования в развитие [1, с. 418]. Таким образом, эффективно управлять ликвидностью – значит поддерживать оптимальное соотношение между ликвидными активами и обязательствами, обеспечивая *солвентность* компании при одновременном сохранении рентабельности ее деятельности.

Традиционно инструменты управления ликвидностью включают анализ финансовых коэффициентов (таких как коэффициенты текущей, быстрой, абсолютной ликвидности), планирование и прогнозирование денежных потоков, управление оборотным капиталом (дебиторской и кредиторской задолженностью, запасами), а также использование краткосрочных заемных ресурсов и кредитных линий при необходимости [2, с. 187–195]. Классический подход предполагает регулярный (как правило, месячный или квартальный) анализ ликвидности на основе данных бухгалтерской отчетности и бюджета денежных средств. Однако в условиях современной экономики, характеризующейся возросшей волатильностью рынков и быстрым изменением внешних факторов, пассивный и периодический подход к ликвидности становится недостаточно эффективным [3, с. 12]. Как отмечают Д.В. Альбрант и др., ликвидность и платежеспособность относятся к ключевым признакам финансовой устойчивости предприятия [4, с. 12], но методы их оценки и поддержки требуют пересмотра с учетом цифровизации экономики.

Цифровая трансформация бизнес-процессов затрагивает и сферу финансового менеджмента. Появляются новые возможности для более точного и оперативного управления денежными потоками за счет внедрения цифровых аналитических решений – специализированных программных продуктов и технологий анализа данных. Под цифровыми аналитическими решениями в управлении ликвидностью понимается совокупность инструментов бизнес-аналитики, методов обработки больших данных, алгоритмов искусственного интеллекта и других IT-решений, применяемых для планирования, мониторинга и оптимизации показателей ликвидности компании [5, с. 90–97]. Их использование позволяет автоматизировать сбор и обработку финансовых данных, осуществлять прогнозирование денежных потоков в режиме реального времени, проводить многовариантные сценарные расчеты и заблаговременно выявлять потенциальные разрывы ликвидности. В результате управление ликвидностью приобретает проактивный характер: финансовые службы могут не только реагировать на возникновение кассовых разрывов, но и предугадывать их и предпринимать превентивные меры. Это особенно важно в современной нестабильной макроэкономической среде, где резкие колебания цен, рост процентных ставок и другие факторы повышают требования к прозрачности и гибкости управления денежными ресурсами [6].

Следует подчеркнуть, что интерес к цифровизации функций финансового управления постоянно растет. Согласно данным Росстата, уже в 2022 году свыше 40% российских компаний использовали те или иные цифровые решения в сфере финансового анализа и управления финансами [5, с. 103–109]. К 2025 году эта доля увеличилась до 58% за счет активного внедрения систем автоматизированной обработки данных и бизнес-аналитики. Тем не менее уровень применения наиболее продвинутых технологий пока остается относительно невысоким: например, лишь около 7% организаций сообщили о практическом использовании алгоритмов искусственного интеллекта для финансового анализа [5, с. 135–143]. Для сравнения, в глобальной практике корпоративного казначейства наблюдается стремительный рост интереса к AI-технологиям – по данным опроса PwC, порядка 74% финансовых служб крупных компаний в мире уже используют или планируют активно задействовать искусственный интеллект (машинное обучение, предиктивную аналитику) в процессах казначейства, включая прогнозирование ликвидности [10]. Это подтверждает актуальность темы и обусловливает необходимость исследования практики применения цифровых аналитических решений в управлении ликвидностью предприятия.

Обзор литературы. Теоретической основой исследования послужили работы, посвященные управлению ликвидностью и финансовой устойчивостью предприятия, а также исследования влияния цифровизации на финансовый анализ. В классических трудах по финансовому менеджменту (например, учебнике Е.С. Стояновой) ликвидность определяется как способность предприятия своевременно выполнять свои краткосрочные обязательства за счет оборотных средств, а эффективное управление ликвидностью рассматривается в контексте общей стратегии управления оборотным капиталом фирмы [1, с. 212–214]. Ряд отечественных авторов (В.А. Макарова, И.П. Скобелева и др.) в своих работах систематизировали методы оценки ликвидности и обосновали необходимость двухуровневой системы управления ликвидностью – на стратегическом и оперативном уровнях – для обеспечения баланса между долгосрочными и текущими финансовыми целями компании, а также между риском и доходностью [2, с. 192–198][3, с. 42–45]. Такой системный подход предполагает, что помимо недопущения кризиса неплатежеспособности (т.е. обеспечения достаточной текущей ликвидности), финансовый менеджмент должен учитывать влияние управления ликвидностью на стоимость компании и ее инвестиционный потенциал [3, с. 46–50].

В традиционной литературе подчёркивается связь ликвидности с рисками и финансовой устойчивостью. Например, И.П. Скобелева и В.А. Макарова отмечают, что анализ ликвидности компании тесно связан с анализом ее платежеспособности и общего финансового состояния, а недостаточное внимание к управлению ликвидностью может привести к утрате кредитоспособности и даже банкротству фирмы [3, с. 43]. С начала 2000-х годов тема управления ликвидностью получила развитие в работах, посвященных управлению денежными потоками и оптимизации оборотного капитала. Зарубежные исследователи (Р. Брейли, С. Майерс, Ф. Аллан и др.) также включают управление краткосрочной ликвидностью в число ключевых задач финансового менеджера, указывая на необходимость поддержания *буфера ликвидности* для защиты от неожиданных финансовых шоков [11, с. 754–756].

С развитием информационных технологий и концепции «финансы 4.0» исследователи обратились к изучению влияния цифровизации на анализ и управление ликвидностью. В работах последних лет все чаще подчёркивается, что цифровая экономика трансформирует традиционные методы финансового анализа, делая акцент на прогнозировании и динамическом мониторинге вместо ретроспективной оценки [5, с. 89–97]. Ю.Д. Шапиро и Е.М. Филимонцева (2025) отмечают, что внедрение технологий big data, искусственного интеллекта и облачных платформ позволяет значительно повысить скорость и точность анализа финансовых показателей, в том числе показателей ликвидности, а также улучшить качество финансового планирования [5, с. 71–79][5, с. 135–143]. Авторы подчеркивают переход от статических методов к динамическим: вместо разового анализа ликвидности по итогам отчетного периода внедряются непрерывные системы мониторинга денежных потоков и прогнозирования, включающие сценарное моделирование различных бизнес-ситуаций [5, с. 99–107].

Научная дискуссия затрагивает и вопрос о том, насколько корректно применять классические показатели ликвидности в условиях цифровой трансформации бизнеса. Так, Д.В. Альбрант в исследовании (2021) выдвинула гипотезу, что распространение цифровых технологий может искажать традиционные оценки ликвидности и платежеспособности предприятия, что в свою очередь чревато ошибками для внешних пользователей финансовой отчетности [4, с. 13–16]. На примере данных ПАО «Аэрофлот» за 2017–2020 гг. было показано, что выводы о финансовой устойчивости, сделанные только на основании классических коэффициентов ликвидности, могут быть неверными в цифровую эпоху [4, с. 16].

Помимо методологических работ, значимое место занимают исследования, посвящённые внедрению конкретных технологий для управления ликвидностью. К примеру, ряд авторов изучали применение методов искусственного интеллекта для прогнозирования денежных потоков предприятия. В работе K. Dadteev и соавт. (2020) были опробованы модели машинного обучения (регрессия, ARIMA, нейронные сети) для предсказания денежного потока, и показано, что нейросетевые модели могут обеспечивать более высокую точность прогноза по сравнению с традиционными статистическими моделями, особенно в условиях высокой динамичности данных [6]. Это открывает путь к использованию AI-инструментов в казначейской функции компаний. Подобные выводы согласуются с практикой крупных финансовых организаций: например, в J.P. Morgan разработан инструмент Cash Flow Intelligence на основе нейросетевых алгоритмов, который позволил сократить объём ручного труда при составлении прогнозов почти на 90% и существенно повысить точность краткосрочных кассовых прогнозов [8]. Другой областью применения цифровых технологий является автоматизация управления дебиторской задолженностью и платежами: внедрение интеллектуальных систем для контроля оплат клиентов, robotization процессов казначейства и использование блокчейн-платформ для ускорения расчетов в цепочке поставок напрямую влияет на ликвидность, уменьшая разрывы между оттоком и притоком денежных средств. Зарубежные обзоры (например, отчет Deloitte и др.) отмечают, что современные корпоративные казначейства активно инвестируют в системы управления ликвидностью (Treasury Management Systems, TMS) и сопутствующие им аналитические модули, чтобы получать глобальную видимость денежных средств и управлять ликвидностью в реальном времени [9].

Обобщая литературные данные, можно констатировать следующее. Цифровизация создала предпосылки для перехода управления ликвидностью на новый уровень, базирующийся на данных и проактивном анализе. Innovative инструменты – от алгоритмов прогнозирования до интерактивных финансовых панелей (dashboard) – способны радикально повысить эффективность контроля денежных потоков. При этом сохраняется необходимость переосмысления традиционных методик: исследователи предлагают новые подходы к оценке ликвидности, учитывающие специфику цифровой экономики, а также акцентируют важность управления информационными рисками. Существующие пробелы в литературе связаны с недостатком эмпирических данных о результатах внедрения таких решений в корпоративной среде, особенно в российской практике. Данное исследование призвано частично заполнить этот пробел, проанализировав актуальные практики и представив систематизацию преимуществ и проблем цифровых аналитических решений в управлении ликвидностью.

Таблица 1 – Распространенность цифровых технологий в финансовом анализе (по данным 2022–2025 гг.)

Показатель (доля компаний)	**2022 г.**	**2025 г.**
Используют цифровые решения в управлении финансами, %	≈40%	58%
Используют анализ данных на основе Big Data, % (МСП)	–	25%
Внедрили алгоритмы искусственного интеллекта в финансовом анализе, %	–	7%
Уверены в защищенности данных при цифровизации, %	–	32%
Примечание: по материалам исследования Шапиро и Филимонцевой [5, с. 135–143]; прочерк означает отсутствие данных за указанный год.		

Из таблицы 1 видно, что за последний период наблюдается существенный рост внедрения цифровых технологий в практику финансового анализа: большинству компаний доступны инструменты автоматизации анализа данных, тогда как использование искусственного интеллекта находится на начальной стадии. Одновременно менее трети организаций уверены в достаточной защите своих данных в цифровой среде, что подчёркивает значимость вопросов информационной безопасности при цифровизации казначейской функции. Эти тенденции, выявленные в литературе, далее будут учтены при формировании методики исследования и анализе результатов.

Методы и материалы. Настоящее исследование носит прикладной характер и основано на комплексном использовании методов анализа данных и обзора практики. В качестве основных методов были применены: монографический метод (изучение и обобщение научной литературы по теме), сравнительный анализ (сопоставление традиционного и цифрового подходов к управлению ликвидностью), метод кейсов (анализ практических примеров внедрения цифровых решений) и экспертная оценка на основе вторичных данных. Информационной базой послужили открытые источники: научные статьи, обзоры консалтинговых компаний, отчетные данные отдельных предприятий, а также статистические сведения об уровне цифровизации финансовых функций. Данные из различных источников подвергались критическому анализу, сопоставлялись между собой и агрегировались для выявления общих закономерностей.

Исследование выполнялось в несколько этапов. На первом этапе был проведен обзор литературы (результаты которого представлены в предыдущем разделе) с целью выявить современные направления и подходы к управлению ликвидностью в условиях цифровизации. Особое внимание уделялось публикациям за последние 5–7 лет, отражающим опыт применения технологий больших данных, искусственного интеллекта и финансовых платформ. Одновременно анализировались классические источники для определения теоретических основ управления ликвидностью и базовых критериев эффективности. Обзор литературы позволил сформулировать гипотезу исследования: внедрение цифровых аналитических решений приводит к повышению эффективности управления ликвидностью за счет улучшения точности прогнозирования и ускорения принятия решений, однако требует преодоления определенных организационных и технологических барьеров.

На втором этапе была разработана методическая схема анализа влияния цифровых решений на управление ликвидностью. Ввиду отсутствия доступа к внутренней финансовой информации конкретных компаний, исследование опиралось на публично доступные данные о результатах внедрения таких инструментов. В качестве материалов были использованы: данные кейса ПАО «Аэрофлот», представленные в работе Д.В. Альбрант (для иллюстрации возможных искажений традиционных оценок ликвидности) [4]; сведения из отчета J.P. Morgan о внедрении AI-инструмента прогнозирования Cash Flow Intelligence (для демонстрации достигнутого эффекта в виде сокращения ручного труда и повышения точности) [8]; результаты глобального опроса PwC 2025 года (для количественной оценки распространения AI и других технологий в управлении ликвидностью на международном уровне) [10]; а также данные Росстата (через работу [5]) по цифровизации финансовых функций. Для анализа эффектов использовался метод сравнения «до и после» и бенчмаркинга. Поскольку прямое экспериментальное исследование не проводилось, выводы носят характер аналитического обобщения на основании совокупности разнородных источников. Такой подход соответствует форме кабинетного исследования (desk research) с элементами case study.

Для наглядной иллюстрации материала в работе подготовлены две аналитические таблицы. Таблица 1 (в разделе обзора литературы) суммирует статистические данные об уровне внедрения цифровых технологий в финансовом анализе. Таблица 2 (в разделе результатов) представляет сравнительную характеристику традиционного и цифрового подхода к управлению ликвидностью по ряду ключевых параметров. Эти таблицы основаны на синтезе информации из литературных и эмпирических источников.

Отдельно следует описать ограничения методологии данного исследования. Во-первых, сделанные выводы базируются преимущественно на случаях крупных и средних компаний, освещенных в доступных источниках, что может несколько ограничивать их универсальность – ситуация малых предприятий может отличаться. Во-вторых, оценка эффективности цифровых решений часто носит качественный характер ввиду конфиденциальности количественных метрик; тем не менее, по некоторым кейсам (например, инструмент J.P. Morgan) имеются конкретные числовые показатели, которые использовались для подтверждения аргументов. В-третьих, принято во внимание, что влияние внешних факторов (экономическая конъюнктура, регуляторные изменения) могло сопутствовать внедрению цифровых инструментов и влиять на результаты – это учитывалось при интерпретации. Для повышения надежности выводов применялся принцип триангуляции источников: факт или тенденция считались обоснованными, если они подтверждались несколькими независимыми источниками.

Таким образом, методология исследования сочетает теоретический и эмпирический анализ. Опираясь на литературные данные и доступную практическую информацию, авторы стремились выявить общие закономерности и лучшие практики использования цифровых аналитических решений в управлении ликвидностью. Полученные результаты и их обсуждение приводятся в следующем разделе.

Результаты и обсуждение. Традиционный подход vs. цифровой подход. Результаты анализа подтвердили существенные различия между традиционной системой управления ликвидностью предприятия и системой, обогащенной цифровыми аналитическими инструментами. Эти различия затрагивают практически все аспекты – от сбора информации до принятия решений. В таблице 2 обобщены ключевые отличия двух подходов.

Таблица 2 – Сравнение традиционного и цифрового подходов к управлению ликвидностью

Аспект управления	Традиционный подход	Цифровой (аналитический) подход
Сбор данных	Данные собираются вручную из разрозненных учетных систем; актуализация – периодическая (ежемесячная, квартальная).	Данные интегрируются автоматически из ERP, CRM, банковских выписок и др. источников в режиме реального времени. Обработка больших массивов (Big Data) обеспечивает полноту информации.
Прогнозирование денежных потоков	Основано на простых трендах прошлого и экспертных оценках финансового менеджера; использование Excel-моделей, ограниченное число сценариев.	Основано на алгоритмах машинного обучения и продвинутой аналитике, которые учитывают множество факторов (продажи, рынок, сезонность и др.) для прогнозов. Генерируются сотни сценариев, применяются Монте-Карло и AI-модели для оценки вероятностей.
Принятие решений	Реактивное: меры принимаются после выявления проблем (дефицит денег, нарушение ковенантов и т.д.). Решения во многом зависят от интуиции менеджеров и разрозненных отчетов.	Проактивное и данные-ориентированное: система раннего предупреждения сигнализирует о кассовых разрывах до их наступления. Решения поддерживаются рекомендациями аналитических систем (например, AI может предложить оптимальную стратегию размещения средств или привлечения кредитов).
Прозрачность и контроль	Ограниченная видимость: трудно получить единый взгляд на ликвидность группы компаний или по подразделениям в любой момент времени без подготовки отчетов.	Полная прозрачность: панель мониторинга (dashboard) отображает текущий остаток денег по всем счетам и подразделениям, обновляется онлайн; возможен drill-down до каждой транзакции. Руководство имеет доступ к ключевым показателям ликвидности 24/7.
Скорость и частота анализа	Низкая скорость: составление отчета о движении денежных средств и анализ ликвидности занимают дни и недели, проводятся, как правило, раз в месяц.	Высокая скорость: автоматизированные отчеты формируются мгновенно, обновление показателей – хоть ежечасно. Это позволяет проводить анализ ликвидности практически непрерывно и быстрее реагировать на отклонения.

Как видно из табл.2, цифровой подход обеспечивает ряд преимуществ: более точное прогнозирование, основанное на интеллектуальных моделях; повышение *оперативности* и гибкости финансового планирования; сквозную прозрачность, позволяющую видеть полную картину ликвидности; снижение доли ручного труда и человеческого фактора. В совокупности это повышает качество управления ликвидностью – компания способна лучше предвидеть кассовые разрывы, оптимизировать распределение денежных ресурсов и избегать лишних заимствований. Например, использование нейросетевых моделей для прогноза денежных потоков позволяет учесть нелинейные взаимосвязи и множество влияющих факторов, что приводит к сокращению ошибки прогноза. По данным отдельных кейсов, применение AI-моделей уменьшает погрешность прогнозирования денежных потоков на 30–50% по сравнению с традиционными методами. Кроме того, реальный пример – инструмент AI Forecasting в J.P.Morgan – показал, что с помощью алгоритмов можно добиться высокой точности и стабильности прогнозов, а также сократить ручную работу: около 2 500 клиентов банка получили возможность практически полностью автоматизировать краткосрочное финансовое планирование, высвободив до 90% времени своих казначейских отделов [8]. Это наглядно демонстрирует потенциал цифровых решений.

Преимущества цифровых аналитических решений. На основе проведенного анализа можно выделить ключевые преимущества внедрения цифровых аналитических инструментов в управление ликвидностью:

Рост точности и качества прогнозирования. Интеллектуальные модели (машинное обучение) учитывают сложные паттерны в данных, что ведет к более надежным прогнозам будущих денежных поступлений и выплат. В условиях, когда по оценкам EY только ~28% компаний ранее могли точно спрогнозировать свободный денежный поток с погрешностью менее 10% [9], внедрение современных алгоритмов позволяет значительно улучшить этот показатель. Чем точнее прогноз, тем меньше «замороженных» средств компания держит в резерве и тем реже прибегает к авральному привлечению кредитов. Следовательно, улучшается эффективность использования капитала.

Оперативность и проактивность. Цифровые решения дают возможность мониторить показатели ликвидности в реальном времени. Например, облачные платформы казначейства агрегируют данные по всем расчетным счетам мгновенно, обеспечивая единую картину текущего денежного положения фирмы. Это позволяет финансовому директору или казначею принимать решения незамедлительно до того, как ситуация выйдет из-под контроля. Проактивное управление, подкрепленное аналитическими предупреждениями, значительно снижает вероятность кассовых разрывов. Как отметил один из руководителей данных и аналитики крупного банка, теперь финансовые менеджеры «начинают преломлять рабочий процесс, предвидя проблемы вместо реагирования постфактум» [8].

Оптимизация оборотного капитала и высвобождение денег. Благодаря лучшему контролю дебиторской и кредиторской задолженности, более точному прогнозу поступлений, компания может сократить избыточные запасы ликвидности и направить эти средства на развитие или снижение долговой нагрузки. По данным исследования O. Adebayo и соавт., цифровая трансформация способствует оптимизации рабочего капитала и высвобождению «застрявших» денежных средств, улучшая показатели ликвидности без привлечения внешнего финансирования. Топ-менеджеры отмечают, что наличие прозрачной информации о глобальной позиции денежных средств позволяет им эффективнее вести переговоры с поставщиками и кредиторами. В итоге снижается средневзвешенная стоимость капитала компании и повышается ее рыночная устойчивость.

Повышение устойчивости к внешним шокам. Быстро меняющаяся рыночная среда требует столь же быстрых адаптивных действий. Цифровые системы могут автоматически пересчитывать прогноз ликвидности при изменении внешних параметров и даже рекомендовать меры хеджирования рисков. В работе Adebayo et al. отмечено, что применение технологии блокчейн и смарт-контрактов позволяет ускорить трансграничные расчеты и снизить операционные ошибки, тем самым укрепляя позиции компании в условиях нестабильности. Кроме того, расширенная аналитика обеспечивает руководству *раннее предупреждение* о надвигающихся кризисных явлениях – например, резком повышении просрочек платежей клиентов или росте дебиторки – что дает больше времени для выработки защитных мер. Недаром глобальные опросы показывают, что для финансовых директоров сейчас приоритетом стало внедрение «cash-first» культуры, где на первое место ставятся точный прогноз и мгновенная видимость денежных средств как залог гибкости в кризисных ситуациях.

Снижение издержек и повышение эффективности персонала. Автоматизация процессов управления ликвидностью ведет к сокращению трудозатрат на подготовку отчетности, сверку платежей, проведение расчетов. Освобожденное время сотрудники финансовых служб могут направить на стратегический анализ, поиск оптимальных финансовых решений, взаимодействие с бизнес-подразделениями. Таким образом, роль казначейства эволюционирует от операционного бухгалтера к стратегическому партнеру, создающему дополнительную ценность для компании [9]. В числовом выражении эффект может проявляться в снижении административных расходов: меньше ручных ошибок – меньше штрафов и пени, более точные прогнозы – меньше переплат процентов по избыточным кредитам или, наоборот, недополученных скидок. В совокупности цифровизация финансовой функции повышает экономическую эффективность предприятия.

Проблемы и риски внедрения цифровых решений. Вместе с тем, анализ выявил и ряд проблемных аспектов, которые сопровождают внедрение цифровых аналитических решений в управление ликвидностью. О них важно упомянуть, чтобы обеспечить полный и объективный взгляд. Главные вызовы можно сгруппировать следующим образом:

Интеграция данных и систем. Многие компании исторически используют разнородные ИТ-системы (учет, казначейство, банковские клиенты и пр.). Внедрение единой платформы или аналитического модуля требует интеграции этих источников данных. На практике это часто оказывается сложной технической задачей. Фрагментированные системы и *децентрализованные данные* приводят к тому, что значительное время уходит на настройку обмена информацией, разработку интерфейсов между программами [10]. Пока интеграция не выполнена полностью, цифровой инструмент не сможет раскрыть весь потенциал – данные могут поступать несвоевременно или неполно. Решение видится в поэтапной консолидации ИТ-ландшафта и переходе к модульным экосистемам с использованием API, что отмечается в отчете PwC как новый тренд (65% организаций планируют расширять применение API для обеспечения гибкости). Однако реализация этого требует инвестиций и времени, что не все готовы сразу обеспечить.

Кадровые навыки и сопротивление изменениям. Внедрение продвинутых аналитических инструментов требует соответствующей компетенции персонала. Возникает потребность в финансистах, обладающих базовыми знаниями в области data science, умении работать с системами бизнес-аналитики, понимать принципы работы ML-моделей. Нехватка таких навыков может затруднять использование системы на полную мощность – сотрудники продолжают действовать по старинке, доверяя больше своему опыту, чем «подсказкам» алгоритмов. Кроме того, любое нововведение часто встречает организационное сопротивление: персонал опасается, что автоматизация сделает их работу ненужной, или не доверяет новым подходам. Это подтверждается и практикой: по опросам, до 46% компаний сталкиваются с отсутствием мотивации бизнес-подразделений вносить вклад в новую систему прогнозирования. Преодолеть эти проблемы можно через обучение (повышение квалификации финансовых сотрудников в области цифровой аналитики) и изменения культуры – важно донести, что цель внедрения AI/BI не заменить людей, а помочь им принимать более обоснованные решения. Показательно, что руководители, успешно внедрившие AI-инструменты, подчеркивают: «искусственный интеллект не заменяет экспертизу казначеев, а дополняет ее, освобождая время для стратегических задач» [8].

Киберриски и надежность систем. Переход к цифровым платформам означает, что критически важная финансовая информация компании оборачивается в электронном виде и часто хранится в облачных сервисах. Это повышает риски кибербезопасности: утечка или взлом системы управления ликвидностью может привести к колоссальным потерям. Не случайно менее трети компаний (32%) выражают уверенность в защищенности своих данных при цифровизации [5, с. 135–143]. Каждый новый интерфейс интеграции или подключенный сервис – потенциальная уязвимость. Более того, высокая зависимость от ИТ означает, что сбой в системе способен нарушить процесс планирования платежей. Поэтому организации должны вкладываться в безопасность: шифрование данных, резервирование каналов связи, многофакторную аутентификацию, регулярный аудит защищенности. Кроме того, нужен план непрерывности бизнеса на случай технических сбоев – финансовая служба должна уметь действовать и в «ручном режиме», если вдруг цифровой помощник временно недоступен. В глобальном опросе PwC 2025 особо отмечено: возрастающая роль цифровых инструментов делает кибербезопасность одним из приоритетов казначеев [10]. Без адекватных мер по защите и надежности любые достижения цифровизации могут быть нивелированы единичным инцидентом.

Обсуждая результаты, следует отметить, что эффективность цифровых аналитических решений не одинакова для всех. Крупные многонациональные корпорации, имеющие сложную структуру счетов и глобальные денежные потоки, получают наибольший эффект от внедрения – для них критична централизация ликвидности и мгновенный обзор позиций по всему миру. В то же время небольшие предприятия, возможно, не испытывают такой острой необходимости в дорогих AI-системах – им достаточно простых автоматизированных финансовых отчетов. Тем не менее, тренд очевиден: «цифровой стек» инструментов финансового управления постепенно становится нормой и для среднего бизнеса. По мере удешевления технологий даже компании с ограниченными ресурсами могут использовать элементы продвинутой аналитики.

Таким образом, результаты свидетельствуют: цифровые аналитические решения при правильном внедрении способны существенно усилить функцию управления ликвидностью, сделав ее более точной, оперативной и стратегически ориентированной. Это подтверждают как теоретические выкладки (в работах [4][5][12] и др.), так и практические кейсы. В то же время, компании должны осознавать и активно управлять рисками, сопутствующими цифровизации – прежде всего, уделять внимание кибербезопасности и развитию компетенций сотрудников. В следующем заключительном разделе суммируются главные выводы исследования и даются рекомендации по использованию цифровых инструментов для повышения финансовой устойчивости предприятия.

Заключение. Выполненное исследование позволило всесторонне оценить практику применения цифровых аналитических решений в управлении ликвидностью предприятия и сформулировать ряд выводов. Ниже представлены ключевые итоги:

Цифровизация кардинально изменяет подход к управлению ликвидностью. Если традиционный подход носит реактивный характер и основан на ретроспективном анализе ограниченного набора данных, то современный цифровой подход – проактивный, опирающийся на непрерывный мониторинг и прогнозирование денежных потоков с использованием Big Data и искусственного интеллекта. Это позволяет финансовым менеджерам предвидеть кассовые разрывы и управлять ликвидностью более эффективно, что напрямую способствует повышению финансовой устойчивости компании. Выявлено, что цифровые решения обеспечивают рост точности прогнозов и ускорение подготовки информации, что подтверждают как научные исследования, так и практический опыт ведущих компаний.

Выявлены основные препятствия и риски на пути внедрения цифровых решений в управление ликвидностью. Среди них: проблемы интеграции разнородных ИТ-систем и качества исходных данных; недостаток квалификации персонала и сопротивление изменениям устоявшихся процессов; вопросы информационной безопасности (возрастающие киберриски) и необходимость надежного резервирования систем; а также регуляторные ограничения и необходимость значительных инвестиций. Установлено, что успешное преодоление этих препятствий требует системного подхода: разработки четкого плана цифровой трансформации финансовой функции, обучения и вовлечения сотрудников (формирования культуры, восприимчивой к инновациям), обеспечения кибербезопасности на уровне стандарта отрасли и постоянного диалога с руководством об отдаче от инвестиций. Безусловно, компании, которые игнорируют эти аспекты, могут столкнуться с тем, что внедренная система не приносит ожидаемого эффекта или создает новые уязвимости.

Подводя итог, можно заключить, что внедрение цифровых аналитических решений в управление ликвидностью предприятия – это актуальный и перспективный шаг, продиктованный объективными условиями цифровой экономики. Несмотря на наличие определенных рисков и первоначальных трудностей, выгоды от цифровизации данной области очевидно перевешивают издержки. Цифровые инструменты позволяют сделать управление ликвидностью более прозрачным, точным и оперативным, что прямо способствует укреплению финансовой устойчивости и повышению стоимости бизнеса. В конечном счете, компания, сумевшая выстроить эффективную систему управления ликвидностью с применением передовых технологий, получает не только внутренние преимущества (оптимизация ресурсов, снижение риска кризиса ликвидности), но и внешние – более высокий кредитный рейтинг, доверие инвесторов и партнеров, способность гибко реагировать на изменения рынка. Таким образом, цифровая трансформация управления ликвидностью следует рассматривать как часть общей стратегии цифровизации предприятия и укрепления его конкурентных позиций в современной экономике.

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FEATURES OF THE COST OPTIMIZATION PROCESS AND ITS IMPACT ON IMPROVING THE ACTIVITIES OF AGRICULTURAL COOPERATIVES

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Summary. *The important role of the development of agricultural consumer cooperatives in improving the efficiency of farms and personal subsidiary farms, in ensuring the sustainable development of rural areas is recognized by both scientists and representatives of state and local governments. It should be noted that in the last five years, the state's attention to solving this problem has increased significantly, which has been expressed in the implementation of appropriate measures to support cooperatives at the national and regional levels. The traditional criticism of the authorities regarding the insufficient amount of financial support for small businesses in the agricultural sector, including cooperatives, is certainly justified. However, more and more often scientists express the opinion that only an increase in financial injections will not solve the problem of cooperation development.*

Keywords: *agricultural sector, process of cost optimization, finance, economic development, improvement of agriculture.*

ОСОБЕННОСТИ ПРОЦЕССА ОПТИМИЗАЦИИ ЗАТРАТ И ЕГО ВЛИЯНИЕ НА СОВЕРШЕНСТВОВАНИЕ ДЕЯТЕЛЬНОСТИ СЕЛЬСКОХОЗЯЙСТВЕННЫХ КООПЕРАТИВОВ

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Аннотация. *Важная роль развития сельскохозяйственных кооперативов отводится повышению эффективности деятельности сельских хозяйств, в обеспечении устойчивого развития сельских территорий признается учеными и представителями органов государственной власти и местного самоуправления. Важно отметить, что в последнюю пятилетку внимание государства к решению данной задачи существенно возросло, что получило выражение в реализации важнейших мер поддержки кооперативов на республиканском и региональном уровнях. Традиционная критика власти относительно недостаточного объема финансовой поддержки малого бизнеса и среднего в аграрной сфере, и в том числе кооперативов, безусловно, оправдана. Однако, все чаще ученые высказывают мнение о том, что только увеличением финансовой поддержки проблему развития кооперации не решит.*

Ключевые слова: *аграрный сектор, процесс оптимизации затрат, финансы, экономическое развитие, совершенствование сельского хозяйства.*

Difficulties with the sale of products, unequal access to markets compared to large companies, low prices for products sold and high prices for purchased resources are traditional problems of farms, among others, and their relevance has not decreased in recent years. Agricultural consumer cooperatives created by farmers and personal subsidiary farms should contribute to solving these problems. The factors hindering the development of agricultural consumer cooperation in our country have also been studied in sufficient detail. The following can be noted as the most significant: imperfection of the regulatory framework; lack of qualified personnel in the cooperative; lack of own funds of cooperatives and their potential members; unwillingness of farmers and personal subsidiary farms to join a cooperative due to fears of limiting independence and unfair behavior of other shareholders; remoteness of farmers of the same specialization from each other; price discrimination by processors [1, p. 43].

Foreign experience shows that the problems of cooperatives in our country are not unique. By itself, farmers' participation in cooperatives does not lead to an increase in production indicators and incomes due to possible inefficient management in cooperatives. In some cases, contract manufacturing can provide more substantial benefits to farmers. The complexity of coordinating important management decisions between members and the significant time costs of making such decisions require a high level of trust in the cooperative and the development of mechanisms for coordinating the interests of all participants [2, p. 127]. The transformation of cooperative organizations in the agri-food sector of Western countries has been taking place since the 1990s, characterized by mergers, liquidation of cooperatives, and demutualization (transformation of a cooperative into another organizational and legal form). The concept of hybrid cooperatives is introduced into scientific and practical circulation, the appearance of which can be considered an evolutionary stage in the development of cooperation, the result of the consolidation of traditional cooperatives, changes in market conditions. The development of cooperatives is not an end in itself, their value is determined by how effectively they ensure the integration of farms and personal subsidiary farms into agri-food value chains. Of particular relevance is the inclusion of farms and their cooperatives in short supply chains, when the entire cycle of value creation from the production of raw materials to retail sales is localized at the local level, which contributes to the development of rural areas [3, p. 87].

Results and discussion

The cooperative, in fact, is also an intermediary between the farmer and the consumer of the final product. And its attractiveness to members will be determined by how significant the increase in their share in the value chain within the framework of cooperation is. At the same time, assessing the benefits of a farmer from participating in the activities of a cooperative, it is advisable to identify two of its components [4, p. 137]. The first is a direct increase in the selling price of products. The second is an increase in the share in the equity of the cooperative. These elements are directly interrelated. If the cooperative, all other things being equal, minimizes profits, a higher price may be set for a specific transaction with a member of the cooperative. Reducing the price of purchasing products by the cooperative from its members increases its profit, which can contribute to an increase in the cooperative's own capital. This, in turn, allows the cooperative to develop, increase and modernize its material and technical base, and strengthen its own market positions. Each member of the cooperative actually has to make a choice – to maximize his benefit in the current transaction, or to give up part of the benefit in favor of the future development of the cooperative. The correspondence of the individual preferences of the farmer to the policy implemented by the cooperative in this matter will determine his motivation to participate in the activities of the cooperative. We analyzed the prices of sales of products by farms of the Zhetysu region according to the data of 2023. In total, data from 211 farms were analyzed. The coefficient of variation was calculated to estimate the level of price spread. The higher the value of the coefficient of variation, the greater the difference in the price level of the individual 12 farms in the study population. The results are presented in table 1.

Table 1 – Coefficients of variation in the price level of certain types of products sold by farms of the Zhetysu region in 2023

Product type / number of farms analyzed	The value of the coefficient of price variation, %
Crop production	
Wheat / 180	24,14
Sunflower / 138	21,57
Potatoes / 19	42,71
Sugar beet /28	17,36
Livestock products	
Meat of cattle / 26	39,77
Pork / 7	42,87
Milk / 78	24,29

Note: compiled by the author

Prices for potatoes, cattle meat and blue in the studied population of farmers are characterized by high heterogeneity, for other types of products, price differences can be described as moderate, but quite significant.

The assessment of the dependence of the selling price on individual indicators of the farm's activity allowed us to draw the following conclusions:

- for potatoes, the dependence of the farmer's ability to provide higher sales prices on the scale of the farm's activities is traced. On average, the larger the farm (the larger the acreage and production volumes), the higher the selling price of potatoes. Potato farmers, in order to gain access to higher value–added chains, should strive to increase production volumes. A similar effect can be achieved with the cooperation of several small producers;
- for wheat grain producers, there is little feedback between the farmer's ability to get a higher sales price and the area of crops. It can be assumed that with an increase in the total sown area beyond a certain limit, farmers are forced to sell more substantial amounts of grain at lower prices;
- for pork producers, an increase in livestock has a positive effect on the ability to ensure sales at higher prices; - an increase in milk production allows you to master more profitable sales channels for novice farmers with small production, then this influence is being leveled.

The analysis showed that the spread of product sales prices by individual farms can be quite significant, which indicates significantly different capabilities of producers to ensure an increase in their own share in the value chain. At the same time, the impact of the volume factor on access to more profitable sales channels varies for different industries and types of activities. Increasing the scale of activities can lead to a positive effect in terms of increasing sales prices, primarily for such activities as potato and milk production. And in some cases, the effect of scale in terms of price can be negative. But it is precisely small volumes of production by farmers that are often considered as a factor limiting their access to high-value-added sales chains and as an incentive to cooperate.

20.7% of the surveyed farmers sell products directly to the population. This applies mainly to grain in small batches and in small packages, which are purchased by personal subsidiary farms that raise livestock and poultry. Small farms producing meat sell their products directly to the population. 6.9% of the surveyed farmers sell their products through their own shops and retail outlets. In order to assess the most promising areas of cooperation between farms, the interview also asked about the forms of cooperation with other farms and personal subsidiary farms. More than 40% of farmers reported that they interact with other agricultural producers in the course of their activities. Moreover, such interaction is widespread mainly in mixed and crop farms. 75% of farmers engaged in animal husbandry reported a lack of cooperation and informal cooperation [5, p. 28].

Conclusion

Approaches to the organization of cooperatives in various sectors of agriculture should differ. Thus, potato and milk producers can benefit by accumulating larger batches of products and storing them (for potatoes) within the framework of a cooperative. Producers of cereals, sugar beet, beef and pork can benefit from cooperation not by forming larger batches of products, but by deeper processing, that is, by participating in the activities of processing cooperatives. In most cases, farms have the opportunity to sell products directly to processing organizations. The sale of products through intermediaries is most common when selling crop products. Short supply chains to local markets are also widely used, mainly for the sale of meat and grain in small packages. If short supply chains clearly lead to an increase in the share of farms in the value added structure, then the choice in favor of direct supply of products to a processing enterprise or sale to intermediaries is not always obvious. In some cases, intermediaries can buy back products at a higher price.

This may be due to the fact that intermediaries have access to more profitable product sales channels that are not associated with a local processing enterprise. The involvement of farms in the activities of agricultural consumer cooperatives is extremely low, and the experience of such participation is often negative. But at the same time, the practice of informal farmers' cooperation is quite common, primarily when using machinery and purchasing resources. Accordingly, these areas may be quite promising from the point of view of organizing consumer cooperatives.

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