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THE ROLE OF FOREIGN INVESTMENT AND ENTREPRENEURSHIP IN THE DEVELOPMENT OF THE NATIONAL ECONOMY

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Abstract: The sustainable development of a national economy increasingly depends on the effective integration of foreign investment and entrepreneurial activity. Foreign Direct Investment (FDI) serves as a major source of capital inflow, technological diffusion, and global market integration, while entrepreneurship stimulates innovation, job creation, and economic diversification. According to recent global reports, FDI inflows reached approximately $1.3 trillion worldwide in 2023, demonstrating its continued importance despite global economic uncertainty. At the same time, small and medium-sized enterprises (SMEs), driven by entrepreneurial initiatives, account for over 90% of businesses and more than 50% of employment globally. This paper provides a comprehensive analysis of how these two forces interact and contribute to national economic growth, particularly in developing economies. It also examines structural challenges and offers policy recommendations for maximizing their impact.

Keywords: Foreign Direct Investment (FDI), Entrepreneurship, Economic Growth, SMEs, Innovation, Investment Climate, Sustainable Development

Introduction

In the 21st century, globalization and economic interdependence have fundamentally transformed how national economies grow and compete. Traditional growth models based solely on domestic resources are no longer sufficient. Instead, countries increasingly rely on external capital flows and internal entrepreneurial capacity to drive development.

Foreign investment has become a cornerstone of economic policy in many countries. For instance, developing economies collectively attracted nearly 70% of global FDI inflows in recent years, reflecting their growing importance in the global economic system. Simultaneously, entrepreneurship has emerged as a critical engine of growth, particularly in countries transitioning toward market-based economies.

In my view, the real strength of a modern economy lies not only in how much capital it attracts, but in how effectively it empowers its people to create value. This is where entrepreneurship complements foreign investment—turning financial resources into sustainable economic outcomes.

Foreign Direct Investment (FDI) is defined as a long-term investment by a foreign entity in the productive capacity of another country. It differs from portfolio investment because it involves management control and lasting interest.

Statistical Importance of FDI

Global FDI flows: approximately $1.3 trillion (2023)

Developing countries' share: ~65–70% of total inflows

FDI contributes up to 10–15% of GDP in some emerging economies

Economic Contributions

1. Capital Formation

FDI supplements domestic savings, which are often insufficient in developing economies. For example, in many Central Asian countries, domestic investment rates remain below 30% of GDP, making foreign capital essential for infrastructure and industrial projects.

2. Technology Transfer and Innovation

Multinational corporations introduce advanced technologies, automation systems, and digital transformation practices. Studies show that firms with foreign ownership are on average 30–50% more productive than purely domestic firms.

3. Employment Generation

FDI creates both direct and indirect employment. For example, one large manufacturing investment can generate thousands of jobs directly and many more through supply chains.

4. Export Expansion

Foreign-invested firms often integrate host countries into global value chains. In many developing nations, over 50% of exports come from foreign-owned or joint ventures.

From my perspective, the most transformative impact of FDI is not immediate economic growth, but long-term structural change. It pushes economies toward higher productivity sectors and global competitiveness.

The Role of Entrepreneurship in Economic Development

Entrepreneurship is widely recognized as a fundamental driver of economic dynamism. It transforms ideas into economic value and plays a crucial role in adapting to changing market conditions.

Global Statistics on Entrepreneurship

SMEs represent over 90% of all businesses worldwide

SMEs generate 50–60% of global employment

In developing countries, SMEs contribute up to 40% of GDP

Key Contributions

1. Job Creation

Entrepreneurial ventures, especially startups and SMEs, are the largest source of new jobs. In many economies, over 70% of new employment comes from small businesses.

2. Innovation and Technological Progress

Entrepreneurs are responsible for disruptive innovations. Companies like startups in fintech, e-commerce, and AI sectors demonstrate how small firms can reshape entire industries.

3. Economic Diversification

Entrepreneurship reduces dependence on a single sector (e.g., natural resources) and promotes diversification into services, manufacturing, and technology sectors.

4. Social and Cultural Impact

Entrepreneurship encourages independence, resilience, and creativity. It also empowers marginalized groups, including women and youth.

In my opinion, entrepreneurship is the “human face” of the economy. While statistics measure growth, entrepreneurs represent ambition, risk, and vision—the true forces behind sustainable progress.

Interaction Between Foreign Investment and Entrepreneurship

The relationship between foreign investment and entrepreneurship is highly complementary.

Positive Synergies

1. Knowledge Spillovers

Local entrepreneurs benefit from exposure to international best practices, management techniques, and innovation strategies.

2. Supply Chain Development

Foreign firms often rely on local suppliers, creating opportunities for domestic businesses to grow.

3. Access to Finance and Markets

Partnerships with foreign investors can provide entrepreneurs with funding and entry into international markets.

4. Startup Ecosystem Growth

Countries with strong FDI inflows often experience rapid development of startup ecosystems, particularly in technology sectors.

Potential Risks

Market dominance by multinational corporations

Limited growth opportunities for local firms

Profit repatriation reducing domestic reinvestment

From a critical perspective, the key challenge is balance. Foreign investment should act as a catalyst, not a substitute, for local entrepreneurship.

Challenges and Limitations

Challenges Related to Foreign Investment

Political instability reduces investor confidence

Weak legal systems discourage long-term commitments

Corruption increases transaction costs

Infrastructure gaps limit investment potential

Challenges for Entrepreneurship

Limited access to capital (especially for startups)

High interest rates and financial barriers

Lack of business education and mentorship

Regulatory complexity and bureaucracy

Statistically, about 50–70% of startups fail within the first five years, highlighting the risks associated with entrepreneurship.

In my view, the biggest issue is not lack of talent or ideas, but lack of support systems. Without proper institutions, both investors and entrepreneurs face unnecessary obstacles.

Policy Implications

To maximize the benefits of foreign investment and entrepreneurship, governments should adopt a comprehensive strategy:

1. Improve Investment Climate

Ensure political and economic stability

Strengthen legal frameworks and property rights

Reduce corruption and bureaucracy

2. Support Entrepreneurs

Provide access to affordable financing

Develop business incubators and accelerators

Promote entrepreneurship education

3. Encourage Innovation

Invest in research and development (R&D)

Support digital transformation initiatives
Foster collaboration between universities and businesses
4. Ensure Balanced Development
Protect local businesses from unfair competition
Encourage joint ventures and partnerships
Promote inclusive growth policies
A well-balanced policy approach can create a sustainable ecosystem where both foreign investors and local entrepreneurs thrive.

Conclusion

Foreign investment and entrepreneurship are indispensable components of modern economic development. While FDI brings capital, technology, and global integration, entrepreneurship ensures adaptability, innovation, and long-term sustainability.

Statistical evidence clearly shows that countries that successfully combine these two elements achieve higher growth rates, better employment outcomes, and greater economic resilience.

In conclusion, the future of national economies depends on their ability to create synergy between external resources and internal capabilities. In my opinion, true development is achieved not when a country simply attracts investment, but when it empowers its people to become creators of value themselves.

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THEORETICAL AND PRACTICAL FOUNDATIONS OF THE UCHDM DELINTERING MACHINE

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Annotatsiya. Maqolada delinterning yuqori kamerasida qirib olingan kalta tolalarning kombinatsiyalashgan arra-metall cho‘tkali silindri sirti bo‘ylab ko‘chishi $r(t_1) < r_0$ shartini bajarsa, bunday massadagi tolalar kombinsiyalashgan arra-metall cho‘tkali silindri sirtida saqlanib qolishi, agar $r(t_1) > r_0$, u holda bunday kalta tola kombinatsiyalashgan arra-metall cho‘tkali silindri sirtidan ajralib, erkin tolaga aylanishi sharti aniqlandi. O‘tkazilgan ko‘p omilli tajribalarda delinterning maqbul parametrlari xaqida ma’lumotlar keltirilgan.

Kalit so‘zlar: delinter, chigit tuksizlantirish, kamera, arra-metall cho‘tka, kombinatsiyalashgan, kuch, omil.

Аннотация. В статье установлено, что если выполняется условие, что короткие волокна, соскобленные в верхней камере делинтера, движутся вдоль поверхности комбинированного пильно-металлического щеточного цилиндра, то волокна такой массы останутся на поверхности комбинированного пильно-металлического щеточного цилиндра, а если , то такое короткое волокно отделится от поверхности комбинированного пильно-металлического щеточного цилиндра и превратится в свободные волокна. Представлены данные об оптимальных параметрах делинтера в проведенных многофакторных экспериментах.

Ключевые слова: удаление волокон древесины, удаление шерсти, камера, щетка для пильного металла, комбинированный, коэффициент мощности.

Abstract. The article establishes that if the condition is met that the short fibers scraped off in the upper chamber of the delinter move along the surface of the combined saw-metal brush cylinder, then fibers of such mass will remain on the surface of the combined saw-metal brush cylinder, and if, then such a short fiber will separate from the surface of the combined saw-metal brush cylinder and turn into free fibers. Data on the optimal parameters of the delinter in the conducted multifactorial experiments are presented.

Keywords: delinter, cotton seed delinting, chamber, saw-metal brush, combined cylinder, force, factor.

Machines of the UCHDM type are designed for delinting seeds, ensuring a delintiness of up to 0.5% when preparing delinted seeds and up to 2.00-5% when preparing less delinted seeds. The UCHDM type machine is used in the equipment complex of single-stage delinting shops, as the machine itself performs two stages [1, 2].

The positive aspect of the technical solution developed by JSC "Paxtasanoat ilmiy markazi" is that it prevents the seeds from mixing with the suction pipe of lint separated from the upper chamber. However, replacing the saw cylinders used in the upper working chamber of the UCHDM seed delinting machine with cylinders with metal brushes can lead to a decrease in its productivity.

In addition, in our opinion, the closed multifaceted chamber used in the upper working chamber of the UCHDM machine may have caused an increase in mechanical damage to the seeds.

Theoretical research was carried out using the laws of mechanics, algebra, and descriptive geometry. Experimental studies were conducted on an experimental sample of a delinter using appropriate GOST standards, existing and specially developed methods. The results of the experiment were processed on a computer using mathematical statistics.

The angle between the radius of the saw blade and the direction of the cylinder wire with a metal brush (the brush wires are bent in the direction of the cylinder's movement) is taken *as. D Determine the coordinates of the point by (x, y).*

In the chosen coordinate system, their expressions are as follows:

$$x = (R + r\cos\beta)\cos(\omega t + \alpha_0)$$
$$y = (R + r\cos\beta)\sin(\omega t + \alpha_0) \quad (1)$$

here - the angle formed by the radius of the saw disc with *the axis ox* at the initial moment.

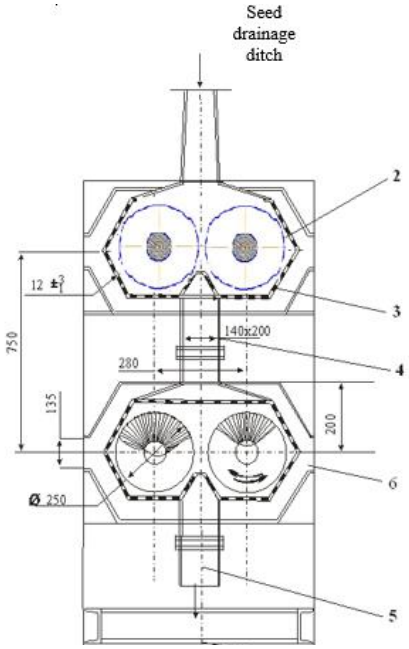

Fig. 1. Side view of the seed delinting machine, improved according to the developed technical solution

1. frame; 2 - saw or combined (saw-brush) cylinder; 3 - chamber casing; 4 - transition channel; 5-seed discharge chute; 6 - lint suction opening

Based on the foregoing, a technical solution for improving the UCHDM seed delinting machine was developed.

In the research process, methods of theoretical and applied theory of machines and mechanisms, mechanics, higher mathematics and vibration theory, mathematical modeling of technological machine operating processes, mathematical statistics, and computational mathematics were used.

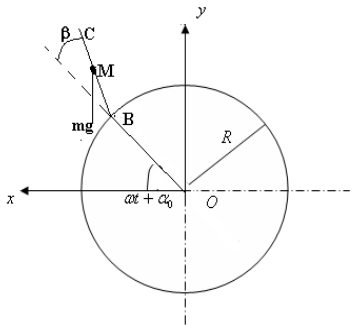

Fig. 2. Diagram of the movement of a short fiber with a mass of *m* over a brush wire

Determine the forces acting on the short fiber scraped with combined saw-metal brush cylinders. These are the force of gravity of the fiber, the force of friction, and the force of action of the suction air along the brush wire.

During the movement of the combined saw-metal brush cylinders, the direction of the action of these forces changes. Therefore, the preservation of the scraped short fiber on the brush wires or its free movement depends on the mass of the fiber, the rotation speed of the saw-metal brush cylinder, and the force of the suction air. The forces of gravity and friction acting on short fibers depend on the angle formed by the brush cylinder wire relative to the saw blade and the speed of the working cylinder. Using Figure 3, we find the projections of the force of gravity and the friction forces in the direction of the brush wire [8]:

$$F_{TP} = f \cdot N \qquad (2)$$

Here: m - short fiber mass;

N - normal force acting on a short fiber, taking into account gravity, centrifugal force, and Coriolis force, it looks like this:

$$N = 2m\omega\dot{r}\cos\beta + mg\cos(\alpha_0 + \omega t + \beta) + m(r\cos\beta + R)\omega^2 \sin\beta \qquad (3)$$

In addition to these forces, the centrifugal force on the fiber:

$$m(R + r\cos\beta)\omega^2\cos\beta \qquad (4)$$

And the force of air suction is affected by:

$$F_0 = c(v_0 - \dot{r}) \qquad (5)$$

Here: - air velocity in the direction of the brush wire;
s - air resistance coefficient.
Taking these forces into account, we write the equation of motion of the short fiber along the brush wire [9, 10]:

$$m\ddot{r} = m(R + r\cos\beta)\cos\beta\omega^2 - mg\sin(\alpha_0 + \omega t + \beta) - f\left[2m\omega\dot{r}\cos\beta + mg\cos(\alpha_0 + \omega t + \beta) - \right.$$
$$\left. - fm(\cos\beta + R)\omega^2\sin\beta + c(v_0 - \dot{r})\right. \quad (6)$$

We can rewrite this equation as follows:

$$\ddot{r} + \dot{r}(2\omega\cos\beta + \gamma) - r\omega^2(\cos\beta - f\sin\beta)\cos\beta =$$
$$= R\omega^2(\cos\beta - f\sin\beta) - g[\sin(\alpha_0 + \omega t + \beta) + f\cos(\alpha_0 + \omega t + \beta)] + \gamma v_0 \quad (7)$$

here $\gamma = c/m$

Using the following notations $\alpha = \alpha(t) = \alpha_0 + \omega t + \beta$, $n = (2\omega + \gamma)/2$, $c_0 = \cos\beta - f\sin\beta$, $a = c_0\omega^2$, $b = R\omega^2 c_0 + \gamma v_0$, we reduce equation (6) to the following form.

$$\ddot{r} + 2n\dot{r} - ar = b - g[\sin\alpha(t) - f\cos\alpha(t)] \quad (8)$$

Equation $r = r_1,\ \dot{r} = 0,\ t = 0$ (8) is integrable $0 < t < t_1$ in the interval when, where; $t_1 = \frac{L}{\omega}$,

L- length of the arc of the saw blade in contact with the airflow.
The solution of equation (6) satisfying the above conditions has the form:

$$r = Ae^{k_1 t} + Be^{k_2 t} - \frac{b}{a} + A_0\sin(\omega t + \alpha_0 + \beta) + B_0\cos(\omega t + \alpha_0 + \beta) \quad (9)$$

here:

$$A = \frac{c_1 k_2 - c_2}{k_2 - k_1};\ B = \frac{c_2 - k_1 c_1}{k_2 - k_1};\ c_1 = b/a - A_0\sin\alpha_1 - B_0\cos\alpha_1;$$
$$c_2 = -\omega(A_0\cos\alpha_1 - B_0\sin\alpha_1);\ k_1 = -n + \sqrt{n^2 + a};$$
$$k_2 = -n - \sqrt{n^2 + a};\ B_0 = g\frac{\omega^2 + a + 2n\omega f}{\Delta};\ A_0 = g\frac{\omega^2 + a - 2n\omega f}{\Delta}; \quad (10)$$
$$\Delta = (\omega^2 + a)^2 + 4n^2\omega^2;\ \alpha_1 = \alpha_0 + \beta.$$

By depicting the solution of equation (6) in the form of a graph at different masses, it is possible to analyze the preservation of short fibers on the surface of a combined saw-metal brush cylinder or cases of separation from it.
Graphs of the change in fiber displacement r (t) over time in a cylinder with a combined saw-metal brush according to the calculation results are presented in Fig. 4. The calculation yields t1=0.0125 sec. Analyzing the graphs, it was established that short

fibers with masses m=0.1 g and m=0.2 g are not stored in a combined saw-metal brush cylinder.

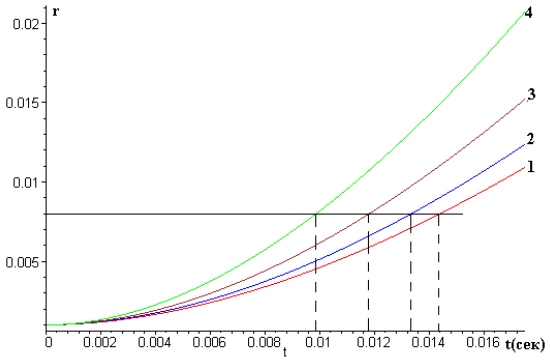

Fig. 4. Graphs of the displacement of short fibers of different masses over time on the surface of a combined saw-metal brush cylinder:
1. 2; 3; 4.

If the abrasive short fibers satisfy the condition of movement along the surface of the combined saw-metal brush cylinder, such a mass of fibers remains on the surface of the combined saw-metal brush cylinder, then such a short fiber separates from the surface of the combined saw-metal brush cylinder and turns into a free fiber. The following values were taken in the calculation:

$$R = 0.125m,\ L = 0.05m,\ c = 0.001Hc/m,\ v_0 = 10m/s,\omega = 7{,}5crl/s,\ r_1 = 1мм,\ r_0 = 2{,}0mm,$$

$$f = 0.2,\ \alpha_0 = 15^0,\ \beta = 15^0.$$

The adequacy of the regression equation and model obtained according to the Fisher criterion was determined, taking into account the calculated value of the Cochran criterion.

Conclusion: Multi-factor experiments were conducted through mathematical planning of the experiments. As a result of the conducted experiments, the following optimal parameters were obtained: x_1 - productivity of the improved delinter for the delinted seeds - 520 kg/hour, x_2 - air consumption from the upper chamber of the delinter - 1.5 m3/s, x_3 - rotational speeds of the combined saw-metal brush drum in the upper chamber of the delinter-810 rpm. Due to the fact that the upper chamber of the improved delinter was modified into a multifaceted one, and high-performance combined saw-metal brush cylinders were used in its chambers, and the product obtained from the upper chamber was separated using separate pneumatic pipes, it was possible to obtain 3-5% lint instead of lint.

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YANGI O‘ZBEKISTONNING QADIMGI SIVILIZATSIYALARDAN MUSTAQILLIK DAVRIGACHA RIVOJLANISH BOSQICHLARI

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Annotatsiya: Mazkur maqolada Yangi O‘zbekistonning shakllanish jarayoni qadimgi sivilizatsiyalardan boshlab mustaqillik davrigacha bo‘lgan tarixiy bosqichlar asosida tahlil qilinadi. Unda O‘zbekiston hududida yuzaga kelgan dastlabki davlatlar, Buyuk Ipak yo‘li orqali rivojlangan savdo-iqtisodiy aloqalar, islom sivilizatsiyasi davridagi ilmiy yuksalish, Temuriylar davrining ijtimoiy-iqtisodiy taraqqiyoti hamda xonliklar, mustamlaka va sovet davrlaridagi o‘zgarishlar yoritib berilgan. Shuningdek, mustaqillik yillarida amalga oshirilgan islohotlar va “Yangi O‘zbekiston” konsepsiyasining mazmun-mohiyati ochib beriladi.

Kalit so’zlar: O‘zbekiston tarixi, qadimgi sivilizatsiyalar, Buyuk Ipak yo‘li, Temuriylar davri, mustamlaka davri, sovet davri, mustaqillik, Yangi O‘zbekiston, iqtisodiy islohotlar, madaniy rivojlanish, tarixiy meros.

KIRISH

O‘zbekiston hududi insoniyat sivilizatsiyasining eng qadimiy markazlaridan biri bo‘lib, ming yillar davomida yirik tarixiy jarayonlar, davlatlar, madaniyatlar va ilmiy maktablar shakllangan makon hisoblanadi. Bugungi “Yangi O‘zbekiston” konsepsiyasi ham ana shu boy tarixiy merosga tayangan holda rivojlanmoqda.

Mamlakat taraqqiyotining tarixiy bosqichlarini o‘rganish zamonaviy islohotlar mazmunini chuqur anglashga va kelajak rivojlanish strategiyalarini to‘g‘ri belgilashga yordam beradi. Shu jihatdan O‘zbekiston tarixini qadimgi davrlardan boshlab mustaqillik va hozirgi islohotlar davrigacha bo‘lgan uzviy jarayon sifatida tahlil qilish muhim ahamiyatga ega.

1. QADIMGI SIVILIZATSIYALAR VA DASTLABKI DAVLATLAR

O‘zbekiston hududi insoniyat tarixining eng qadimiy sivilizatsiya o‘choqlaridan biri hisoblanadi. Miloddan avvalgi ming yilliklarda bu hududda yuksak madaniyatga ega bo‘lgan ilk davlat tuzilmalari shakllangan. Xususan, Xorazm, Baqtriya va So‘g‘diyona kabi tarixiy hududlar Markaziy Osiyoda siyosiy, iqtisodiy va madaniy rivojlanishning muhim markazlari sifatida ajralib turgan.

Mazkur davlatlarda sug‘orma dehqonchilik tizimi rivojlanib, Amudaryo va Sirdaryo havzalarida yirik irrigatsiya inshootlari barpo etilgan. Bu esa qishloq xo‘jaligi mahsuldorligini oshirishga va aholining o‘troq hayot tarziga o‘tishiga zamin yaratgan.

Chorvachilik, ayniqsa ko‘chmanchi va yarim ko‘chmanchi aholining asosiy mashg‘ulotlaridan biri bo‘lib, iqtisodiy tizimning muhim tarkibiy qismi hisoblangan.

Shu bilan birga, hunarmandchilik ham yuqori darajada rivojlangan. Kulolchilik, metallga ishlov berish, to‘qimachilik va zargarlik kabi sohalar nafaqat ichki ehtiyojlarni qondirgan, balki tashqi savdoda ham muhim o‘rin tutgan. Bu esa hududlararo iqtisodiy aloqalarning kengayishiga olib kelgan.

Savdo-sotiq munosabatlarining rivojlanishi natijasida dastlabki shaharlar paydo bo‘lib, ular iqtisodiy va ma’muriy markazlarga aylangan. Shaharlarning shakllanishi bilan birga ijtimoiy mehnat taqsimoti chuqurlashgan, boshqaruv tizimlari murakkablashgan va davlat institutlari rivojlangan.

Qadimgi davrda shakllangan ushbu iqtisodiy, ijtimoiy va siyosiy asoslar keyingi tarixiy bosqichlarda yirik davlatlarning paydo bo‘lishi va sivilizatsiyalarning rivojlanishi uchun mustahkam poydevor vazifasini bajargan. Aynan shu jarayonlar O‘zbekiston hududini qadimdan rivojlangan madaniyat va sivilizatsiya markazlaridan biriga aylantirgan.

2. BUYUK IPAK YO‘LI VA XALQARO SAVDO ALOQALARI

O‘zbekiston hududi qadimdan Sharq va G‘arbni bog‘lovchi strategik makon bo‘lib kelgan. Ayniqsa, **Buyuk Ipak yo‘li** bu hududning iqtisodiy va madaniy taraqqiyotida beqiyos rol o‘ynagan.

Buyuk Ipak yo‘li orqali Xitoy, Hindiston, Eron, Arab mamlakatlari va Yevropa o‘rtasida keng ko‘lamli savdo aloqalari yo‘lga qo‘yilgan. Ushbu yo‘l orqali ipak, ziravorlar, qimmatbaho toshlar, metall buyumlar, hunarmandchilik mahsulotlari kabi turli tovarlar almashinuvi amalga oshirilgan. Bu esa nafaqat iqtisodiy rivojlanishni ta’minlagan, balki hududlar o‘rtasida savdo infratuzilmasining shakllanishiga ham turtki bergan.

Ipak yo‘lining eng muhim jihatlaridan biri shundaki, u faqat savdo yo‘li bo‘lib qolmay, balki madaniyatlararo muloqot vositasiga aylangan. Ushbu yo‘l orqali ilm-fan yutuqlari, texnologiyalar, diniy qarashlar va madaniy qadriyatlar keng hududlarga tarqalgan. Natijada turli sivilizatsiyalar o‘rtasida o‘zaro ta’sir va boyish jarayoni yuzaga kelgan.

Bu jarayon ayniqsa Samarqand, Buxoro va Xiva kabi shaharlarda yaqqol namoyon bo‘lgan. Ushbu shaharlar yirik savdo markazlariga aylanish bilan birga ilm-fan, madaniyat va hunarmandchilik rivojlangan maskanlar sifatida ham tanilgan. Bu yerda karvonsaroylar, bozorlar, ustaxona va madrasalar faoliyat yuritib, xalqaro savdo va madaniy almashinuvning rivojlanishiga xizmat qilgan.

Shuningdek, Buyuk Ipak yo‘li transport va logistika tizimlarining rivojlanishiga ham katta ta’sir ko‘rsatgan. Karvon yo‘llari, yo‘l bo‘yi infratuzilmalari va savdo markazlarining shakllanishi hududlararo iqtisodiy integratsiyani kuchaytirgan.

Umuman olganda, Buyuk Ipak yo‘li O‘zbekiston hududini xalqaro sivilizatsiyalar o‘rtasidagi muhim bog‘lovchi ko‘prikka aylantirib, uning iqtisodiy va madaniy taraqqiyotida beqiyos ahamiyat kasb etgan. Bu tarixiy jarayon bugungi kunda ham mamlakatning global aloqalarini rivojlantirishda muhim tarixiy asos bo‘lib xizmat qilmoqda.

3. ISLOM UYG‘ONISH DAVRI VA ILMIY TARAQQIYOT

VII–VIII asrlardan boshlab Markaziy Osiyo hududida islom dini keng tarqalib, bu jarayon jamiyatning ijtimoiy, siyosiy va madaniy hayotida tub burilish yasadi. Islom sivilizatsiyasining kirib kelishi bilan yangi qadriyatlar, ilmiy an’analar va boshqaruv tamoyillari shakllandi. Ayniqsa, Buxoro va Samarqand shaharlari islom olamining yirik ilmiy va madaniy markazlariga aylandi.

Mazkur davr tarixda “Sharq Uyg‘onish davri” nomi bilan mashhur bo‘lib, ilm-fan va tafakkur rivojining yuqori bosqichi sifatida e’tirof etiladi. Bu davrda Markaziy Osiyodan yetishib chiqqan buyuk allomalar jahon ilm-fani taraqqiyotiga ulkan hissa qo‘shdilar. Jumladan, matematika, astronomiya, tibbiyot, geografiya va falsafa sohalarida muhim ilmiy kashfiyotlar amalga oshirildi.

Xususan, Muhammad al-Xorazmiy matematika va algebra faniga asos solib, hisoblash tizimlarini rivojlantirdi. Shuningdek, Abu Ali ibn Sino tibbiyot sohasida beqiyos ilmiy meros qoldirib, uning asarlari asrlar davomida dunyo tibbiyotida asosiy qo‘llanma bo‘lib xizmat qilgan. Bundan tashqari, Abu Rayhon Beruniy astronomiya, geografiya va fizika fanlari rivojiga katta hissa qo‘shgan.

Bu davrda ilmiy maktablar, kutubxonalar va madrasalar faoliyati kengayib, ilm olish jarayoni tizimli shaklga keltirildi. Madrasalar nafaqat diniy bilim beruvchi maskan, balki ilmiy tadqiqotlar olib boriladigan markaz sifatida ham faoliyat yuritgan. Bu esa ilm-fanning rivojlanishiga va bilimlarning avloddan-avlodga o‘tishiga xizmat qilgan.

Shuningdek, ushbu davrda tarjima faoliyati ham keng rivojlanib, yunon, hind va boshqa sivilizatsiyalarga oid ilmiy asarlar arab tiliga tarjima qilindi. Bu esa ilmiy bilimlarning boyishiga va yangi ilmiy g‘oyalar shakllanishiga imkon yaratdi.

Umuman olganda, Islom uyg‘onish davri Markaziy Osiyo, xususan O‘zbekiston hududini jahon ilm-fani va madaniyatining muhim markaziga aylantirdi. Bu davrda yaratilgan ilmiy meros keyingi asrlar rivoji uchun mustahkam asos bo‘lib xizmat qildi va bugungi kunda ham o‘z ahamiyatini yo‘qotmagan.

4. AMIR TEMUR VA TEMURIYLAR DAVLATI

O‘zbekiston tarixining eng yuksak va shonli bosqichlaridan biri Temuriylar davri hisoblanadi. Bu davr **Amir Temur** nomi bilan chambarchas bog‘liq bo‘lib, u tomonidan asos solingan davlat qisqa vaqt ichida ulkan hududlarni qamrab olgan qudratli imperiyaga aylangan.

Amir Temur markazlashgan kuchli davlat barpo etish orqali siyosiy barqarorlikni ta’minladi. U o‘z davrida samarali boshqaruv tizimini joriy etib, harbiy, ma’muriy va iqtisodiy sohalarda muhim islohotlarni amalga oshirdi. Natijada davlat ichki va tashqi siyosatda mustahkam o‘rin egalladi.

Temuriylar davrida iqtisodiyot sezilarli darajada rivojlandi. Savdo yo‘llari tiklanib, xalqaro savdo aloqalari kengaydi. Diplomatika sohasida ham yutuqlarga erishilib, turli davlatlar bilan siyosiy va iqtisodiy aloqalar o‘rnatildi. Bu esa mamlakatning global miqyosdagi nufuzini oshirdi.

Samarqand shahri imperiyaning poytaxti sifatida nafaqat siyosiy markaz, balki ilm-fan va madaniyat o‘chog‘iga aylandi. Bu yerda ko‘plab olimlar, me’morlar va san’atkorlar jamlanib, ijodiy faoliyat olib bordilar.

Temuriylar davrining eng muhim jihatlaridan biri – me’morchilik san’atining yuksak darajada rivojlanishidir. Samarqand, Buxoro va boshqa shaharlarda bunyod etilgan masjidlar, madrasalar va maqbaralar o‘zining betakror me’moriy uslubi bilan ajralib turadi. Ushbu inshootlar bugungi kunda ham jahon madaniy merosining muhim qismi sifatida e’tirof etiladi.

Shuningdek, bu davrda ilm-fan ham yuksak darajada rivojlandi. Ayniqsa, Mirzo Ulug‘bek tomonidan barpo etilgan rasadxona astronomiya fanining rivojlanishida muhim rol o‘ynadi. Ulug‘bekning ilmiy ishlari va yulduzlar jadvali jahon ilm-fanida katta ahamiyat kasb etgan.

Umuman olganda, Temuriylar davri O‘zbekiston tarixida siyosiy barqarorlik, iqtisodiy taraqqiyot, ilm-fan va madaniyatning yuksalishi bilan ajralib turadi. Bu davrda yaratilgan boy tarixiy va madaniy meros bugungi kunda ham o‘z ahamiyatini saqlab qolgan.

5. XONLIKLAR DAVRI VA SIYOSIY PARCHALANISH

Temuriylar davlatining zaiflashuvi va parchalanishi natijasida Markaziy Osiyo hududida bir necha mustaqil siyosiy tuzilmalar – Buxoro, Xiva va Qo‘qon xonliklari shakllandi. Ushbu davr O‘zbekiston tarixida siyosiy markazlashuvning susayishi va hududiy boshqaruvning bo‘linib ketishi bilan tavsiflanadi.

Har bir xonlik o‘ziga xos boshqaruv tizimi, iqtisodiy siyosati va tashqi aloqalariga ega bo‘lgan. Xonliklar o‘rtasida ba’zan savdo-iqtisodiy aloqalar rivojlangan bo‘lsa-da,

ko‘pincha hududiy nizolar va harbiy to‘qnashuvlar yuzaga kelib turgan. Bu esa umumiy siyosiy barqarorlikka salbiy ta’sir ko‘rsatgan.

Mazkur davrda iqtisodiyot asosan qishloq xo‘jaligi va hunarmandchilikka tayanib rivojlangan. Sug‘orma dehqonchilik an’analari davom ettirilib, paxtachilik, bog‘dorchilik va chorvachilik asosiy xo‘jalik tarmoqlari sifatida saqlanib qolgan. Hunarmandchilik, xususan kulolchilik, zargarlik, to‘qimachilik va yog‘och o‘ymakorligi yuqori darajada rivojlangan bo‘lib, ichki bozor ehtiyojlarini qondirish bilan birga tashqi savdoda ham muhim o‘rin tutgan.

Savdo aloqalari to‘liq uzilib qolmagan. Karvon yo‘llari orqali qo‘shni hududlar bilan iqtisodiy munosabatlar davom ettirilgan. Bozorlar, karvonsaroylar va savdo markazlari iqtisodiy hayotning muhim tarkibiy qismi bo‘lib qolgan.

Biroq ichki siyosiy nizolar, markazlashgan boshqaruvning yo‘qligi va tashqi xavf-xatarlar iqtisodiy rivojlanishni sekinlashtirgan. Bu holat xonliklarning harbiy va iqtisodiy jihatdan zaiflashishiga olib kelgan.

Shunga qaramay, mazkur davrda milliy an’analar, urf-odatlar va madaniy meros saqlanib qolgan. Adabiyot, xalq og‘zaki ijodi, me’morchilik va hunarmandchilik rivoji davom etib, xalqning madaniy o‘ziga xosligi asrab qolingan.

Umuman olganda, xonliklar davri siyosiy parchalanganlik bilan xarakterlansa-da, iqtisodiy va madaniy hayotning uzluksiz davom etgani bilan ham ahamiyatlidir. Bu davr keyingi tarixiy jarayonlar, jumladan mustamlaka davriga o‘tish uchun muayyan sharoitlarni shakllantirib berdi.

6. MUSTAMLAKA DAVRI VA IJTIMOIY-IQTISODIY O‘ZGARISHLAR

XIX asrning ikkinchi yarmida Markaziy Osiyo, jumladan hozirgi O‘zbekiston hududi Rossiya imperiyasining Turkistonni bosib olishi natijasida Rossiya imperiyasi tarkibiga kiritildi. Bu jarayon mintaqaning siyosiy tuzilmasi, iqtisodiy tizimi va ijtimoiy hayotida tub o‘zgarishlarga olib keldi.

Mustamlaka davrida hududda yangi boshqaruv tizimi joriy etilib, mahalliy hokimiyat tuzilmalari imperiya manfaatlariga moslashtirildi. Siyosiy qarorlar markaz tomonidan qabul qilinib, hududning iqtisodiy resurslari asosan imperiya ehtiyojlariga yo‘naltirildi.

Iqtisodiy sohada muhim o‘zgarishlar yuz berdi. Temir yo‘llarning qurilishi, xususan, Transkaspiy va boshqa yo‘nalishlarning ishga tushirilishi hududni tashqi bozorlar bilan bog‘lashga xizmat qildi. Bu esa savdo hajmining oshishiga va yangi iqtisodiy aloqalarning shakllanishiga olib keldi. Shu bilan birga, sanoatning dastlabki shakllari paydo bo‘lib, paxta tozalash zavodlari, kichik ishlab chiqarish korxonalari tashkil etildi.

Biroq iqtisodiyotning rivojlanishi asosan xomashyo yetishtirishga yo‘naltirilgan edi. Paxtachilikning keskin kengaytirilishi natijasida qishloq xo‘jaligida bir yoqlama

ixtisoslashuv yuzaga keldi. Bu esa oziq-ovqat xavfsizligiga salbiy ta’sir ko‘rsatdi va iqtisodiy muvozanatni buzdi.

Ijtimoiy hayotda ham sezilarli o‘zgarishlar kuzatildi. Aholi turmush tarzida yangilanishlar yuzaga kelgan bo‘lsa-da, mustamlaka siyosati mahalliy aholining huquq va manfaatlarini cheklab qo‘ydi. Ijtimoiy tengsizlik kuchayib, boy va kambag‘al qatlamlar o‘rtasidagi tafovut ortdi.

Shu bilan birga, bu davrda ma’lum darajada ta’lim tizimi va madaniy hayotda ham o‘zgarishlar kuzatildi. Yangi usul maktablari paydo bo‘lib, jadidchilik harakati shakllandi. Bu harakat ma’rifatparvarlik, ilm-fan va milliy ongni rivojlantirishga qaratilgan bo‘lib, keyingi mustaqillik g‘oyalarining shakllanishiga zamin yaratdi.

Umuman olganda, mustamlaka davri O‘zbekiston tarixida qarama-qarshi jarayonlar bilan tavsiflanadi: bir tomondan infratuzilma va iqtisodiy aloqalar rivojlangan bo‘lsa, ikkinchi tomondan mahalliy iqtisodiyotning mustaqilligi cheklanib, ijtimoiy muammolar kuchaygan. Bu davr keyingi tarixiy bosqich – sovet davri va mustaqillik harakatlari uchun muhim tarixiy sharoitni shakllantirib berdi.

7. SOVET DAVRI VA INDUSTRIAL TARAQQIYOT

XX asr boshlarida Markaziy Osiyoda yuz bergan siyosiy o‘zgarishlar natijasida O‘zbekiston hududi Sovet Ittifoqining tashkil topishi tarkibiga kiritildi. Bu davr mamlakat tarixida markazlashgan boshqaruv tizimi, rejalashtirilgan iqtisodiyot va keng ko‘lamli ijtimoiy-iqtisodiy o‘zgarishlar bilan tavsiflanadi.

Sovet davrida sanoatlashtirish siyosati ustuvor yo‘nalishga aylandi. Yirik zavod va fabrikalar, sanoat korxonalari barpo etilib, og‘ir va yengil sanoat tarmoqlari rivojlantirildi. Ayniqsa, mashinasozlik, kimyo sanoati va energetika sohalari sezilarli darajada kengaydi. Bu jarayon mamlakatda urbanizatsiya darajasining oshishiga, yangi shahar va sanoat markazlarining vujudga kelishiga olib keldi.

Qishloq xo‘jaligida kollektivlashtirish siyosati amalga oshirilib, yirik kolxoz va sovxozlar tashkil etildi. Paxta yetishtirish asosiy tarmoq sifatida rivojlantirilib, O‘zbekiston sobiq ittifoqning muhim xomashyo bazasiga aylantirildi. Biroq bu bir yoqlama ixtisoslashuv ekologik muammolar, jumladan yer va suv resurslarining noto‘g‘ri foydalanilishiga olib keldi.

Ijtimoiy sohada sezilarli yutuqlarga erishildi. Ta’lim tizimi kengaytirilib, umumiy savodxonlik darajasi keskin oshdi. Oliy o‘quv yurtlari, ilmiy tadqiqot institutlari tashkil etilib, ilm-fan rivojiga e’tibor qaratildi. Sog‘liqni saqlash tizimi ham rivojlanib, aholiga tibbiy xizmat ko‘rsatish imkoniyatlari kengaydi.

Shu bilan birga, sovet davri siyosiy jihatdan cheklovlar bilan ham xarakterlanadi. Markazlashgan boshqaruv tizimi mahalliy tashabbuslarni cheklab qo‘ydi, milliy

qadriyatlar va an’analar ayrim davrlarda bosim ostida qoldi. Iqtisodiy siyosat esa asosan markaz manfaatlariga xizmat qilgan.

Umuman olganda, sovet davri O‘zbekiston tarixida sanoat va ijtimoiy infratuzilmaning rivojlanishi bilan birga, iqtisodiy mustaqillikning cheklanishi va ekologik muammolarning yuzaga kelishi bilan tavsiflanadi. Bu davr keyingi bosqich – mustaqillik davri uchun muhim tajriba va saboq bo‘lib xizmat qildi.

8. MUSTAQILLIK VA “YANGI O‘ZBEKISTON” BOSQICHI

1991-yilda O‘zbekiston mustaqilligi e’lon qilinishi bilan mamlakat tarixida tub burilish yuz berdi va yangi taraqqiyot bosqichi boshlandi. Mustaqillik O‘zbekistonga o‘zining siyosiy, iqtisodiy va ijtimoiy rivojlanish yo‘lini mustaqil belgilash imkonini berdi.

Mustaqillikning dastlabki yillarida iqtisodiyotni bozor munosabatlariga o‘tkazish, davlat boshqaruv tizimini isloh qilish va milliy davlatchilik asoslarini mustahkamlashga alohida e’tibor qaratildi. Xususiylashtirish jarayonlari amalga oshirilib, kichik biznes va xususiy tadbirkorlik rivojlantirildi. Bu esa iqtisodiyotda raqobat muhitini shakllantirishga xizmat qildi.

Ijtimoiy sohada ham keng ko‘lamli islohotlar amalga oshirildi. Ta’lim tizimi modernizatsiya qilinib, yangi o‘quv dasturlari va xalqaro standartlar joriy etildi. Sog‘liqni saqlash tizimi takomillashtirilib, aholiga sifatli tibbiy xizmat ko‘rsatish darajasi oshirildi. Ijtimoiy himoya tizimi kuchaytirilib, aholining turmush darajasini yaxshilashga qaratilgan dasturlar amalga oshirildi.

So‘nggi yillarda mamlakat taraqqiyotida yangi bosqich – “Yangi O‘zbekiston” konsepsiyasi shakllandi. Ushbu yondashuv davlat boshqaruvini yanada ochiq va samarali qilish, qonun ustuvorligini ta’minlash, fuqarolik jamiyatini rivojlantirish hamda inson manfaatlarini ustuvor qo‘yishga qaratilgan.

Iqtisodiy sohada diversifikatsiya siyosati amalga oshirilib, sanoat, xizmatlar sohasi va raqamli iqtisodiyot jadal rivojlantirilmoqda. Xorijiy investitsiyalarni jalb qilish, eksport salohiyatini oshirish va innovatsion texnologiyalarni joriy etish ustuvor yo‘nalishlarga aylandi.

Raqamli transformatsiya jarayoni ham jadallashib, davlat xizmatlari elektron shaklga o‘tkazilmoqda, biznes yuritish uchun qulay muhit yaratilmoqda. Bu esa mamlakatning xalqaro maydondagi raqobatbardoshligini oshirishga xizmat qilmoqda.

Shuningdek, O‘zbekistonning tashqi siyosatida ochiqlik va o‘zaro manfaatli hamkorlik tamoyillari ustuvor bo‘lib, mintaqaviy va xalqaro aloqalar sezilarli darajada kengaymoqda.

Umuman olganda, mustaqillik va “Yangi O‘zbekiston” bosqichi mamlakat tarixida yangi sifat darajasini boshlab berdi. Bu davrda amalga oshirilayotgan keng ko‘lamli

islohotlar O‘zbekistonni barqaror, raqobatbardosh va zamonaviy davlat sifatida rivojlantirishga xizmat qilmoqda.

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BIOLOGIYA VA ZOOLOGIYA FANLARINI O‘QITISHDA MUAMMOLI VAZIYATLAR ASOSIDA STEAM YONDASHUVNI QO‘LLASH ORQALI O‘QUVCHILARNING TADQIQOTCHILIK KOMPETENSIYALARINI RIVOJLANTIRISH.

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Annotatsiya: Ushbu maqolada zoologiya fanini o‘qitishda STEAM (Science, Technology, Engineering, Art, Mathematics) yondashuvini qo‘llashning nazariy-metodik asoslari, amaliy imkoniyatlari hamda o‘quvchilarning kompetensiyalarini rivojlantirishdagi samaradorligi tahlil etilgan. Tadqiqot jarayonida STEAM integratsiyasi asosida o‘qitishning afzalliklari, dars jarayonida qo‘llaniladigan usullar, loyiha va tajribalar misolida o‘quvchilarning ilmiy fikrlash, muammo yechish, ijodkorlik, ekologik savodxonlik hamda raqamli madaniyat kabi kompetensiyalarining shakllanishi o‘rganildi. Natijalar shuni ko‘rsatdiki, STEAM asosidagi mashg‘ulotlar zoologiya fanini o‘rganishga qiziqishni oshiradi, nazariy bilimlarning hayot bilan bog‘lanishini ta’minlaydi va o‘quvchilarni real muammolarni hal qilishga yo‘naltiradi.
Kalit so‘zlar: STEAM ta’limi, zoologiya, biologiya ta’limi, innovatsion pedagogika, fanlararo integratsiya, raqamli texnologiyalar, 3D modellashtirish, virtual laboratoriyalar, biomimikriya, ekologik savodxonlik, populyatsiya dinamikasi, loyiha asosida o‘qitish, kreativ fikrlash, ilmiy izlanish, kompetensiya yondashuvi, interaktiv metodlar, tajriba-sinov ishlari, injenerlik yondashuvi, ta’lim samaradorligi, ekologik muvozanat.

Kirish: Hozirgi kunda ta’lim tizimida amalga oshirilayotgan islohotlar o‘quv jarayonini zamonaviy pedagogik yondashuvlar asosida tashkil etishni taqozo etmoqda. Jamiyatning ijtimoiy-iqtisodiy rivojlanishi, fan va texnologiyalarning jadal taraqqiyoti ta’lim tizimi oldiga o‘quvchilarda mustaqil fikrlash, muammolarni hal eta olish, ijodiy yondashuv hamda amaliy ko‘nikmalarni rivojlantirish kabi muhim vazifalarni qo‘ymoqda. Shu nuqtai nazardan, ta’lim jarayonida integrativ yondashuvga asoslangan

STEAM (Science, Technology, Engineering, Art, Mathematics) ta’lim texnologiyalarini qo‘llash dolzarb masalalardan biri hisoblanadi.

Biologiya fani tabiatdagi tirik organizmlarning tuzilishi, rivojlanishi va o‘zaro bog‘liqligini o‘rganadigan muhim fanlardan biri bo‘lib, u o‘quvchilarda ilmiy dunyoqarashni shakllantirishda alohida ahamiyatga ega. Mazkur fan o‘quvchilardan nafaqat nazariy bilimlarni egallashni, balki kuzatish, tahlil qilish, taqqoslash, xulosa chiqarish hamda olingan bilimlarni amaliyotda qo‘llash kabi ko‘nikmalarni ham talab etadi. Shu sababli biologiya darslarini tashkil etishda o‘quvchilarning faol bilish faoliyatini rag‘batlantiradigan zamonaviy metodlardan foydalanish muhim hisoblanadi.

Muammoli ta’lim texnologiyasi ana shunday samarali pedagogik yondashuvlardan biri bo‘lib, u o‘quvchilarning mustaqil fikrlashini rivojlantirish, muammoli vaziyatlarni tahlil qilish va ularni hal etish jarayonida yangi bilimlarni egallash imkonini beradi. Dars jarayonida muammoli vaziyatlarni yaratish orqali o‘quvchilar mavzu yuzasidan savollar qo‘yadi, fikr yuritadi, o‘z nuqtai nazarini asoslaydi hamda muammoga turli yondashuvlar orqali yechim topishga harakat qiladi. Bu jarayon esa o‘quvchilarning ijodiy va tanqidiy fikrlash ko‘nikmalarining shakllanishiga xizmat qiladi.

Biologiya fanining muhim bo‘limlaridan biri bo‘lgan zoologiya tirik organizmlar dunyosining muhim qismi bo‘lgan hayvonlarning tuzilishi, hayot faoliyati, xilma-xilligi va tabiatdagi ahamiyatini o‘rganadi. Zoologiya fani o‘quvchilarda tabiatga nisbatan ilmiy dunyoqarashni shakllantirish bilan birga, kuzatish, tahlil qilish, taqqoslash va xulosa chiqarish kabi muhim bilish ko‘nikmalarini rivojlantirishga xizmat qiladi. Shu sababli zoologiya fanini o‘qitishda o‘quvchilarning amaliy faoliyatini faollashtiradigan, ularni tadqiqotga yo‘naltiradigan zamonaviy pedagogik texnologiyalardan foydalanish muhim hisoblanadi.

STEAM ta’lim texnologiyasi fanlararo integratsiya asosida tashkil etilgan ta’lim modeli bo‘lib, unda tabiiy fanlar, texnologiya, muhandislik, san’at va matematika o‘zaro uyg‘un holda o‘qitiladi. Ushbu yondashuv o‘quvchilarning bilimlarini faqat nazariy jihatdan emas, balki amaliy faoliyat orqali mustahkamlashga, ularning tadqiqotchilik qobiliyatlarini rivojlantirishga ham xizmat qiladi. Zoologiya darslarida STEAM yondashuvidan foydalanish orqali o‘quvchilar turli tajribalar o‘tkazadi, kuzatishlar olib boradi, muammoli vaziyatlarni hal qiladi hamda o‘z bilimlarini amaliyotda qo‘llash imkoniyatiga ega bo‘ladi.

Shuningdek, STEAM texnologiyalarini qo‘llash o‘quvchilarning ijodiy fikrlashini rivojlantiradi, ularni mustaqil izlanishga undaydi va fanlararo bog‘liqlikni anglashga yordam beradi. Zoologiya fanini o‘qitishda turli tajribalar, kuzatish ishlari, loyiha faoliyati hamda modellashtirish jarayonlari orqali o‘quvchilarning amaliy va

tadqiqotchilik kompetensiyalari shakllanadi. Bu esa o‘quvchilarning biologiya faniga bo‘lgan qiziqishini oshirish bilan birga, ularning ilmiy tafakkurini rivojlantirishga xizmat qiladi.

Hozirgi kunda ta’lim tizimida kompetensiyaviy yondashuv asosida o‘qitish muhim ahamiyat kasb etmoqda. Shu sababli zoologiya fanini o‘qitishda STEAM ta’lim texnologiyalaridan foydalanish orqali o‘quvchilarning amaliy va tadqiqotchilik kompetensiyalarini rivojlantirish masalasini ilmiy-pedagogik jihatdan o‘rganish muhim hisoblanadi.

Mazkur tadqiqot ishida zoologiya fanini o‘qitishda STEAM ta’lim texnologiyalaridan foydalanishning nazariy asoslari, metodik imkoniyatlari hamda o‘quvchilarning amaliy va tadqiqotchilik kompetensiyalarini rivojlantirishdagi samaradorligi ilmiy-pedagogik jihatdan tahlil qilinadi.

XXI asrda ta’lim jarayonining modernizatsiyasi global tendensiyalar ta’sirida yangi pedagogik yondashuvlarga ehtiyojni kuchaytiradi. Ayniqsa tabiiy fanlarning amaliy ahamiyatini oshirish, o‘quvchilarda ilmiy fikrlash, tadqiqotchilik va texnik kreativlikni shakllantirish dolzarb masalalardan biri hisoblanadi. Shu nuqtai nazardan STEAM ta’lim texnologiyalari o‘quv jarayonini innovatsion, integrativ va tadqiqotga yo‘naltirilgan holga keltirishning eng samarali vositalaridan biri bo‘lib bormoqda.

Zoologiya — biologiya fanining asosiy bo‘limlaridan biri sifatida murakkab biologik jarayonlar, turli hayvonlar guruhlarining morfologiyasi, fiziologiyasi, evolyutsiyasi va ekologiyasini o‘rganadi. An’anaviy yondashuvlar ko‘pincha nazariy bilimlar bilan chegaralanib qolgan bo‘lsa, STEAM yondashuvi mazkur bilimlarni amaliyot, raqamli texnologiyalar va muammoli vaziyatlar bilan boyitishga yordam beradi.

Shu sababli zoologiya fanida STEAM yondashuvini qo‘llash — fanni zamonaviy talablarga mos ravishda o‘qitishning muhim bosqichi hisoblanadi.

1. STEAM TA’LIMINING NAZARIY ASOSLARI

STEAM — beshta asosiy yo‘nalishlar sinteziga asoslanadi:

- **S (Science)** — ilmiy izlanish, kuzatish va tajriba o‘tkazish;
- **T (Technology)** — raqamli texnologiyalar, dasturlash, virtual laboratoriyalar;
- **E (Engineering)** — modellashtirish, konstruktsiya yaratish, muammolarni injenerlik yondashuvi bilan hal qilish;
- **A (Art)** — dizayn, vizual modellashtirish, kreativ ifoda;
- **M (Mathematics)** — hisob-kitoblar, statistik tahlil, miqdoriy model yaratish.

Bu integratsiya natijasida o‘quvchi nafaqat bilim oladi, balki bilimni real hayotdagi vazifalarni bajarishda qo‘llay oladi.

2. ZOOLOGIYA FANIDA STEAM TEXNOLOGIYALARINI QO‘LLASHNING ZARURLIGI

Zoologiya fanini o‘qitishda quyidagi muammolar mavjud:

- mavzularning murakkabligi sababli tushunchalarni o‘zlashtirishda qiyinchiliklar;
- an’anaviy darslarda ko‘rgazmali materiallarning yetishmasligi;
- amaliy tajribalar o‘tkazish imkoniyatlarining cheklanganligi;
- o‘quvchilarning fan bilan hayot orasidagi bog‘liqlikni yetarli darajada ko‘ra olmasligi.

STEAM yondashuvi ushbu muammolarni hal qilishga yordam beradi. Masalan:

- hayvonlar anatomiyasining 3D modellarini yaratish,
- populyatsiyalarni matematik modellashtirish,
- biomimikriya asosida injenerlik loyihalari ishlab chiqish,
- hayvonlar yashash muhitini VR texnologiyalar orqali modellashtirish,
- ekologik muammolarni interaktiv loyihalar yordamida tahlil qilish.

3.METODOLOGIYA

Tadqiqot jarayonida quyidagi metodlardan foydalanildi:

- pedagogik kuzatish;
- eksperiment (nazorat va tajriba sinflari asosida);
- o‘quvchilar faoliyati mahsulotlarini tahlil qilish;
- so‘rovnoma va intervyular;
- STEAM darslari ssenariylarini ishlab chiqish va amaliyotga joriy etish.

Tajriba-pedagogik ishlar 7–9-sinflarda olib borildi. Mavzular “Umurtqasizlar zoologiyasi”, “Umurtqalilar zoologiyasi”, “Ekologiya” bo‘limlari asosida tanlandi.

4. ZOOLOGIYA FANIDA STEAM TEXNOLOGIYALARI ASOSIDA TASHKIL ETILGAN DARS NAMUNALARI

1. “Quyosh kapalaklarining ranglanish sabablari” mavzusida STEAM loyihasi

- **Science:** kapalak qanotlaridagi pigment va mikroyuzalar strukturasini o‘rganish.
- **Technology:** mikroskop ostida tasvirlarni raqamli qayta ishlash.
- **Engineering:** yorug‘lik sinishi modelini 3D dasturda yaratish.
- **Art:** ranglarning optik effektlarini san’at asarlarida tasvirlash.
- **Math:** yorug‘lik to‘lqin uzunliklarini hisoblash.

Natija: o‘quvchilar yorug‘lik fizikasi bilan biologiyaning bog‘liqligini angladilar.

2. “Qushlar parvoz mexanizmini o‘rganish” STEAM loyihasi

- qanot shaklining aerodinamik tahlili,
- turli shakldagi qanot modellarini 3D printerda yaratish,
- parvoz tezligi va ko‘tarilish kuchi bo‘yicha matematik hisoblar.

Natija: o‘quvchilar muammoli vaziyatlarda injenerlik fikrlashini rivojlantirdilar.

NATIJALAR

Tadqiqot natijalariga ko‘ra:

1. **O‘quvchilar bilim sifatida o‘sish 21–35 % ga ortdi.**
2. STEAM darslaridan so‘ng zoologiya faniga qiziqish sezilarli oshdi (so‘rovnoma natijasi bo‘yicha 78 % o‘quvchi fanga qiziqishi kuchayganini bildirgan).
3. Analitik fikrlash, kuzatish, tajriba o‘tkazish, loyiha qilish ko‘nikmalarida ijobiy o‘zgarishlar kuzatildi.
4. O‘quvchilar ekologik muammolarga ijodiy yechimlar taklif qila oldilar.
5. Guruhda ishlash, kommunikatsiya va dizayn kompetensiyalari rivojlandi.

Xulosa: Xulosa qilib aytganda, zamonaviy ta’lim jarayonida o‘quvchilarning amaliy va tadqiqotchilik kompetensiyalarini rivojlantirish, ularni mustaqil fikrlash, ijodiy va tanqidiy yondashuv asosida muammolarni hal eta olishga o‘rgatish muhim pedagogik vazifalardan biridir. Shu nuqtai nazardan zoologiya fanini o‘qitishda **STEAM ta’lim texnologiyalaridan** foydalanish ta’lim jarayonining samaradorligini oshirishda muhim vosita hisoblanadi.

Shuningdek, biologiya darslarida muammoli vaziyatlar yaratish o‘quvchilarning ijodiy tafakkuri va tanqidiy fikrlash ko‘nikmalarini shakllantirishga xizmat qiladi. O‘quvchilar muammoli vaziyatlarni hal etish jarayonida mustaqil izlanadi, mavjud bilimlarni yangi vaziyatlarda qo‘llaydi hamda turli yechim variantlarini taklif etadi. Bu jarayon esa o‘quvchilarning kreativ fikrlashi, tahliliy yondashuvi va muammolarni hal etish kompetensiyalarini rivojlantirishga yordam beradi.

Tadqiqot natijalari shuni ko‘rsatdiki, STEAM yondashuvi asosida tashkil etilgan darslar o‘quvchilarning nazariy bilimlarini amaliy faoliyat bilan mustahkamlash, turli tajribalar va loyiha ishlari orqali tadqiqotchilik ko‘nikmalarini rivojlantirishga xizmat qiladi. Shu bilan birga, o‘quvchilar fanlararo integratsiyani anglash, kuzatish va tahlil qilish, muammoli vaziyatlarni hal etish hamda o‘z yechimlarini asoslash kabi muhim bilim va ko‘nikmalarni egallaydi.

STEAM texnologiyalarini qo‘llash o‘quvchilarning darsga bo‘lgan qiziqishini oshiradi, ularni mustaqil izlanishga rag‘batlantiradi va ijodiy tafakkurini rivojlantiradi. Natijada o‘quvchilarda amaliy va tadqiqotchilik kompetensiyalari sezilarli darajada oshadi, ularning ilmiy tafakkuri va biologiya faniga qiziqishi kuchayadi.

Shunday qilib, zoologiya fanini o‘qitishda STEAM ta’lim texnologiyalarini tizimli va maqsadga muvofiq qo‘llash o‘quvchilarning amaliy va tadqiqotchilik kompetensiyalarini shakllantirishda yuqori pedagogik samaradorlikka ega bo‘lib, kelajakda ilmiy tafakkurga ega, kreativ va mustaqil fikrlay oladigan yosh avlodni tarbiyalashda muhim omil hisoblanadi.

Shu bois, zoologiya fanini o‘qitishda STEAM texnologiyalarini tizimli ravishda joriy etish, o‘qituvchilarning metodik malakasini oshirish va zamonaviy texnik vositalar bilan ta’minlash ta’lim sifatini yanada yuksaltirishning muhim omili hisoblanadi.

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DEVELOPMENT OF AN INVERSION VOLTAMMETRIC METHOD FOR DETERMINING Pb^{2+} IONS IN WASTEWATER

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Abstract. This article analyzes the theoretical and practical foundations for developing an inversion voltammetric method to determine Pb^{2+} ions in wastewater. The relevance of the topic is обусловлена? Need avoid Russian. Rewrite. The relevance of the topic is determined by the high toxicity of lead, its persistence in aquatic environments, and its ability to pose biological hazards even at low concentrations. The text examines, as an integrated system, the physicochemical essence of inversion voltammetry, its preconcentration stage and anodic recording process, as well as such factors as electrode material, supporting electrolyte, potential regime, time parameters, and matrix effects. Based on the work of Uzbek scientists, bismuth-modified carbon electrodes and biosorption-based preconcentration approaches are substantiated as among the most suitable directions specifically for Pb^{2+} monitoring. Local studies have shown a working range of 10–160 μg/dm³ and $R^2 \geq 0.98$ for the determination of Pb^{2+} and Cd^{2+} on Bi-modified electrodes, while some industrial laboratories have achieved detection down to 10 μg/L with a relative error of about 5%. On this basis, a methodological solution is proposed that relies on sample preparation for wastewater, electrode selection, optimization of the working medium, calibration by the standard addition method, and verification of results under complex matrix conditions.

Keywords. Pb^{2+}, wastewater, inversion voltammetry, anodic stripping voltammetry, bismuth-modified electrode, supporting electrolyte, biosorption preconcentration, standard addition method, electrochemical monitoring.

Introduction.

Lead is one of the most hazardous metal pollutants from ecological and sanitary perspectives. The World Health Organization notes that lead exposure damages many systems of the human body, and that the risk is especially high for children and women of reproductive age. According to WHO data, more than 1.5 million deaths in 2021 were associated with lead exposure, and there is no exposure level that can be considered safe. The presence of lead in aquatic environments is particularly important because it can enter drinking water, irrigation chains, or recycled process water. WHO maintains 10 μg/L as a provisional guideline value for drinking water and recommends keeping concentrations as low as possible. Under such conditions, a rapid, sensitive,

and economical method for determining Pb^{2+} in wastewater is not merely a laboratory issue, but an instrument of environmental safety.

In the Uzbek scientific school, a distinct research tradition has developed in analytical chemistry, chemical sensors, and modified electrodes, associated with such researchers as Academician Sh.T. Tolipov, A.M. Gevorgyan, M.A. Nasimov, and Z.A. Smanova. Local authors have developed practical solutions for determining heavy metal ions using carbon-paste, carbon-graphite, and bismuth-modified electrodes. The strength of this school lies in the fact that the studies did not remain at a purely theoretical level, but were linked to real objects such as zinc electrolytes, wastewater, natural waters, and process solutions. In developing a method for determining Pb^{2+} ions in wastewater, it is precisely this local experience that should serve as the foundation, because the value of a method lies not only in maximum sensitivity, but also in its reproducibility under domestic laboratory conditions, low cost, and adaptability to industrial monitoring.

Literature Review.

An analysis of the work of Uzbek researchers shows that inversion voltammetry was not chosen in this field by chance. In N.A. Atakulova's dissertation abstract, the development of a detection method using modified electrodes was structured as a consistent scientific task that included selecting the modifier, determining optimal conditions, identifying the half-wave potential, evaluating analytical and metrological characteristics, testing interfering ions, and applying the method to real samples. This approach is directly applicable to the determination of Pb^{2+} in wastewater, because the main problem is not simply detecting the presence of the ion, but reliably isolating and quantifying it in a complex ionic and organic matrix. Local literature shows that modified carbon-paste electrodes can improve sensitivity, selectivity, and the working concentration range.

One of the most important local results directly relevant to Pb^{2+} is the work of S.D. Aronbayev and co-authors on bismuth-modified carbon electrodes. In that study, bismuth was shown to be a suitable modifier for stripping analysis because it is far less toxic than mercury and is capable of forming intermetallic systems with many heavy metal ions. The authors demonstrated the possibility of determining trace amounts of Pb^{2+} and Cd^{2+} using Bi-modified electrodes, and reported a working range of 10–160 $\mu g/dm^3$ for Pb^{2+} with a calibration curve showing R^2 of at least 0.98. The experimental conditions were also clearly specified: 0.2 M HCl + $0.5 \cdot 10^{-4}$ M $Bi(NO_3)_3$, pH < 1, Eacc = –1.2 V, tacc = 60 s, and a scan rate of 50 mV/s. These data provide a ready-made local foundation for developing a Pb^{2+} method.

A second important direction in local sources is associated with preconcentration. In Aronbayev's doctoral research, a method was developed for the inversion voltammetric determination of Cd^{2+}, Pb^{2+}, and Cu^{2+} in aqueous media using biosorbents based on yeast cell walls. It was shown that this approach can increase sensitivity by one to two orders of magnitude and keep the error below 10%. In addition, Pb^{2+} exhibited a higher tendency toward biosorption than Cd^{2+} and Cu^{2+}, and a flow rate of 2–5 mL/min was found optimal for effective sorption under dynamic conditions. This result is highly important for wastewater analysis, because in real samples Pb^{2+} is often detected more accurately after preconcentration due to the presence of background ions and organic matter.

Analysis and Results.

The essence of inversion voltammetry in the determination of Pb^{2+} is based on a two-stage process. First, at a certain potential, the ions are accumulated on the electrode surface or reduced to the metallic state and preconcentrated. Then, when the potential is shifted in the anodic direction, the accumulated substance passes back into solution, and the resulting current maximum is proportional to the amount of analyte. The main advantage of the method is that the analytical signal is amplified by the mass accumulated during the preconcentration stage. For this reason, for trace metal ions such as lead, this approach can work at low concentrations even without expensive instruments such as atomic absorption spectrometers or ICP systems. The practical value of stripping voltammetry is also confirmed by the fact that the U.S. EPA has described a method for determining lead in water by differential pulse anodic stripping voltammetry as an official method.

The most important stage in the development of a methodology for determining Pb^{2+} in wastewater is sample preparation. If the aim is to determine dissolved Pb^{2+}, the water sample should be passed through a 0.45 μm filter in the field or immediately upon arrival at the laboratory, and the filtrate should be acidified with HNO_3 to $pH < 2$. If the aim is to determine total recoverable lead, the sample should not be filtered, but instead acidified directly and homogenized before analysis. This exact approach is recommended in EPA Method 200.8. Because wastewater contains a large amount of suspended matter, colloids, and organic substances, neglecting this stage may lead to shifts in voltammetric peaks or underestimation of the signal. Therefore, more than the "physical sensitivity" of the method, it is "sample discipline" that becomes the decisive factor.

Based on local results, the main recommended working scheme for Pb^{2+} can be formulated as follows. A three-electrode cell is used. The working electrode is an ex situ bismuth-modified carbon-graphite paste electrode, the reference electrode is

Ag/AgCl, and the auxiliary electrode is made of an inert material. The supporting electrolyte is selected as 0.2 M HCl + $0.5 \cdot 10^{-4}$ M $Bi(NO_3)_3$. The accumulation potential is –1.2 V, the accumulation time is 60 s, the potential sweep range is from –1.2 to +0.3 V, the alternating voltage amplitude is 20 mV, and the scan rate is 50 mV/s. In local studies, linearity for Pb^{2+} was observed under exactly these conditions in the 10–160 μg/dm³ range. This interval can be considered a practically sufficient starting zone for many wastewater monitoring situations.

In such a methodology, calibration is more appropriately performed not by an external standard method, but by the standard addition method. The reason is that the ionic strength of wastewater, chloride content, surfactants, dissolved organics, and multimetal character do not affect the electrode process uniformly. In local doctoral research, the “method of additions” and the “introduced–found” approach were used as reliability criteria for real, model, and reference samples. Applying the same approach to Pb^{2+} protects the analytical result from matrix-related errors. In practice, this means that known concentrations of a Pb^{2+} standard solution are added to three or four aliquots of the same sample, and the initial amount is recalculated from the change in peak height. This method appears simple, but for complex objects such as wastewater it is one of the most correct approaches.

If the Pb^{2+} content in the sample is very low or the matrix is highly aggressive, it is advisable to introduce a biosorption preconcentration stage into the method. Aronbayev’s work demonstrated that Pb^{2+}, Cd^{2+}, and Cu^{2+} can first be accumulated on a biosorbent based on yeast cell walls, then desorbed, and finally determined by inversion voltammetry. According to the authors’ data, this approach increased sensitivity by one to two orders of magnitude, kept the error below 10%, and was implemented in the practice of the Navoi Mining and Metallurgical Combine. Another local source reported that, using a bismuth electrode, Cd^{2+} and Pb^{2+} could be determined in wastewater and natural waters down to 10 μg/L, with a relative error of about 5%, and that the method was introduced into the laboratory of the Muborak Gas Processing Plant. These results make it possible to evaluate the proposed methodology for wastewater not as a theoretical concept, but as a practical solution.

The issue of electrode material is of particular importance in the determination of Pb^{2+}. Historically, mercury electrodes have been highly sensitive in stripping analysis, but their high toxicity creates serious limitations from both ecological and laboratory safety perspectives. Local authors therefore selected bismuth as a suitable alternative. Bismuth is also capable of forming intermetallic phases, but its toxicity is significantly lower than that of mercury. In addition, Aronbayev and co-authors showed that, in a solution containing a Bi-modified electrode, the Cu^{2+} peak is not expressed as strongly

as it is on classical mercury electrodes. This may reduce the influence of certain neighboring cations during Pb^{2+} determination. In the work of N.A. Atakulova, D.A. Ziyayev, and co-authors on copper and zinc, it was also shown that modified graphite electrodes allow the inversion voltammetric determination of several metal ions in one sample. Thus, the method being developed for Pb^{2+} can in the future be expanded into a multielement monitoring format.

Based on local literature, the analytical characteristics of the proposed method for determining Pb^{2+} in wastewater can be summarized as follows. When working directly with a Bi-modified electrode, the linear working range is formed around 10–160 μg/dm³. If biosorption preconcentration is used, the sensitivity increases by one to two orders of magnitude, and the method can reach down to about 10 μg/L. In local voltammetric studies, a control level of 0.06 mg/dm³ for Pb^{2+} in wastewater monitoring has been mentioned. This means that the proposed method is sufficient not only for controlling that level, but also for working at values below it. In this respect, the method is suitable not merely for "presence or absence" testing, but also for evaluating wastewater treatment efficiency and controlling recycled water systems.

Discussion.

The advantage of inversion voltammetry for determining Pb^{2+} in wastewater lies in its simplicity, its suitability for automation, low reagent consumption, increased sensitivity through pre-accumulation of the analyte on the electrode surface, and the possibility of use near the object of study. Local review papers note that precisely these characteristics make electrochemical control methods preferable for environmental objects. Recent local work on screen-printed and modified carbon electrodes shows a movement toward miniaturization, disposable sensors, and monitoring tools adapted to field conditions. This creates the possibility of moving Pb^{2+} monitoring beyond large centralized laboratories.

The weaknesses of the method are also clear. Wastewater is not ordinary water. It contains dissolved salts, suspensions, organic matter, multivalent cations, complex-forming anions, and sometimes technological additives occurring together. Local dissertation studies have also shown that the identification of interfering ions, testing of model mixtures, selection of the optimal supporting electrolyte, and separate assessment of metrological properties are mandatory parts of the research. Here, the main error often lies not in electrode material selection, but in insufficient evaluation of matrix effects. In an ideal solution, the relationship between the actual concentration of Pb^{2+} and the peak on the voltammogram is simple, but in real wastewater it becomes reliable only with an adapted methodology. For this reason, sample preparation, the

standard addition method, repeated measurements, blank control, and, when necessary, preconcentration must be treated as integral components of the method.

Among the directions for further development, three appear especially strong. The first is the introduction of mercury-free, environmentally safe electrodes. In this regard, bismuth electrodes have justified themselves in local practice. The second is the integration of biosorption preconcentration into the methodology. This makes it possible to capture Pb^{2+} even at very low levels and combines wastewater treatment technology with analytical control into a single chain. The third is the development of miniaturized solutions such as screen-printed electrodes, ergonomic sensors, and "drop-based measurement" formats. Local studies report that a patent has been obtained for an electrochemical sensor, that there are developments involving Bi-modified screen-printed electrodes, and that this direction is expanding. This indicates that creating an inexpensive and portable technological platform for Pb^{2+} monitoring under Uzbek conditions is a realistic task.

Conclusion.

In developing an inversion voltammetric method for determining Pb^{2+} ions in wastewater, two directions of the local school of analytical chemistry are of particular importance as foundational points. The first is the use of bismuth-modified carbon electrodes, and the second is biosorption-based preconcentration. Bismuth electrodes provide the sensitivity required for lead determination, relatively low toxicity, and the possibility of application to real water objects. The biosorption stage reveals the true capacity of the method when working with low concentrations, complex matrices, and industrial wastewater. On this basis, standardizing sample preparation for Pb^{2+}, using a supporting system based on 0.2 M HCl + Bi(III), employing a preconcentration regime at –1.2 V, calculating results by the standard addition method, and introducing biosorption preconcentration where necessary appear to be the most substantiated methodological solution for laboratories in Uzbekistan. Such an approach can bring environmental monitoring to a reliable level even without expensive instrumental complexes.

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3D METAL COMPLEXES WITH PHENOXYACETIC ACID DERIVATIVES: SYNTHESIS AND CRYSTAL STRUCTURES

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Abstract: Phenoxyacetic acid derivatives occupy an important place in coordination chemistry because they combine a chemically active carboxyl group with an aromatic aryloxy fragment that influences steric environment, electron density, supramolecular packing, and solid-state stability. In complexes of 3d-series metal ions, these ligands behave as structurally flexible O-donor systems and can coordinate in monodentate, chelating, or bridging modes. This determines whether the final products crystallize as hydrated mononuclear compounds, binuclear units, or extended coordination polymers. Published structural studies show that Co(II) and Ni(II) complexes of chlorophenoxyacetic acids often form octahedral environments with coordinated water molecules, whereas Cu(II) more readily gives square-planar or bridged motifs depending on synthesis conditions. Complexes based on 2,4-dichlorophenoxyacetic acid and 4-chlorophenoxyacetic acid demonstrate that the same ligand family can produce 0D, 1D, 2D, and 3D architectures, especially when auxiliary N-donor ligands or hydrothermal conditions are used. The scientific value of these compounds is not limited to structural chemistry. They are relevant for crystal engineering, modeling herbicide–metal interactions, studying the effect of coordination on biological and physicochemical behavior, and designing functional materials with tunable packing and intermolecular contacts.

Key words: 3d metals, phenoxyacetic acid derivatives, coordination compounds, crystal structure, carboxylate coordination, single-crystal X-ray diffraction, analysis, supramolecular architecture.

Introduction

Complex compounds of **3d metals** with oxygen-containing organic ligands remain one of the most productive directions of modern inorganic chemistry because the geometry, nuclearity, and physical properties of such compounds are highly sensitive to small changes in ligand structure and synthesis conditions. **Phenoxyacetic acid derivatives** are especially informative in this respect. Their coordination behavior is governed by deprotonation of the carboxyl group, while the aryloxy fragment affects hydrophobicity, intermolecular packing, and the distribution of substituent effects across the aromatic ring. Chlorinated representatives such as **2,4-**

dichlorophenoxyacetic acid and **4-chlorophenoxyacetic acid** are of particular interest because their donor properties and steric profile allow the formation of multiple coordination modes with Mn, Co, Ni, Cu, and Zn ions. This gives a convenient platform for studying the regularities of structure formation in metal carboxylates and for understanding how the central ion controls coordination number, ligand arrangement, and crystal packing [1].

The relevance of this topic is strengthened by its practical dimension. Phenoxyacetic acid derivatives are not abstract ligands. Many of them are connected with agrochemical systems and with real processes of metal binding in soil, plants, and technical media. When they coordinate with 3d metal ions, their physicochemical behavior changes substantially. Solubility, thermal stability, hydration state, magnetic response, and supramolecular organization may all be altered. This makes the study of their synthesis and crystal structures important not only for academic coordination chemistry, but also for environmental chemistry, crystal engineering, and the targeted design of metal-organic systems with predictable properties [3].

Literature Review

Classical crystallographic work laid the foundation for this field by showing that phenoxyalkanoate ligands do not impose a single coordination pattern. Early studies by **G. Smith, E. J. O'Reilly, C. H. L. Kennard, K. Stadnicka, and B. Oleksyn** demonstrated that phenoxyacetic and chlorophenoxyacetic systems can generate both discrete aqua complexes and strongly bridged copper carboxylates. The structural series reported in **Inorganica Chimica Acta** established that the carboxylate fragment is the decisive coordination center, while the aromatic substituent and hydration state influence molecular symmetry and packing. These works were important because they moved the discussion from simple composition to real crystal architecture and showed that ligand identity alone does not determine structure. The same ligand family can yield markedly different motifs in the presence of different metal ions or under different crystallization regimes [1], [2].

A more detailed structural interpretation was later developed in studies on **2,4-dichlorophenoxyacetic acid** complexes of Co, Ni, and Cu. In the work of **Drzewiecka-Antonik, Ferenc, Wolska, Klepka and co-authors**, XAFS and DFT data were used together with synthesis and structural analysis. That study showed that **Co(2,4-D)2·6H2O** and **Ni(2,4-D)2·4H2O** possess octahedral environments in which two carboxylate groups and four water molecules complete the coordination sphere. By contrast, **Cu(2,4-D)2·4H2O** displays a square-planar arrangement built by two monodentate carboxylate ligands and two water molecules. An especially important result was the observation that recrystallization of the nickel compound produced a

binuclear "Chinese lantern" structure with bridging carboxylate groups. This is a strong illustration of the fact that crystal structure in this class is governed not only by the metal ion, but also by solvent history and recrystallization pathway [3].

Research on **4-chlorophenoxyacetic acid** broadened the picture further. **Long Li, Kaisheng Diao, Yuqiu Ding, and Xianhong Yin** described several complexes in which the same ligand yielded different dimensionalities and intermolecular assemblies. In one series, complexes such as **[CoL2(H2O)4]** and **[CuL2(H2O)2]** were characterized by single-crystal X-ray diffraction and shown to form **0D molecular units**, while hydrogen bonding and weak contacts generated higher-order supramolecular organization. In a hydrothermal series, the same ligand produced **1D, 2D, and 0D architectures** depending on the metal ion and auxiliary ligands. In the manganese system **[MnL2(4,4′-bipy)]**, each carboxylate bridge linked adjacent Mn centers into **infinite Mn–O–C–O rods**, which then assembled into a three-dimensional supramolecular framework [6].

Uzbek researchers have also contributed to the structural and theoretical development of this area. **Alimnazarov, Ashurov, Eshimbetov, Turaev, and Ibragimov** analyzed the **electronic structure of diaquabis (p-chlorophenoxyacetato) copper (II)** by DFT and reported a low-lying LUMO with a dominant metal d-orbital contribution above 60%, which is important for understanding reactivity and electronic redistribution in Cu-based aryloxyacetate complexes. Related Uzbek studies by **Ruzmetov**, **Razzoqova**, **Ibragimov**, and co-authors on other carboxylate and N,O-donor coordination systems have demonstrated the value of combining **single-crystal X-ray diffraction** with **Hirshfeld surface analysis**, a methodology that is directly relevant for future work on phenoxyacetic acid derivatives because it links molecular coordination to packing contacts and crystal stability [10].

Analysis and Results

A comparative reading of the available structural data shows a clear regularity. In complexes of phenoxyacetic acid derivatives, the **carboxylate group** is the principal coordination center, while the phenoxy oxygen usually does not dominate as the primary donor in the final crystal structure. The structural outcome is largely determined by five factors: the preferred geometry of the 3d metal ion, the degree of ligand deprotonation, the number of coordinated water molecules, the presence of auxiliary N-donor ligands, and the crystallization medium. When hydration dominates and no strong co-ligand competes for coordination sites, **Co(II)** and **Ni(II)** frequently form hydrated octahedral complexes. When Jahn–Teller-active **Cu(II)** is involved, lower-symmetry environments and bridged motifs become more probable. When

bipyridyl ligands are introduced, dimensionality increases and polymeric or rod-like architectures become accessible [6].

This behavior can be illustrated by several concrete cases. In the **2,4-D** system, the Co and Ni compounds crystallize as hydrated species with regular octahedral coordination, while the Cu compound adopts a square-planar arrangement. The difference is not accidental. It reflects the distinct stereochemical preferences of the metal ions and the stronger structural flexibility of Cu(II). In the recrystallized Ni compound, the structure changes from a hydrated mononuclear environment to a **binuclear carboxylate-bridged "Chinese lantern" motif**, proving that even when elemental composition is similar, the structural type may change sharply under modified crystallization conditions [3]. In the **4-chlorophenoxyacetic acid** series, one set of compounds remains discrete at the molecular level, whereas hydrothermal synthesis and the addition of aromatic N-donor bridges convert the system into chain or network structures. This confirms that ligand substitution alone is not enough to predict the structure. The whole **reaction environment** must be treated as a structure-forming factor [4].

Another important result concerns **crystal packing**. In these complexes, the final crystal structure is stabilized not only by metal–oxygen bonds but also by **O–H···O**, **C–H···Cl**, and sometimes **π–π** contacts. Such interactions influence crystal density, hydration stability, and the persistence of a given polymorphic form. The DFT study of the p-chlorophenoxyacetate copper complex by Uzbek authors adds an electronic argument to this structural picture. A low-lying LUMO with strong copper d-character means that the metal center remains electronically active and may strongly affect redox behavior, spectroscopic response, and intermolecular interactions in the crystal. This is one reason why purely geometric analysis is no longer sufficient. Electronic structure must be discussed together with coordination geometry [5], [7].

Discussion

The scientific meaning of these results goes beyond structural description. Complexes of 3d metals with phenoxyacetic acid derivatives are model systems for understanding how **ligand substitution, hydration, and co-ligation** control the transition from molecular compounds to supramolecular and polymeric frameworks. This makes them useful for **crystal engineering**. A researcher who knows how a carboxylate ligand behaves with Co, Ni, Cu, or Mn under conventional and hydrothermal conditions can deliberately direct synthesis toward a desired topology. For practical chemistry, that is valuable because structure determines thermal stability, solubility, and the distribution of intermolecular contacts, all of which influence handling and application [3].

The applied significance of this field is also visible in environmental and biological contexts. Phenoxyacetic herbicides can interact with metal ions in natural media, and this may reduce metal uptake by plants. In wheat treated with phenoxyacetic herbicides, the reported decrease reached about **50% for Mn**, **20% for Cu**, and **13% for Zn** compared with untreated systems. This indicates that metal binding by such ligands is not only a laboratory phenomenon. It can affect real migration processes in agrochemical environments [11]. In another direction, **aqua(aryloxyacetato)copper(II)** complexes were shown to inhibit oxygen evolution in spinach chloroplasts and were associated with changes at the donor side of photosystem II. That result does not mean every complex of this class is directly applicable in biology, but it does show that coordination changes can substantially alter biological activity and mechanism [12].

At the same time, the field has clear methodological and practical problems. The first is **structural variability caused by hydration**. A compound isolated from aqueous medium may differ from the recrystallized form even when the ligand and metal are unchanged. The second is **phase purity**. Powder products can contain mixtures of hydrates and coordination isomers, while the single crystal chosen for X-ray analysis may represent only one stable fraction. The third problem is the **gap between solid-state and solution-state behavior**. A crystal structure gives precise information about one form of matter, but catalytic, biological, or environmental behavior may depend on partially dissociated or solvent-reorganized species. The fourth issue is **ecological caution**. Since many phenoxyacetic derivatives are connected with herbicidal chemistry, the design of new metal complexes in this family must be accompanied by toxicity, stability, and mobility assessment rather than by structural description alone [12].

The most realistic way to develop this direction is methodological integration. Future studies should combine **single-crystal X-ray diffraction** with **IR spectroscopy**, **thermal analysis**, **XAFS**, **DFT**, and **Hirshfeld surface analysis**. X-ray diffraction establishes the coordination framework. IR spectroscopy helps identify carboxylate binding behavior. Thermal methods clarify hydration and decomposition stages. XAFS is valuable when single crystals are not ideal. DFT explains electron distribution and frontier orbitals. Hirshfeld analysis quantifies the intermolecular contacts that make one packing arrangement more stable than another. Uzbek structural chemistry has already shown the usefulness of this combined approach in related carboxylate systems, and extending it systematically to phenoxyacetic acid derivatives of Mn, Co, Ni, and Cu would produce more robust and practically relevant results [10].

Conclusion

The available evidence shows that **3d metal complexes with phenoxyacetic acid derivatives** form a structurally rich and chemically meaningful class of coordination compounds. Their central закономерность is clear: the same ligand family can generate hydrated mononuclear species, binuclear bridged units, and extended coordination polymers depending on metal-ion preferences, solvent, hydration, recrystallization conditions, and the presence of auxiliary ligands. The strongest results in this area come from studies that do not stop at empirical synthesis but connect **coordination mode, crystal structure, supramolecular contacts, and electronic structure**. That is the line along which the field can be advanced most effectively in future work [10].

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THEORETICAL ANALYSIS OF THE FORCES GENERATED BY THE PRESSURE FORCE OF THE YARN FROM THE TOP OR BOTTOM OF THE YARN WINDING CYLINDER

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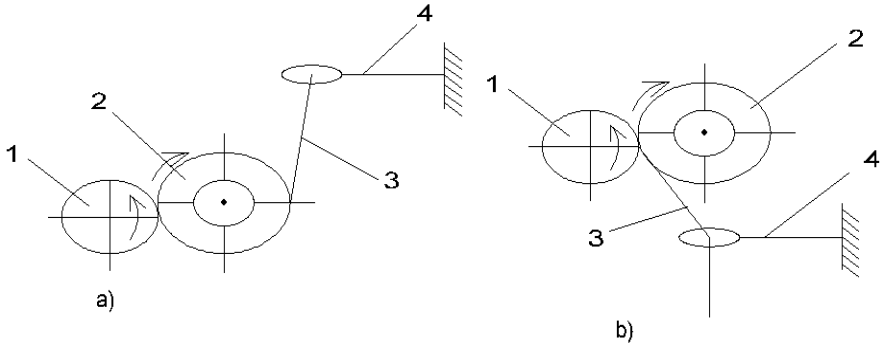
Annotation. This in the article textile in the industry the threads wrapping in the process to the surface coming mechanic forces dynamics research Thread hunter to the cylinder of the thread from above and from below orientation as a result harvest to be friction forces two kind hypothesis based on analysis Research during friction power and coverage angle between dependency graphs taken and compared. Results this shows that the thread cylinder high from the part transfer friction strength reduces, this and thread interruptions prevent to take and wrapping density optimization opportunity gives.

Keywords: Textile industry, yarn winding, cylinder, workbench power, coverage angle, mechanical dynamics, hypothesis, tension.

Textile industry main from the joints one these are the threads weaving for preparation process This process is physicist forces, mechanical pressure and threads between relative actions based on done Especially the threads direction, their how forces under movement to do and in the cylinder location important importance has. The thread hunter to the cylinder from above and from below threads when transferred harvest to be forces dynamics seeing we will go out [1].



1. a) Thread the thread onto the thread winding cylinder. from below impact.
b) Thread the thread onto the thread winding cylinder from above impact.
Here: The worker who gives the main rotational movement shaft
2 – A cylindrical object on which a thread is wound.
3 – Thread.
4 – Thread when moving direction integral accordingly provider device.

In Figure 1, we analyze the relationship between the pressure forces generated when the yarns are passed from above and below the yarn-winding cylinder during the winding process and their mechanical effect on the yarn winding. These pressure forces arise during the movement of the yarns and vary depending on the degree of tension between them, the elasticity of the yarn material, and the speed of the yarn winding process. During the winding process, the cylinder begins to be affected by pressure forces from below or above (Figures 1. a and b). In studying this situation, it is mainly necessary to find the friction force. There are two hypotheses for these cases [2].

First hypothesis. The yarn and the cylinder winding the yarn are considered as a kinematic rotating pair, and the pressure of the yarn on the cylinder is equal to the elements of the kinematic pair, that is, the specific pressure is assumed to be a constant quantity. Using the first hypothesis, the yarn is directed towards the cylinder from below For case (1) we find an analytical representation of the friction force (Figure 1. a) [3].

$$F_{ish} = \frac{fQ\alpha_0}{\sin\alpha_0} \qquad (1)$$

Second hypothesis. Since the elasticity of the yarn winding cylinder is very small, it is assumed that it is not deformed. Under the action of the yarn from above, a compressive force is created. This force is selected along the direction of the line of action. The vertical wear of the yarn winding cylinder is a constant value. Using the second hypothesis, we find the analytical form of the friction force (2) for the case where the yarn is directed to the cylinder from above. (Fig. 1. b)[4].

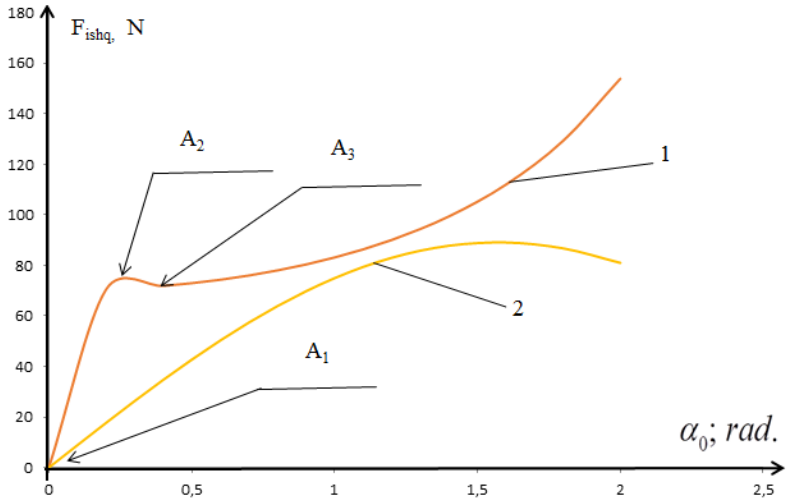
$$F_{ishq} = \frac{4Qf}{\pi}\sin\alpha_0; \qquad (2)$$

Here: -The angle of winding the thread around the cylinder, rad.

Q- Which thread is coming from below or above? pressure power , N.

- Thread and cylinder between friction coefficient

We consider the expressions in formulas (1) and (2) as a function of the angle and the friction force and draw a graph of their relationship. In order to more accurately represent the process under study, values close to practical values of the required quantities were selected.



Friction power and coverage angle between connection graph.

Curve 1 on the graph mechanic from the point of view analysis we do:

A 1 A 2: This in between friction power sharp increase our vision possible. Such process to be main because of peace friction coefficient in motion friction coefficient big to be and of power impact circle increasing is going.

A 2 A 3: In this range thread move starts. Thread move from the beginning after peaceful friction coefficient decrease on account of friction power decreases, thread tension as a result of the thread to the cylinder touching finished surface decreases.

A 3 in the process after coverage angle friction increases strength also increased to go our vision possible.

(2)- from equality using above brought We draw curve (2) on the graph. As can be seen from this graph, as the angle of rotation increases to its chosen value, the friction force also increases.

As can be seen from functions (1) and (2), the friction force generated by the forces acting on the cylinder from above and below depends mainly on the parameters of the yarn, the direction of the yarn, the angle of the cylinder winding, and the coefficient of friction. This directly affects the mechanical movement of the yarn during the winding process. [5]

A general analysis of curves (1) and (2) presented in the graph shows that the friction force arising when the thread is passed through the upper part of the cylinder is smaller than when it is directed through its lower part. This fact indicates a direct dependence of the friction force on the trajectory and direction of the thread movement during the winding process on the bobbin and confirms the study of the mechanical properties of this process. An increase in the friction force is considered a factor that negatively affects the proper functioning of the technological process in the operating mode. In particular, an increase in the friction force generated in the thread leads to an increase in the number of breaks, which leads to an increase in the strength limit of the thread.

At the same time, an excessively dense winding of the thread on the bobbin is observed, which leads to an increase in the thread density above the standard values. As a result, the physical and mechanical properties of the thread, including elasticity, flatness and general quality indicators, decrease. The theoretical formulas studied above substantiated the dependence of the friction force on the direction of yarn movement and showed that, in terms of increasing the efficiency of the technological process, it is advisable to pass the yarn through the upper part of the cylinder.

This recommendation allows reducing yarn breaks, optimizing the density of the yarn, and improving the quality of the finished product.

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MACHINE TRANSLATION VS. HUMAN TRANSLATION: A COMPARATIVE STUDY

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Abstract

Machine Translation (MT) has become a routine tool in education, business, and public services, especially after the rapid maturation of neural MT and post-editing workflows. Yet many institutions still rely on informal assumptions such as “MT is fast but inaccurate” or “human translation is always best,” which leads to weak decision-making in curriculum design, workplace communication, and quality assurance. This comparative study proposes an evaluation model that aligns translation goals with measurable outcomes, and contrasts MT and human translation across three common professional genres: technical instructions, customer-service communication, and promotional/marketing texts. Using a small pilot design with blind rating and an error-typology rubric, the study compares quality (accuracy, fluency, terminology, register, and consistency), efficiency (time, effort), and risk factors (confidentiality, accountability, and harm potential). The results indicate that MT performs competitively for predictable, terminology-driven technical content, but remains vulnerable to pragmatic meaning, politeness strategies, idioms, and brand voice. Human translation shows higher reliability for high-stakes and audience-sensitive texts, while hybrid MT + human post-editing offers the best balance of speed and quality when the task is well-scoped and supported by clear style guides. Practical recommendations are provided for teachers and administrators on how to integrate MT responsibly into lessons, assessment, and workplace-oriented language training.

Keywords: machine translation, human translation, post-editing, quality assessment, ESP, professional education

Introduction

Translation in professional settings is not merely a language exercise; it is a quality- and risk-sensitive service. In professional education institutions (technical schools, vocational colleges, and training centers), learners often meet English through job-related tasks: reading equipment manuals, writing emails, completing service dialogues, and understanding safety instructions. At the same time, students and teachers increasingly use MT tools on phones and laptops as a shortcut for comprehension and writing. This creates a new methodological question: when does

MT support learning and communication, and when does it introduce errors, reputational damage, or safety risks?

MT today is mainly driven by neural architectures and large-scale training data. In practice, it is strong at producing fluent output and handling frequent sentence patterns. However, fluency is not the same as correctness. A translation can sound natural while still being wrong in meaning, missing a requirement, or choosing the wrong register. Human translation, by contrast, relies on professional judgement: clarifying ambiguity, adapting to the audience, preserving legal or medical nuance, and matching cultural expectations. Human work is slower and costlier, but it can be more accountable, especially when consequences matter.

This article frames MT vs. human translation as a measurable comparison rather than a slogan. It asks three practical questions. (1) How do MT and human translation differ in quality across typical professional genres? (2) How large is the efficiency gap, and how does post-editing change the picture? (3) What are actionable guidelines for integrating MT into teaching English for professional purposes without lowering standards or encouraging dependency?

To answer these questions, the study uses a compact evaluation model aligned with common quality dimensions. Although the pilot scale is small, the method is replicable in a classroom or institutional context and can inform lesson planning, assessment design, and departmental policy on translation use.

Methods

Design. A comparative pilot design was used to evaluate MT output against human translation output. The goal was not to "prove" a universal winner, but to map strengths and failure modes by genre and communicative purpose.

Materials. Nine short source texts were created for the study (all original, non-copyrighted), grouped into three genres:

• Technical instructions (e.g., device setup, safety steps, troubleshooting)

• Customer-service communication (e.g., complaint response, appointment scheduling, polite requests)

• Promotional/marketing texts (e.g., short ads, product descriptions, service announcements)

Language pair and context. The evaluation model was designed to be applicable to common language pairs used in Central Asian professional education contexts (for example, English to Uzbek or English to Russian), but the rubric itself is language-neutral. The key assumption is that professional texts require more than literal equivalence: they require correct intent, appropriate register, and terminological consistency.

Systems and translators. MT output was produced by a contemporary neural MT engine (any widely used system can be substituted). Human translations were produced by trained bilinguals familiar with professional communication conventions. To reduce bias, all outputs were anonymized and randomly ordered for evaluation.

Evaluation rubric. Two raters scored each translation using a five-point scale across five dimensions: (1) Accuracy, (2) Fluency, (3) Terminology, (4) Register and pragmatics, and (5) Consistency. In addition to numeric ratings, raters tagged errors using a simplified MQM-like typology: meaning error, terminology error, grammar error, style/register error, and omission/addition. Disagreements were resolved through short consensus discussion.

Efficiency measurement. Translators recorded the time required for human translation and for post-editing MT output to a publishable level. Time was used as a proxy for effort; in real settings, cost and workload can be mapped from the same logs.

Analysis. Average scores were calculated by genre and method (MT vs. human). Qualitative notes were summarized to identify typical error patterns and pedagogically relevant insights.

Table 1. Quality dimensions used in the comparative evaluation.

Dimension	**What it checks**	**Typical failure signs**
Accuracy	Meaning, instructions, logical relations, obligation/permission	Wrong requirement, reversed meaning, missing condition
Fluency	Grammar, coherence, readability	Awkward phrasing, agreement errors, broken sentence flow
Terminology	Domain terms and consistency	Wrong term, inconsistent equivalents, mistranslated abbreviations
Register & Pragmatics	Tone, politeness, audience fit, intent	Too rude/too informal, wrong honorifics, misread request vs. order
Consistency	Numbers, units, names, formatting, repeated terms	Unit mismatch, number change, inconsistent formatting

Results

Across the nine texts, human translation achieved higher average quality scores than raw MT in every genre, with the largest gap in customer-service and marketing communication. MT performed best in technical instructions, where sentence structures were predictable and terminology was repeated. In those cases, MT often produced fluent output with correct procedural sequencing, especially when the source text used clear imperative forms and standardized phrasing.

However, MT showed systematic vulnerabilities in pragmatic meaning and audience management. In customer-service texts, small register mistakes changed the perceived politeness and responsibility of the institution. For example, MT tended to overuse direct imperatives where a human translator would choose softer requests, hedging, or empathy markers. In marketing texts, MT frequently preserved literal meaning but failed to recreate persuasive tone, rhythm, and culturally appropriate calls to action.

Terminology errors were not equally distributed. When a term appeared multiple times, MT sometimes switched between synonyms, creating confusion in training contexts where learners are expected to adopt stable equivalents. Human translations were more consistent, especially when a brief term list was provided.

Efficiency results showed a strong speed advantage for MT-assisted workflows. Post-editing MT to publishable quality required less time than full human translation for technical texts, but the advantage shrank for marketing and customer-service texts because post-editing demanded significant rewriting to fix tone and intent. In a classroom setting, this indicates that MT can be time-saving for terminology-focused reading and controlled writing tasks, but it is not a shortcut for pragmatic competence.

Table 2. Average quality scores by genre (1 = poor, 5 = excellent).

Genre	**Machine Translation (raw)**	**Human Translation**	**MT + Post-editing**
Technical instructions	3.8	4.6	4.4
Customer-service texts	3.1	4.7	4.2
Marketing/promotional	2.9	4.5	4.0

Table 3. Typical time patterns (per 200-250 words, indicative).

Genre	**Human translation (min)**	**Post-edit MT (min)**	**Main time driver**
Technical instructions	30-45	15-25	Terminology checks, units, procedural clarity

Customer-service texts	35-55	25-40	Tone, empathy, politeness strategy
Marketing/promotional	40-70	30-60	Rewriting for voice, rhythm, persuasion

Discussion

The results support a practical conclusion: MT is not a single "good or bad" tool; its value depends on genre, risk, and learning goals. For professional education, the question should be framed as alignment: what outcome is required, and what level of reliability is acceptable?

Why MT succeeds in technical genres. Technical instructions often contain constrained vocabulary, repetitive actions, and standardized structures (e.g., "press," "connect," "turn off," "do not operate"). MT benefits from these patterns and can produce near-human fluency. If a term base is provided and the source text is written clearly, MT output can be close to publishable with light post-editing. This is particularly useful in vocational English classes where the goal is comprehension of manuals, safety rules, and operational procedures.

Why MT fails more often in customer-service and marketing. These genres are pragmatic: they carry social meaning beyond the literal sentence. Customer-service communication requires empathy, appropriate apologies, controlled responsibility, and polite problem-solving. Marketing communication requires persuasive voice, audience targeting, and culturally acceptable slogans. MT may produce grammatically correct sentences but miss the "social contract" of the text. In real workplaces, such errors can lead to customer dissatisfaction or brand damage.

Hybrid workflows as a middle path. MT + human post-editing can be highly effective if the task is bounded and the post-editor has clear standards. Professional practice often distinguishes between light post-editing (understandable, fit for internal use) and full post-editing (publishable, client-facing). In education, the same distinction can become a teaching strategy: students learn to decide when "good enough" is acceptable and when it is not.

Pedagogical implications for English teaching in vocational contexts. Teachers can integrate MT without reducing learning quality by using it as an object of analysis. For example, a lesson can start with a short MT output and ask learners to: identify terminology inconsistencies, repair register in customer dialogues, correct numbers and warnings in safety instructions, and justify choices using a rubric.

This turns MT from a shortcut into a diagnostic tool that develops language awareness. Crucially, assessment must be aligned: if students are graded only on final text, they

may hide their MT use and learn less. If they are graded on process (drafting, justification, editing logs, and reflection), MT becomes a controlled learning aid.

Risk and ethics. Professional institutions must consider confidentiality. Sending internal documents, patient information, or sensitive contracts to a public MT service may violate policy or law. Even when privacy is not an issue, accountability remains: MT systems do not take responsibility for harmful output. Therefore, high-stakes domains (healthcare, law, safety-critical engineering) should require human review at minimum.

Practical recommendations. Institutions can adopt a simple policy matrix: (1) Low risk + internal use + technical genre: MT allowed, light post-editing recommended. (2) Medium risk + external communication: MT allowed only with full post-editing and rubric-based review. (3) High risk (medical, legal, safety) or strong brand voice: human translation required; MT may be used only for initial drafting under strict controls. Such policies help teachers and students develop professional judgement instead of relying on technology blindly.

Conclusion

This comparative study shows that machine translation and human translation differ less in fluency than in reliability of meaning, terminological stability, and pragmatic appropriateness. MT can be highly useful for technical, pattern-driven texts and for time-saving comprehension activities in vocational English lessons. However, raw MT remains risky for customer-service and marketing genres where tone, empathy, and persuasion are central. Human translation provides stronger accountability and audience adaptation, particularly in high-stakes contexts.

For professional education institutions, the most realistic and educationally productive approach is not to ban MT, but to teach controlled use: define the goal of the translation, apply an explicit rubric, require reflection on editing decisions, and protect confidentiality. When purpose, outcome, and assessment are aligned, MT becomes a tool for developing language and professional competence rather than a replacement for it.

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KIBERXAVFSIZLIKNI TA’MINLASHDA SUN’IY INTELLEKTDAN FOYDALANISH VA UNING AHAMIYATI

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Muhammad al-Xorazmiy nomidagi TATU, Axborot xavfsizligi kafedrasi katta o‘qituvchisi

Annotatsiya. Sun’iy intellekt (SI) axborot xavfsizligini ta’minlashda yangi imkoniyatlar ochib bermoqda. Bugungi kunda kiberhujumlar murakkablashib, an’anaviy usullar bilan xavfsizlikni ta’minlash qiyinlashmoqda. Ushbu maqolada SI texnologiyalarining kiberxavfsizlik sohasidagi roli, ularning tahdidlarni aniqlash va oldini olishdagi samaradorligi, shuningdek mamlakatimizda yuzaga kelayotgan kiberjinoyatlar holati statistik ma’lumotlar asosida keltirilgan. SI yordamida xavfsizlikni ta’minlash va mavjud muammolarni bartaraf etish istiqbollari ko‘rib chiqilgan.

Kalit so‘zlar: sun’iy intellekt, kiberhujum, kiberjinoyat.

Raqamli taraqqiyot jamiyat hayotining barcha sohalariga kirib borgan sari axborot xavfsizligi dolzarb muammoga aylandi. Internet asosidagi tizimlar, bank xizmatlari, davlat onlayn xizmatlari va ijtimoiy tarmoqlarga bo‘lgan talab ortgani sari kiberhujumlar soni ham keskin ortib bormoqda. Ayni paytda sun’iy intellekt(SI) texnologiyalarining kiberxavfsizlik sohasida qo‘llanilishi xavfsizlikni ta’minlashda kalit omilga aylanmoqda. SI algoritmlari yordamida katta hajmdagi trafik tahlil qilinadi, anomal xatti-harakatlar aniqlanadi va tahdidlar real vaqt rejimida oldini olish imkoniyati yaratiladi[1].

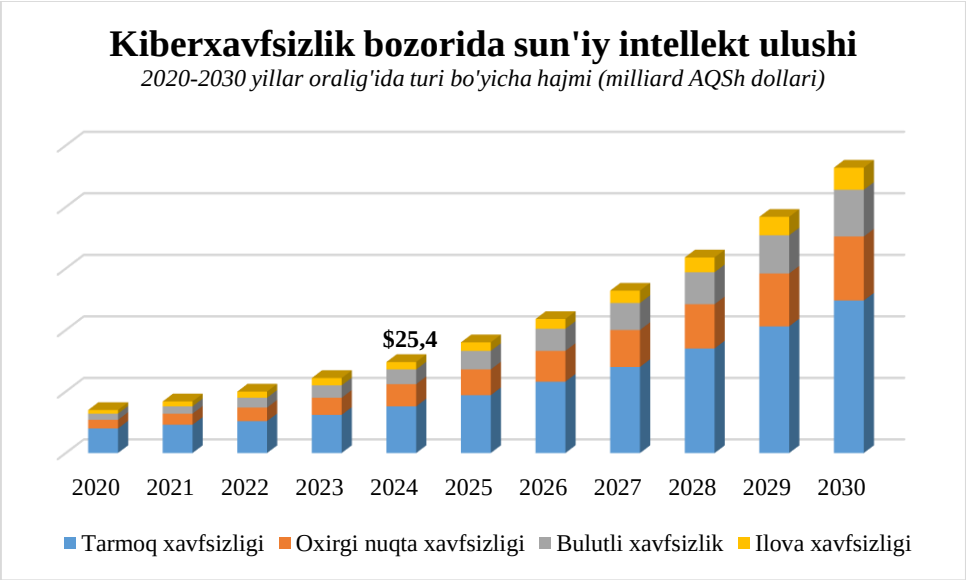
Kiberxavfsizlikni ta’minlashda SI texnologiyalarining asosiy imkoniyatlari quyidagi yo‘nalishlar orqali namoyon bo‘ladi:

Tahdidni aniqlash - SI yordamida anomaliyalarni aniqlash an’anaviy usullarga qaraganda sezilarli yuqori darajada amalga oshadi (70%+).

Xavfsizlikni avtomatlashtirish - SI tizimlari xavfsizlik jarayonlarini 80% gacha avtomatlashtiradi(1-rasm) [2].

Zero-day hujumlarga qarshi kurash - SI yordamida oldindan bashorat qilish va himoya qilish imkoniyati oshadi[3].

Foydalanuvchi xatti-harakatini tahlil qilish - Xulq-atvor tahlili yordamida ichki tahdidlarni 40% gacha aniqlash samaradorligi oshadi.



1-rasm. Kiberxavfsizlikni ta’minlashda SI dan foydalanish.

Statistik tadqiqotlarga ko‘ra, global tashkilotlarning 57% SI texnologiyalarni anomaliyalarni aniqlash uchun qo‘llamoqda, 50% esa zararli dasturlarni aniqlash uchun SIga tayanmoqda[4].

Bugungi kunda dunyoda har soniyada taxminan 2200 ta kiberhujum sodir bo‘ladi[5]. SI yordamida yaratilgan fishing hujumlar soni so‘nggi yillarda sezilarli darajada oshgan, bu esa an’anaviy xavfsizlik tizimlariga katta bosim ko‘rsatmoqda.

O‘zbekiston sharoitida ham kiber jinoyatlar soni oshib bormoqda. Mahalliy statistikaga ko‘ra:

Ko‘rsatkich	2024 yil 1-yarim yillik
Ekspertiza o‘tkazilgan saytlar	79 ta
“.UZ” domenida aniqlangan xavfsizlik hodisalari	63 ta
Davlat tashkilotlarida aniqlangan holatlar	22 ta

Bundan tashqari, norasmiy statistik ma’lumotlarga ko‘ra, oxirgi besh yil ichida O‘zbekistonda kiber jinoyatlar soni 68 barobar ko‘paygani va 2024 yilda 12 million yaqin kiberhujum sodir bo‘lgani qayd etilgan (noaniq, lekin trendni ko‘rsatadi)[6]. 2025-yilning birinchi 11 oyi davomida kiberjinoyatlar oqibatida fuqarolarga yetkazilgan moddiy zarar miqdori qariyb 1,9 trillion so‘mni (aniqrog‘i 1 trillion 890 milliard so‘m) tashkil etdi.

Ushbu sohadagi asosiy ko‘rsatkichlar:

- *Zararning o‘sishi*: So‘nggi 5 yil (2021–2025) ichida jami zarar miqdori 3,73 trillion so‘mga yetgan bo‘lib, uning qariyb yarmi aynan 2025-yil hisobiga to‘g‘ri kelmoqda.
- *Jinoyatlar soni*: Kiberjinoyatlar soni oxirgi 5 yilda 11 baravardan ziyod ko‘payib, 4 865 tadan 62 440 taga oshgan.
- *Asosiy yo‘nalish*: Kiberjinoyatlarning 98 foizi bank kartalari bilan bog‘liq o‘g‘rilik va firibgarliklardir.

Bu holatlar O‘zbekiston raqamli infratuzilmasida SI texnologiyalarini keng ko‘lamda joriy etish zaruratini yana bir bor ko‘rsatmoqda.

Kiberjinoyatlarni aniqlashda sun’iy intellektni qo‘llash quyidagi imkoniyatlarni beradi:

Tahdidlarni aniqlash va oldini olish. SI modellar tarmoq trafikini real vaqt rejimida tahlil qilib, anomaliyalarga asoslangan xujumlarni tezda aniqlaydi. Anomaliyalarni aniqlash darajasi an’anaviy usullarga qaraganda sezilarli darajada yuqoriroq hisoblanadi.

Xavfsizlikni avtomatlashtirish. Aksariyat tashkilotlar SI yordamida hodisalarga avtomatik javob berish tizimlarini yaratmoqda, bu esa xodimlar ish yuklamasini kamaytiradi va vaqtni tejaydi.

Murakkabliklar va cheklovlar. Sun’iy intellektdan foydalanish quyidagi murakkabliklarni ham olib keladi:

- SI tizimlarini noto‘g‘ri o‘rgatish xavfi va noto‘g‘ri huquqiy qarorlar qabul qilish xavfi[7].
- SI asosidagi tizimlarning ham hujumga uchrashi ehtimoli (masalan, adversarial attack)[8].
- Ma’lumotlar maxfiyligi va etik masalalar.

Bugungi axborot xavfsizligi sohasi murakkablashib borar ekan, sun’iy intellekt texnologiyalari xavfsizlikni ta’minlashda strategik ahamiyat kasb etadi. SI asosidagi tizimlar tahdidlarni tezda aniqlash, avtomatlashtirilgan javob berish, hamda oldini olish choralarini kuchaytiradi. O‘zbekiston sharoitida kiberjinoyatlar sonining ortishi milliy xavfsizlik tizimlarini modernizatsiya qilish va SI yechimlarini keng joriy etishni talab qiladi. Shu bois, SIni kiberxavfsizlik tizimlariga integratsiya qilish ham xalqaro standartlarga rioya etish, ham tizim samaradorligini oshirish uchun muhimdir.

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