

Abstract Book

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INNOVATIONS IN MODERN SCIENCE,
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Conference schedule

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17-19 July, 2024

10:00 Eastern European Summer Time (EEST)

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10:05	Ronghui Tan	EFFECTIVENESS OF DEVELOPMENT-LIMITING BOUNDARIES IN CURBING URBAN SPRAWL IN CHINESE CITIES: A CASE STUDY OF WUHAN
10:12	Borovyk Kateryna	GALECTIN-3 AS A MARKER OF CARDIOVASCULAR RISK IN PATIENTS WITH HEART FAILURE AND CONCOMITANT TYPE 2 DIABETES
10:17	Snjezana Babić	THE INTRODUCTION OF VAR TECHNOLOGY IN FOOTBALL: ENHANCING DECISION-MAKING PROCESSES
10:25	Oleksandra Poltoratska	APPLICATION OF ELEMENTS OF RESEARCH EDUCATION IN THE PROCESS OF TEACHING PHYSICS

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THE ENVIRONMENTAL IMPACT OF SILVER NANOPARTICLES ON MEDITERRANEAN SEA URCHIN EMBRYONAL DEVELOPMENT

Petra Burić, Assistant professor, Juraj Dobrila University of Pula, Croatia

The proliferation of silver nanoparticles (AgNP) across various industrial and consumer products raises concerns about their potential environmental impact, particularly in aquatic ecosystems [1, 2, 3]. This study evaluates the species-specific effects of 60 nm AgNP on embryonal development in three Mediterranean sea urchin species: *Arbacia lixula*, *Paracentrotus lividus*, and *Sphaerechinus granularis*. Exposing embryos to AgNP concentrations ranging from 1 to 100 $\mu\text{g L}^{-1}$ revealed significant developmental abnormalities, especially in *A. lixula* at the lowest concentrations. Our findings highlight the importance of exposure timing, with later stages showing greater sensitivity, suggesting additional mechanisms of AgNP toxicity. This research underscores the need for careful consideration of developmental stages in nanoparticle toxicity testing.

Engineered nanoparticles (ENP), particularly silver nanoparticles (AgNP), are increasingly prevalent in various applications, from electronics to biomedicine. Their release into aquatic environments poses potential risks due to their stability and toxicity, particularly to marine organisms. AgNP are highly toxic to aquatic life, with toxicity influenced by their aggregation, agglomeration, and dissolution behaviors in high ionic strength environments like seawater. Understanding their environmental fate and impact is crucial for assessing ecological risks.

Chemicals and AgNP Characterization: Silver nitrate and tri-sodium citrate were used to synthesize AgNP, characterized by UV absorbance

spectroscopy, indicating a peak at 435 nm consistent with 60 nm nanoparticles.

Embryo Exposure: Embryos of *A. lixula*, *P. lividus*, and *S. granularis* were exposed to AgNP concentrations (1–100 $\mu\text{g L}^{-1}$) at different developmental stages (fertilized egg, 4 cell, blastula, and gastrula). Exposure durations varied, with a focus on determining the impact of first exposure time on developmental outcomes.

Species-Specific Sensitivity:

- *Arbacia lixula*: The most sensitive, showing significant developmental abnormalities at 1–10 $\mu\text{g L}^{-1}$. Embryos first exposed at 6 and 24 hours post-fertilization were most affected.

- *Paracentrotus lividus*: Similar effects occurred at higher concentrations (50–100 $\mu\text{g L}^{-1}$), regardless of exposure timing.

- *Sphaerechinus granularis*: Exhibited moderate sensitivity with significant abnormalities at 10–50 $\mu\text{g L}^{-1}$.

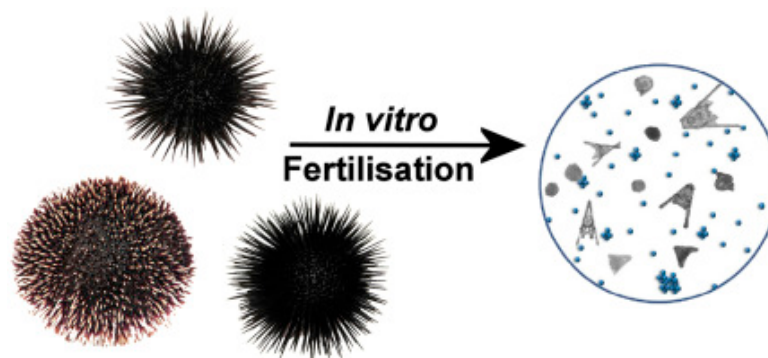


Figure. 1. Fertilisation

Impact of Exposure Timing: Later post-fertilization exposure resulted in greater developmental changes, suggesting that timing is critical in evaluating nanoparticle toxicity.

Our findings align with previous studies indicating that heavy metals and nanoparticles disrupt sea urchin development. The sensitivity

differences among species and stages suggest that AgNP toxicity involves complex mechanisms, potentially including Ag⁺ ion release and nanoparticle-specific interactions. These effects underscore the importance of considering both concentration and exposure timing in nanoparticle toxicity assessments.

Silver nanoparticles significantly impact Mediterranean sea urchin embryonal development, with species-specific sensitivities and timing-dependent effects. *A. lixula* embryos are particularly vulnerable at low concentrations, while *P. lividus* and *S. granularis* show variable sensitivity. This study highlights the need for nuanced approaches in nanoparticle toxicity testing, accounting for species and developmental stage specificity.

This thesis highlights the crucial role of nanoparticles' environmental fate and their species-specific effects on marine organisms, emphasizing the need for thorough and stage-specific toxicity evaluations to better understand and mitigate potential ecological impacts.

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Social Sciences | Соціальні науки

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THE INTRODUCTION OF VAR TECHNOLOGY IN FOOTBALL: ENHANCING DECISION-MAKING PROCESSES

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Croatia

Football, often referred to as the beautiful game, has undergone significant technological advancements in recent years. One of the most transformative innovations has been the introduction of Video Assistant Referee (VAR) technology. VAR aims to enhance the decision-making process for on-field referees by providing them with additional support from a team of experts located in the Video Operations Room (VOR). This collaboration is intended to improve the accuracy of critical decisions during matches, thus preserving the integrity and fairness of the sport. However, the effective implementation of VAR requires thorough education and practical experience for all participants involved. This paper explores the perceptions of Croatian VARs and Assistant VARs (AVARs) regarding the use of VAR technology, highlighting the benefits and challenges associated with its application.

VAR technology was introduced to address the limitations of human refereeing, particularly in situations that are difficult to judge in real-time. The primary functions of VAR include reviewing decisions related to goals, penalties, red cards, and cases of mistaken identity. The process involves a team of VARs and AVARs who analyze video footage and communicate their findings to the on-field referee. This collaboration is intended to ensure that decisions are as accurate as possible, thereby reducing the likelihood of controversial outcomes.

The introduction of VAR has not only revolutionized the decision-making process but also sparked debates among fans, players, and officials. Proponents argue that VAR enhances fairness by correcting clear and obvious errors, while critics contend that it disrupts the flow of the game and may lead to inconsistent interpretations of the rules. Despite these differing viewpoints, the overall goal of VAR is to support referees and uphold the integrity of football.

Education and Practical Experience in VAR Implementation. The successful implementation of VAR technology relies heavily on the education and practical experience of all participants involved. This includes on-field referees, VARs, and AVARs who must be well-versed in the technology and its application. Training programs are designed to equip referees with the skills needed to operate VAR systems effectively and make informed decisions based on video evidence.

Education programs typically cover various aspects of VAR technology, including the technical components, operational procedures, and communication protocols. Referees undergo rigorous training sessions that simulate real match scenarios, allowing them to practice using VAR in a controlled environment. This practical experience is crucial for building confidence and ensuring that referees can seamlessly integrate VAR into their decision-making process during actual matches.

Furthermore, continuous professional development is essential to keep referees updated on the latest advancements in VAR technology and any changes to the rules of the game. Regular workshops, seminars, and assessments help maintain high standards of performance and ensure that referees are proficient in using VAR effectively [1, 2, 3, 4].

Research on Perceptions of VAR Technology Among Croatian VARs and AVARs. To gain insights into the effectiveness of VAR technology and its impact on football, a study was conducted among Croatian VARs and AVARs who have received training and education on the use of VAR. The research aimed to understand their perceptions of VAR, including its benefits, challenges, and overall impact on the decision-making process.

The study employed a mixed-methods approach, combining quantitative surveys with qualitative interviews. The survey was designed to gather data on the participants' experiences with VAR, their confidence in using the technology, and their views on its effectiveness. The interviews provided an opportunity for participants to share their personal experiences and elaborate on their perceptions of VAR in greater detail.

Participants included a diverse group of Croatian VARs and AVARs, all of whom had undergone formal training in VAR technology. The data collected from the surveys and interviews were analyzed to identify common themes and patterns in the participants' responses.

The results of the study revealed several key insights into the perceptions of Croatian VARs and AVARs regarding the use of VAR technology in football:

1. **Enhanced Decision-Making Accuracy:** Participants overwhelmingly agreed that VAR technology has improved the accuracy of decision-making in football. The ability to review video footage and consult with a team of experts allows referees to make more informed decisions, reducing the likelihood of errors and controversial calls.

2. **Increased Confidence:** The training and education provided to VARs and AVARs have significantly increased their confidence in using the technology. Participants reported feeling more assured in their decision-

making abilities, knowing that they have the support of VAR to verify critical decisions.

3. **Challenges and Limitations:** Despite the benefits, participants also identified several challenges associated with VAR technology. One of the primary concerns was the potential for VAR to disrupt the flow of the game. The time taken to review decisions can lead to stoppages, which may affect the momentum of the match and frustrate players and fans.

4. **Consistency in Application:** Another challenge highlighted by participants was the need for consistency in the application of VAR. Different referees may interpret the same incident differently, leading to variations in decision-making. Standardized guidelines and continuous training were suggested as ways to address this issue and ensure uniformity in the use of VAR.

5. **Communication and Coordination:** Effective communication between on-field referees and the VAR team was identified as a critical factor in the success of VAR technology. Participants emphasized the importance of clear and concise communication to ensure that decisions are made efficiently and accurately.

The findings of this study highlight the positive impact of VAR technology on the decision-making process in football, while also underscoring the need for ongoing education and training. The enhanced accuracy and increased confidence reported by Croatian VARs and AVARs demonstrate the potential of VAR to improve the fairness and integrity of the game. However, the challenges related to game flow disruption, consistency, and communication must be addressed to maximize the benefits of VAR.

The insights gained from this research can inform the future development and implementation of VAR technology in football. Based on the findings, several recommendations can be made:

1. Enhanced Training Programs: Continuous professional development and training programs should be established to keep referees updated on the latest advancements in VAR technology and ensure consistent application of the rules.

2. Standardized Guidelines: Developing standardized guidelines for the use of VAR can help ensure uniformity in decision-making and reduce discrepancies between different referees.

3. Improved Communication Protocols: Enhancing communication protocols between on-field referees and the VAR team can streamline the decision-making process and minimize disruptions to the game.

4. Public Education and Transparency: Increasing public awareness and understanding of VAR technology can help mitigate criticism and build trust among fans. Transparency in the decision-making process can also enhance the credibility of VAR.

5. Technological Advancements: Continued investment in technological advancements can improve the efficiency and accuracy of VAR systems. Innovations such as automated offside detection and enhanced video analysis tools can further support referees in making accurate decisions.

Conclusion

The introduction of VAR technology in football has brought about significant changes to the decision-making process, providing referees with valuable support and enhancing the accuracy of critical decisions. The perceptions of Croatian VARs and AVARs highlight the benefits of VAR, including improved decision-making accuracy and increased confidence

among referees. However, challenges related to game flow disruption, consistency, and communication must be addressed to fully realize the potential of VAR technology. The findings of this research offer valuable insights for the future development and implementation of VAR in football. By investing in continuous education, standardized guidelines, improved communication protocols, public education, and technological advancements, the football community can enhance the effectiveness and acceptance of VAR technology. Ultimately, the goal is to uphold the integrity and fairness of the game, ensuring that football remains a sport that is both beautiful and just.

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EFFECTIVENESS OF DEVELOPMENT-LIMITING BOUNDARIES IN CURBING URBAN SPRAWL IN CHINESE CITIES: A CASE STUDY OF WUHAN

Ronghui Tan, Huazhong University of Science & Technology, China

Development-limiting boundaries are critical in regulating land use in Chinese cities, aiming to curb urban sprawl and protect the ecosystem and environment. China's recent land management laws mandate the delineation of urban development boundaries in national-territory spatial planning for each city. However, the effectiveness of these boundaries in containing urban land growth remains underexplored. This study evaluates urban land growth inside and outside the ecological redline in Wuhan, utilizing spatial difference-in-difference models to determine the net effect of these boundaries. Findings indicate that urban land growth inside the ecological redline increased by an average of 2.2% post-policy intervention, suggesting limited effectiveness of the Ecological Baseline Area regulation compared to pro-growth policies in the Urban Construction Area. The study identifies inefficient coordination mechanisms, technical limitations, and the pivotal role of local governments as primary reasons for the policy's ineffectiveness. Future reforms should focus on differentiated and urban-rural integrated land use policy design and public supervision mechanisms.

Urban sprawl presents significant challenges to sustainable development, particularly in rapidly urbanizing nations like China. To address these issues, development-limiting boundaries have been implemented to control urban expansion and safeguard environmental resources. These boundaries are integrated into the land management laws, requiring cities to incorporate them into their spatial planning. Despite their

widespread adoption, the effectiveness of these boundaries in managing urban growth has not been thoroughly examined.

This study aims to fill this gap by investigating the impact of development-limiting boundaries on urban land growth in Wuhan, a major Chinese city. Using spatial difference-in-difference models, the research assesses the net effect of these boundaries on controlling urban sprawl.

Urban sprawl is a global issue, with various countries implementing different policies to manage it. In China, the concept of development-limiting boundaries, including the ecological redline, has been a focal point in urban planning. Previous studies have highlighted the potential benefits of such boundaries in preserving green spaces and promoting sustainable development. However, empirical evidence on their effectiveness is limited.

Research on similar policies in other countries shows mixed results. For instance, urban growth boundaries in the United States have been both praised for preserving farmland and criticized for contributing to increased housing prices. In Europe, green belts have been effective in maintaining open spaces but have faced challenges related to urban density.

This study employs a spatial difference-in-difference model to analyze urban land growth in Wuhan. The model compares areas inside and outside the ecological redline before and after the implementation of the boundary policy. The data sources include satellite imagery, land use records, and policy documents from local government archives.

The analysis reveals that urban land growth inside the ecological redline increased by an average of 2.2% following the policy intervention. This suggests that the ecological baseline area regulation was not as effective in curbing urban expansion as intended. Conversely, pro-growth policies in the Urban Construction Area appear to have facilitated urban growth.

Several factors contribute to the limited effectiveness of development-limiting boundaries in Wuhan:

1. **Inefficient Coordination Mechanisms:** The lack of coordination between different governmental bodies and stakeholders hampers the effective implementation of boundary policies. This results in conflicting interests and priorities that undermine policy objectives.

2. **Technical Limitations:** The precision of boundary delineation and enforcement is constrained by technical challenges, such as outdated mapping technologies and insufficient monitoring infrastructure. This leads to ambiguities and loopholes that developers can exploit.

3. **Role of Local Governments:** Local governments play a crucial role in urban planning and land management. Their pursuit of economic growth often conflicts with environmental protection goals, leading to lenient enforcement of development-limiting boundaries.

Policy Implications

To enhance the effectiveness of development-limiting boundaries, several reforms are necessary:

1. **Differentiated Land Use Policies:** Policies should be tailored to address the specific needs and characteristics of different urban and rural areas. This includes recognizing the varying impacts of development on the environment and local communities.

2. **Urban-Rural Integration:** A holistic approach that integrates urban and rural planning can help balance development needs with environmental protection. This involves creating policies that promote sustainable development across the entire urban-rural continuum.

3. **Public Supervision Mechanisms:** Strengthening public oversight and participation in land use planning can improve transparency and

accountability. Mechanisms such as public hearings, stakeholder consultations, and independent audits can ensure that policies are implemented effectively and fairly.

Conclusion

The study concludes that while development-limiting boundaries are a promising tool for managing urban sprawl, their current implementation in Wuhan is insufficiently effective. The observed increase in urban land growth inside the ecological redline post-policy intervention highlights the need for more robust and coordinated efforts. Future reforms should focus on enhancing coordination mechanisms, addressing technical limitations, and integrating urban and rural planning to achieve sustainable development goals.

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DEVELOPMENT OF THE COMMUNICATION SYSTEM IN THE BUKOVINA IN THE 19TH CENTURY

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The study presents the great progress made by the institution of post, telegraph and telephone in bukovina, especially in the 19th century, when, established on solid foundations, these institutions reached the level of organizations abroad and became important factors of modernization of society. Postal services emerged from the need for long distance communication, which involved finding quick solutions for transporting or transmitting messages.

Since the time of the military administration, a mail service on horseback was organized in bukovina for military-administrative purposes. The first regular civilian post office, with regular postal connections to galicia and transylvania, was opened in chernivtsi on january 1, 1783, by the viennese johann paul vogel. The postal service has developed at a sustained pace in relation to population growth and ever-expanding business relations. In 1908, 213 post offices were operating. Relative to the area and number of inhabitants, a postal serving covered 49 km² and served 3,428 inhabitants.

The steady, thoughtful and consistent development of the postal system over the decades was supplemented very early on by the introduction of the telegraph and, somewhat later, the telephone service. The first telegraph office that included bukovina in the european telegraph network was established in chernivtsi in 1855. At the end of 1896, the telegraph network had a total length of 764.34 km and 45 stations. In 1908, there were 104 post offices with telegraph service and 44 authorized railway telegraph stations.

The first telephone exchange in Bukovina was built in 1883, in Chernivtsi, and then a fixed telephone network was extended in and between the cities and towns of Bukovina.

The postal service arose and existed out of the need for communication. Development of postal and communications networks have given new dimensions to postal services, which, in addition to ensuring state and interpersonal communications, it ensures communications economic, industrial, scientific etc.

On the importance of postal services, Constantin N. Minescu, inspector to the 3rd postal, telegraph and telephone region, he said in his well-known work *The History of the Romanian Post Office since 1916*, the first of its kind in our country: "post modern is one of the most democratic institutions and in this capacity serves interests of the highest order, such as: state affairs, interests the interests of the great merchants and industrialists, as well as of the humblest tradesmen townspeople, that and on of the from the may small village; interests the rich, that and of the poor; and by ingenious combinations, develops and transports all kinds of manifestations of human activity, all over the world, making everything disappear distance and any border" 1 .

In an organized form, postal services have been operating since ancient times. Post a taken living being from need what the have felt people of a correspond between they after they began to group themselves into different forms of organization. During the period of in the beginning, the postal services operated only for the "benefit" of the sovereign, transporting correspondence and the orders this one. Received organization a posts a findings in the the training of couriers, the first messages being carried by couriers on foot or on horseback and building buildings for messaging, for

rest courier and a the horses. Horses they were use that middle of transport in the received phase just with ride, and then harness to wagons, carts (light carriages with two wheels, pulled by a horse), diligences, etc. To ensure the permanent operation of postal services, the organizers had in mind that, in addition to couriers, there would also be post offices, means of transport and maintenance personnel. Post offices were located in a well-defined postal network, through them establishing the continuity of circulation shipments, especially long-distance ones. Also in these post offices place activity and the staff who oversee network postal.

In the nineteenth century, in the language romanian, through the word mail it understood:

- the administration and the house/premises where a service was installed for the presentation and distribution correspondence;

- establishment made from distance to distance, along the roads, where se he found a number of horses necessary to replace those who brought them there cart postal which transport couriers, travels and correspondence;

- measure of road equivalent to 20 km, the usual distance between two stations of mail 2 .

In the romanian principalities, the beginnings of the post office consisted in the provision of services for transporting princely couriers, but because the maintenance was too expensive service, the private transport service was added to it, and more later, as postal networks were organized, mail transport, the pits with money (pouch sealed, which it expedite through post), package and so on in the the centuries xvii-xviii, service postal it was organized of by state and, with authorization of to ruler, could be moved with carriage postal and people. Fees for the maintenance of the postal service they were the responsibility of the lower class population, nobles and

civil servants being exempt. At the beginning of the 19th century they established post stations called menzils, headed by a menzil captain, where se they kept the horses and mail carriages (olace) necessary for the transport of state couriers, official in the mission and people approved of gentleman to travel.

Moldavia it was related with austria by a single road postal, road which start from iasi, passing through whisper, beautiful, botosani, goofy, herta, mihăileni, cernăuți, sniatyn, stanislau towards leMBERG, a city that was connected to warsaw, prague, vienna and brno 3 . In the spring of 1869, a stagecoach left daily postal – the contract for undertaking postal services on this route was owned by theodore ghica vornicul – from iași via the iloaiei bridge, botoșani, cucoreni, mihăileni to sinauti, distance from 158 km being traversed in 34 of 4 hours service postal.

German, the postal service associated with the name thurn and taxis operated as a service imperial mail for more than 200 years, with regular connections through post stations fixed throughout the empire and in neighboring countries 5 , in bucovina, at the time of annexation, there was no well organized postal system and no regular postal traffic. Traffic, with safety very rare of authority secular, it was done of messengers riding, the of monastery and the authorities spiritual of special messages church

When the austrian troops entered the country through sniatyn, a point was established postal campaign between sniatyn and chernivtsi and was organized, of course more in military-administrative purpose, a regular mail service, performed at first on horseback, which tie down vienna of transylvania through leMBERG – chernivtsi – campulung moldavian

– vatra dornei – poiana stampeii – bistrita. Every 20 kilometers the route was provided with post-stations, with lodgings for travellers, and change-

horses. Serving military purposes only, this service was to be replaced by a permanent institution, which had to serve not only the purposes of the new administrative bodies but also need commerce and production industrially and commercial 6 .

The first administrator military of bucovina, general gabriel splény of mihálydy (september 1, 1774 – april 6, 1778) recommends, in the prepared report for the vienna court – description of the bucovina district from 1775 7 -, the establishment, as soon as possible, of post offices: “at a service of postmen we will have to think only when the roads will be built someday fall of communication with transylvania. Of also, all owners in the cause it they might be obliged to build every two miles well drawn up inns and provided for hosting of both people and of cattle" 8 .

The second military administrator of bucovina, karl von enzenberg (april 6 1778 – 16 september 1786), the which a answered the post of to general spleen, a given a special importance to the organization of the post and the establishment of post stations, which on then they were things unknown in the bucovina. Feeling lack these institutions cultural, enzenberg sent, in september 1778, a request to the central government, on the basis of a project by general splény, to organize a postal service – from sniatyn through chernivtsi, siret, suceava, vama, pojorâta, iacobeni, dorna up to barge (the land nășăudului) – in the which to miss need speeding organization the service necessary not only for the new administrative bodies of the state, but also for the needs commerce and industries. Enzenberg a welcome obstacle available of the room of finance a court and, may chosen, of command general military transylvanian, which will to make he link transylvania with bucovina 9 . In the the goal facilitate relationships

and travel between localities, under the enzenberg to beginning, however, organization a service postal in bucovina.

The first "ordinary postal service" in bucovina was established by the viennese johann paul vogel, who came to bucovina in 1782. On january 1, 1783, this first conductor of post bucovina a open, in the chernivtsi, the first office postal civil from bucovina 10 with regular postal connections from chernivtsi, on the one hand to galicia through sniatyn, on the other side to transylvania, through bistrița. Subsequent, entire postal service from country, such as and from the surrounding areas, it was extended for a it includes and transport with diligence postal.

Along the main roads, in the buildings that had been built in some locations and to distances established of administration for the accommodation military who participated in their construction, inns and stations or offices were established postage. Post stations were maintained by a service staff, for which they have houses were built, and housed a number of change horses, for maintenance to which the imperial administration endowed them with extensive lands, especially hayfields, taken through "rooming" some property of locals or of fund church.

In the account of the journey made by an anonymous person in 1819, from bistrita to leMBERG, the post stations on the road section between măgura are mentioned calului and campulung - built between 1780 and 1787 with dorne peasants and câmpulungeni - of the carpathian road (karpaten- or franzensstraße) 11 from tihuța, poiana stampeii, dorna, valea putnei, pojorâta and a rather comfortable inn in the market field 12 . For the post office in pojorâta, where a certain one was the conductor trnka, in 1788, 24.5 square meters of land were reserved located in pojorâta, fundu moldovei and câmpulung, and for the office in valea 25 jaws were given to

putna, of which 14.5 jaws on mount mestecaniş. Office post office in dorna - whose conductor was, from 1788, the "bear hunter" wenzel kratzer13 - a received land in the surface of 53 of yokes and 1 two hundred of hamper square on mount runcu dornei

The constant, well-thought-out and consistent development of the postal system in Bucovina over the decades was supplemented very early by the introduction telegraph and, something more late, a services of telephony. Telegraph It is a device which Enable the transmission of information to distance by coded signal. Samuel FB Morse (1791-1872) conceived, in 1835, a system of ENCODE A THE letters and numbers with lines and points, known that the alphabet Morse. In 1837 he patented the electromagnetic telegraph, and the first public use of ITS A former in the 24 May 1844, between Washington and Baltimore (US).

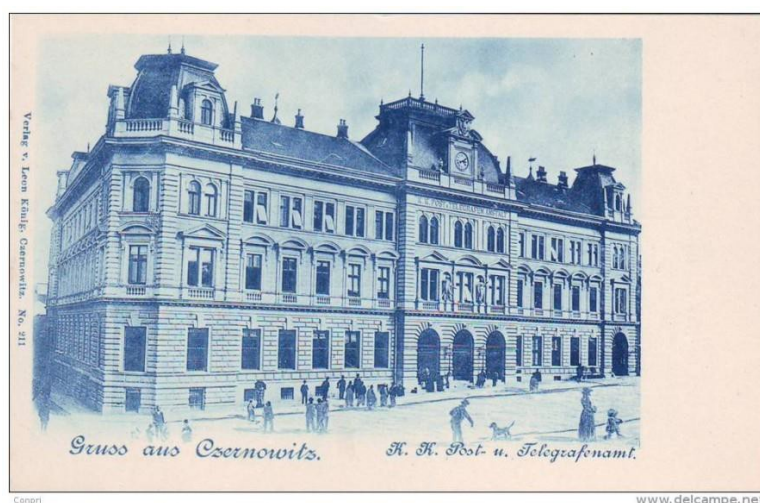


Figure 1. Office postal and telegraph from Chernivtsi

Along with the postal service, the telegraph system was one of the most outstanding means of promoting economic interests. Use of the Service telegraph became more and more widespread, as was the business world convinced of utility of This modal of communication. Minister commerce

granted careful Maxim this middle of communication through extension the network telegraphic.

After what the ministerial authorities have former convinced of great benefits, from a political and administrative point of view, which could be achieved through enlargement of the use of the telegraph throughout the monarchy, the physicist Iulius Gintl 52 , began, yet of July 1848, the design of a state telegraph network to cover the whole Austrian monarchy. The provincial capitals were to be linked to Vienna, but also between them. It was envisaged to design and build direct main lines that would connector the May important points, from point of view administrative and strategic, of the monarchy with the center (Vienna).

The idea of erecting a new post and telegraph building in Chernivtsi came from Felix Pinole Freiherr will Friedenthal, President of then A Bukovina (1887-1890), which A campaigned for endorsement Building TO Minister commerce FROM Vienna. Minister A approved, in the the year 1887, BUILDING A office postal and telegraph in the Chernivtsi.

The communication system developed quite rapidly in Bucovina and became one from the May leading factor of upgrade a company in the century of XIXth.

Established on solid foundations, the postal, telegraph and telephone services amounted to the level of those abroad, corresponded to the requirements of the time and functioned in the mod exemplary in all respects. In the Bucovina calendars one could be found list exact of everyone state post offices and private.

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THE PACT OF 1275 BETWEEN PATRIARCH RAYMOND DELLA TORRE AND DOGE LORENZO TIEPOLO: A HISTORICAL ANALYSIS

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This article examines a significant historical document—a pact concluded in February 1275 between the Patriarch of Aquileia, Raymond della Torre, and the Doge of Venice, Lorenzo Tiepolo. This pact is largely a confirmation of an earlier treaty from 1254 between Patriarch Gregory of Montelongo and Doge Reniero Zeno, with minor additions. The study contextualizes the pact within the early years of Raymond della Torre's reign and explores how Venice expanded its rights and prerogatives within the Patriarchate of Aquileia while offering minimal concessions. The analysis reveals that the Patriarchs, in dire financial straits and in need of Venetian support, were compelled to agree to these unbalanced treaties.

The political landscape of Northern Italy in the 13th century was marked by complex alliances and power struggles among various states and principalities. The Patriarchate of Aquileia, a significant ecclesiastical and

temporal power, frequently found itself in need of strong allies. Venice, a burgeoning maritime republic, leveraged these needs to expand its influence. This article focuses on the pact of 1275 between Patriarch Raymond della Torre and Doge Lorenzo Tiepolo, analyzing its contents, historical context, and implications.

The Patriarchate of Aquileia was a unique entity, holding both religious and secular authority over a vast territory that included parts of modern-day Italy, Slovenia, and Austria. By the mid-13th century, it faced numerous internal and external challenges, including financial difficulties, territorial disputes, and pressure from neighboring states. Venice, on the other hand, was expanding its commercial empire and sought to secure advantageous trade routes and political influence in the region.

Patriarch Raymond della Torre

Raymond della Torre became the Patriarch of Aquileia in 1273. Coming from a powerful Milanese family, he inherited a diocese in turmoil. His predecessors had left the treasury depleted, and the Patriarchate was struggling to assert its authority over rebellious vassals and external threats. Raymond's reign was marked by efforts to stabilize the region and secure financial and military support.

Doge Lorenzo Tiepolo

Lorenzo Tiepolo, Doge of Venice from 1268 to 1275, was a shrewd leader known for his diplomatic and military skills. Under his leadership, Venice continued its strategy of expanding influence through treaties and alliances. Tiepolo recognized the strategic importance of Aquileia and sought to secure Venetian interests through a favorable pact.

The 1254 Treaty

The 1254 treaty between Patriarch Gregory of Montelongo and Doge Reniero Zeno served as the foundation for the 1275 pact. This earlier agreement granted Venice significant privileges within the Patriarchate, including trade rights, tax exemptions, and territorial concessions. In return, Venice provided limited military support and economic assistance.

The 1275 Pact: An Analysis

The pact of February 1275 largely reaffirmed the provisions of the 1254 treaty, with some additional articles aimed at expanding Venetian privileges. Key points of the pact included:

1. **Trade Rights:** Venice retained and expanded its exclusive rights to trade within the Patriarchate. Venetian merchants were granted immunity from local taxes and tolls, solidifying Venice's economic dominance in the region.

2. **Territorial Concessions:** The pact confirmed and extended Venice's control over strategic territories within the Patriarchate, enhancing its ability to influence local politics and trade routes.

3. **Military Support:** Venice pledged limited military assistance to the Patriarchate, primarily as a means to protect its own commercial interests rather than out of altruistic support for Raymond della Torre.

4. **Political Influence:** The pact allowed Venice to exert significant political influence over the Patriarchate, often interfering in local governance and succession matters.

Implications for the Patriarchate of Aquileia

The 1275 pact clearly favored Venice, reflecting the unequal power dynamics between the two entities. For Raymond della Torre, the agreement was a necessary compromise to secure immediate financial relief and

military support. The patriarchs before and after Raymond continued to rely on Venice, often at the cost of ceding substantial autonomy and privileges.

Comparative Analysis of 1254 and 1275 Treaties

While both treaties aimed to formalize the relationship between the Patriarchate and Venice, the 1275 pact showed a marked increase in Venetian demands. The additional articles primarily served to expand Venice's economic and political control, illustrating the gradual erosion of the Patriarchate's autonomy.

Conclusion

The pact of 1275 between Patriarch Raymond della Torre and Doge Lorenzo Tiepolo is a testament to the strategic acumen of Venice and the vulnerabilities of the Patriarchate of Aquileia. By analyzing this historical document, we gain insight into the broader geopolitical landscape of 13th-century Northern Italy. The repeated concessions made by the patriarchs underscore the challenges they faced and the lengths to which they went to secure necessary alliances. This study not only highlights the dynamics between Venice and Aquileia but also contributes to our understanding of medieval diplomacy and statecraft.

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GLOBALIZATION AND THE DIGITAL INFORMATION SOCIETY:
A PSYCHOLOGICAL PERSPECTIVE ON E-LEARNING

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Globalization has profoundly influenced every aspect of contemporary life, including education. This global interconnectedness has ushered in the digital information society, which marks a significant shift from traditional educational systems to interactive, technology-driven learning environments. E-learning, an essential component of this transformation, has emerged as a viable alternative to conventional teaching methods. This paper explores e-learning from a psychological perspective, comparing it

with traditional learning methods and examining the psychosocial and educational characteristics of virtual learning environments. It discusses learning content, interactivity, motivation, and the impacts of new relationships on the autonomy of learners and their selection of educational content. Despite skepticism regarding e-learning's effectiveness, this paper argues that it offers substantial improvements to the educational process.

The Evolution of E-Learning

E-learning refers to the use of electronic technologies to access educational curriculum outside of a traditional classroom. In most cases, it refers to a course, program, or degree delivered completely online. The evolution of e-learning has been driven by advances in technology, including the internet, mobile devices, and various software platforms that facilitate remote instruction and learning.

Historical Context

Historically, education systems have relied heavily on face-to-face interactions in classroom settings. Traditional learning environments are characterized by direct interaction between teachers and students, which fosters immediate feedback, discussion, and collaborative learning. However, these environments also have limitations, such as geographical constraints, rigid scheduling, and limited access to diverse educational resources.

The advent of the internet and digital technologies has transformed educational practices, making learning more accessible and flexible. Online education began with simple correspondence courses and has evolved into comprehensive platforms offering a wide range of interactive features. These include video lectures, discussion forums, virtual simulations, and real-time assessments, which collectively enhance the learning experience.

Psychological Perspectives on E-Learning

From a psychological standpoint, e-learning represents a paradigm shift in how education is delivered and received. The virtual learning environment offers unique psychosocial and educational characteristics that differentiate it from traditional classroom settings.

Learning Content

In e-learning, the content is often more diverse and customizable compared to traditional textbooks and lectures. Digital platforms allow for multimedia content, including videos, interactive simulations, and hyperlinked texts, which can cater to different learning styles. This multimodal approach can enhance comprehension and retention by engaging multiple senses.

Moreover, e-learning platforms can provide instant access to a vast array of up-to-date information and resources, which is particularly beneficial in rapidly evolving fields. This immediacy and breadth of content ensure that learners are exposed to the latest knowledge and research findings.

Interactivity is a crucial component of effective learning, and e-learning platforms offer various interactive features that can enhance engagement and motivation. These features include discussion forums, live chats, quizzes, and interactive simulations, which allow learners to actively participate in the learning process.

Studies have shown that interactive learning environments can improve critical thinking and problem-solving skills. By engaging learners in activities that require active participation, such as discussions and collaborative projects, e-learning platforms can foster a deeper understanding of the material.

Motivation plays a critical role in learning, and e-learning environments can influence motivation in several ways. Self-determination theory (SDT), which emphasizes the importance of autonomy, competence, and relatedness in fostering intrinsic motivation, provides a useful framework for understanding how e-learning can enhance motivation.

- **Autonomy:** E-learning platforms often offer greater flexibility and control over the learning process, allowing learners to set their own pace and choose topics that interest them. This autonomy can increase intrinsic motivation, as learners feel more in control of their education.

- **Competence:** E-learning can enhance feelings of competence by providing immediate feedback through quizzes and assessments. This instant feedback helps learners understand their progress and identify areas for improvement, which can boost confidence and motivation.

- **Relatedness:** Although e-learning lacks face-to-face interaction, it can still foster a sense of community through discussion forums, group projects, and social media integration. These virtual interactions can help learners feel connected to their peers and instructors, which is essential for maintaining motivation.

The shift to e-learning also changes the dynamics of teacher-student relationships. In traditional classrooms, teachers often play a central role in directing the learning process. In contrast, e-learning environments tend to promote a more learner-centered approach, where students have greater responsibility for their learning.

This increased autonomy can be empowering for learners, as it encourages self-directed learning and critical thinking. However, it also requires learners to be more disciplined and self-motivated. Therefore, effective e-learning programs often include support mechanisms, such as

online tutoring and mentoring, to help learners manage their responsibilities and stay on track.

Challenges and Criticisms of E-Learning

Despite its advantages, e-learning is not without its challenges and criticisms. Some educators and learners remain skeptical about its effectiveness, particularly in comparison to traditional learning methods.

Engagement and Motivation

One of the primary concerns with e-learning is maintaining student engagement and motivation. Without the physical presence of an instructor and peers, some learners may struggle to stay motivated and focused. This can be particularly challenging for younger students or those who require more structured guidance.

To address this issue, e-learning platforms must incorporate elements that actively engage learners and sustain their interest. Gamification, interactive content, and regular feedback are some strategies that can help maintain motivation and engagement in virtual learning environments.

Accessibility and Equity

Another significant challenge is ensuring that e-learning is accessible to all students. Access to technology and the internet is not universal, and there are disparities in digital literacy skills. These inequalities can create barriers to effective e-learning, particularly for students from disadvantaged backgrounds.

To mitigate these challenges, it is essential to provide resources and support to ensure that all learners have the tools and skills needed to succeed in an e-learning environment. This includes providing access to devices, internet connectivity, and training on how to use digital platforms effectively.

Social Interaction and Collaboration

The lack of face-to-face interaction in e-learning can also be a drawback. Social interaction and collaboration are essential components of the learning process, and virtual environments can sometimes fall short in replicating these experiences.

However, advancements in technology are helping to bridge this gap. Video conferencing, virtual reality, and collaborative online tools are increasingly being used to facilitate more interactive and social learning experiences. These technologies can help create a sense of presence and community, even in a virtual environment.

Quality of Education

There are concerns about the quality of education provided through e-learning. Some critics argue that online courses may not offer the same depth and rigor as traditional classroom instruction. Ensuring that e-learning programs meet high academic standards is crucial to addressing these concerns.

Accreditation and quality assurance processes are essential for maintaining the credibility and effectiveness of e-learning programs. Institutions must adhere to rigorous standards and continuously evaluate and improve their online offerings to ensure they provide a high-quality education.

The Future of E-Learning

Despite the challenges and criticisms, e-learning is poised to play an increasingly significant role in education. The COVID-19 pandemic has accelerated the adoption of online learning, demonstrating its potential as a flexible and scalable solution for delivering education in times of crisis.

As technology continues to evolve, e-learning platforms will become more sophisticated, offering even more interactive and personalized learning experiences. Artificial intelligence (AI) and machine learning (ML) will play a crucial role in this evolution, enabling adaptive learning systems that can tailor content and feedback to individual learners' needs.

Conclusion

E-learning represents a transformative shift in education, driven by the globalization and digitization of society. From a psychological perspective, e-learning offers several advantages over traditional learning methods, including enhanced interactivity, motivation, and autonomy. However, it also presents challenges that must be addressed to ensure its effectiveness and accessibility.

As education systems continue to evolve, it is essential to embrace the potential of e-learning while also addressing its limitations. By leveraging technology and adopting best practices, educators can create engaging, inclusive, and high-quality learning experiences that meet the needs of all students.

In conclusion, e-learning is not just a temporary solution but a fundamental component of the future of education. By understanding and addressing the psychological aspects of e-learning, we can unlock its full potential and create a more equitable and effective educational landscape for the digital age.

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DEVELOPMENT OF STEM COMPETENCE OF STUDENTS IN THE PROCESS OF LEARNING PHYSICS

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In contemporary education, the development of STEM (Science, Technology, Engineering, and Mathematics) competence is essential to prepare students for the challenges of the 21st century. As the demand for skills in science and technology grows, it becomes crucial to integrate STEM education into the curriculum, particularly in subjects like physics that naturally lend themselves to interdisciplinary approaches. This article explores the development of STEM competence in students through the process of learning physics, emphasizing the relevance of this topic, theoretical foundations, and practical implementation through research projects.

The growing importance of STEM fields in the global economy underscores the need for a workforce proficient in science, technology, engineering, and mathematics. Developing STEM competence in students is not only about imparting knowledge but also about fostering critical thinking, problem-solving, and innovation. Physics education, with its foundational role in understanding natural phenomena and technological applications, provides an ideal platform for integrating STEM principles. By focusing on STEM competence, educators can better prepare students for higher education and careers in these critical fields.

The concept of competence in education refers to the combination of knowledge, skills, attitudes, and values necessary to perform tasks effectively in various contexts. Competence-based education aims to equip students with the ability to apply their learning in real-world situations. The competence approach in education has been influenced by several scholars, including Benjamin Bloom, who developed Bloom's Taxonomy, and John Dewey, who emphasized experiential learning and critical thinking.

STEM competences encompass the integrated application of knowledge and skills from science, technology, engineering, and mathematics to solve complex problems and innovate. These competences include:

1. **Scientific Literacy:** Understanding scientific concepts and processes, enabling informed decision-making and participation in civic and cultural affairs.
2. **Technological Literacy:** The ability to use, manage, and understand technology effectively and responsibly.
3. **Engineering Literacy:** Understanding engineering principles and processes, including design, analysis, and problem-solving.

4. **Mathematical Literacy:** Applying mathematical reasoning and techniques to solve problems and analyze data.

STEM competences can be developed through various educational strategies, including:

1. **Inquiry-Based Learning:** Encouraging students to explore, ask questions, and conduct experiments to discover new knowledge.

2. **Project-Based Learning:** Engaging students in long-term projects that require the application of STEM principles to solve real-world problems.

3. **Collaborative Learning:** Promoting teamwork and communication skills through group activities and projects.

4. **Integration of Technology:** Utilizing technological tools and resources to enhance learning and problem-solving.

5. **Interdisciplinary Approaches:** Combining concepts and skills from multiple STEM disciplines to address complex challenges.

To investigate the impact of STEM-based approaches on the development of competences in physics students, a mixed-methods research design will be employed. This approach combines quantitative and qualitative data collection methods to provide a comprehensive understanding of the educational intervention.

The study will use a quasi-experimental design with a control group and an experimental group. Both groups will consist of 10th and 11th-grade students from a specialized school, matched based on their prior academic performance in physics.

The participants will include 60 students, divided equally between the control and experimental groups. The experimental group will engage in STEM-based physics projects, while the control group will continue with traditional instruction.

Instruments

1. STEM Competence Assessment (SCA): A standardized test to measure students' STEM competences before and after the intervention.
2. Physics Achievement Test (PAT): To assess improvements in physics understanding and application.
3. Student Engagement Questionnaire (SEQ): To evaluate student engagement and attitudes towards physics and STEM.
4. Project Assessment Rubric (PAR): To evaluate the quality of student research projects based on criteria such as scientific rigor, creativity, and collaboration.

Procedure

1. Pre-Test: Administer the SCA and PAT to both groups.
2. Intervention: Over a period of 12 weeks, the experimental group will participate in STEM-based physics projects. These projects will involve formulating research questions, designing and conducting experiments, analyzing data, and presenting findings.
3. Post-Test: Re-administer the SCA and PAT to both groups.
4. Qualitative Data Collection: Conduct interviews and focus group discussions with students and teachers from the experimental group to gather insights into their experiences and perceptions.

Quantitative data will be analyzed using statistical methods to compare the pre- and post-test scores of the control and experimental groups. Qualitative data will be analyzed thematically to identify common themes and insights related to the effectiveness of STEM education in developing competences.

Example of a Research STEM Project in Physics for a Specialized School
Project Title - Designing and Testing a Simple Wind Turbine

Grade Level - 11th Grade

To develop students' STEM competences and deepen their understanding of energy conversion and aerodynamics by designing and testing a wind turbine.

Materials Needed

- Wind turbine kits (including blades, motors, and supports)
- Multimeters
- Anemometers
- Laptops with data analysis software
- Building materials (cardboard, plastic, wood, etc.)
- Project guidelines and worksheets

Project Outline

1. Introduction (1 week)

- Introduction to renewable energy and the principles of wind energy conversion.
- Overview of the scientific method and research project guidelines.
- Formation of student groups and assignment of preliminary research topics related to wind turbine design.

2. Research Question Formulation (1 week)

- Students brainstorm and formulate specific research questions related to wind turbine efficiency (e.g., How does blade shape affect the efficiency of a wind turbine?).
- Teacher approval and feedback on research questions.

3. Experimental Design (2 weeks)

- Students design experiments to investigate their research questions, including identifying variables, controls, and methods of data collection.
- Teacher review and feedback on experimental designs.

4. Building and Testing (3 weeks)

- Students build their wind turbines using provided kits and materials.

- Conduct tests to measure the performance of their turbines under various conditions using multimeters and anemometers.

- Collect and record data systematically.

5. Data Analysis (2 weeks)

- Students analyze their data using appropriate statistical and graphical methods.

- Interpretation of results and drawing conclusions based on data.

6. Presentation of Findings (2 weeks)

- Students prepare presentations of their research projects, including background information, methodology, results, and conclusions.

- Presentation to peers, teachers, and possibly a wider school audience.

7. Reflection and Feedback (1 week)

- Students reflect on their research process, challenges faced, and lessons learned.

- Teachers provide feedback on project quality and student performance.

Conclusion

The development of STEM competences through the process of learning physics is essential for preparing students for future challenges in science and technology. By integrating research-based projects and interdisciplinary approaches, educators can foster critical thinking, problem-solving, and innovation. This study aims to provide empirical evidence of the benefits of STEM education in physics, contributing to the development of teaching

practices that equip students with the competences necessary for success in the 21st century.

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APPLICATION OF ELEMENTS OF RESEARCH EDUCATION IN THE PROCESS OF TEACHING PHYSICS

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In today's rapidly evolving educational landscape, the development of critical thinking and research skills in students is essential. Research education, which emphasizes inquiry-based learning and the scientific method, is particularly effective in fostering these skills. Physics, with its

focus on understanding the fundamental principles governing the natural world, offers an ideal context for incorporating research education. This article explores the application of elements of research education in the process of teaching physics, highlighting its relevance, theoretical foundations, experimental methods, and practical implementation in specialized schools.

Relevance of the Topic

The relevance of this study is underscored by the increasing emphasis on developing higher-order thinking skills and scientific literacy in students. Traditional teaching methods often focus on rote memorization and procedural knowledge, which can limit students' ability to apply concepts in novel situations. Research education, by contrast, encourages active learning, critical thinking, and problem-solving, preparing students for the complexities of modern science and technology. In physics education, incorporating research elements can enhance student engagement, deepen understanding, and foster a lifelong interest in scientific inquiry.

Theoretical Provisions of the Research

Research education involves teaching students how to conduct scientific investigations, including formulating hypotheses, designing experiments, collecting and analyzing data, and drawing conclusions. It is grounded in constructivist theories of learning, which posit that knowledge is actively constructed by the learner through experience and reflection. Key components of research education include inquiry-based learning, collaborative projects, and the use of real-world problems to drive investigation.

Inquiry-Based Learning

Inquiry-based learning (IBL) is a pedagogical approach that encourages students to explore questions, problems, or scenarios, often derived from their own curiosities. IBL promotes active learning and critical thinking by allowing students to take ownership of their learning process. In physics, IBL can involve experiments, simulations, and problem-solving activities that require students to apply theoretical concepts to practical situations.

Physics Education

Physics education aims to develop a deep understanding of the laws of nature, fostering analytical and problem-solving skills. By integrating research education into physics teaching, educators can create a learning environment that emphasizes scientific inquiry and experimentation. This approach not only enhances conceptual understanding but also cultivates skills such as data analysis, critical evaluation, and effective communication of scientific ideas.

Experimental Methods in Pedagogical Research

To investigate the impact of research education on the learning outcomes of physics students, a mixed-methods approach will be employed. This approach combines quantitative and qualitative data collection methods to provide a comprehensive understanding of the educational intervention.

Research Design

The study will use a quasi-experimental design with a control group and an experimental group. Both groups will consist of 10th and 11th-grade students from a specialized school, matched based on their prior academic performance in physics.

Participants

The participants will include 60 students, divided equally between the control and experimental groups. The experimental group will engage in research-based physics projects, while the control group will continue with traditional instruction.

Instruments

1. Physics Achievement Test (PAT): To assess improvements in physics understanding and application.
2. Critical Thinking Skills Test (CTST): To measure the development of critical thinking skills before and after the intervention.
3. Student Engagement Questionnaire (SEQ): To evaluate student engagement and attitudes towards physics.
4. Project Assessment Rubric (PAR): To evaluate the quality of student research projects based on criteria such as scientific rigor, creativity, and presentation.

Procedure

1. Pre-Test: Administer the PAT and CTST to both groups.
2. Intervention: Over a period of 12 weeks, the experimental group will participate in research-based physics projects. These projects will involve formulating research questions, designing and conducting experiments, analyzing data, and presenting findings.
3. Post-Test: Re-administer the PAT and CTST to both groups.
4. Qualitative Data Collection: Conduct interviews and focus group discussions with students and teachers from the experimental group to gather insights into their experiences and perceptions.

Data Analysis

Quantitative data will be analyzed using statistical methods to compare the pre- and post-test scores of the control and experimental groups.

Qualitative data will be analyzed thematically to identify common themes and insights related to the effectiveness of research education in physics.

Example of a Research Project in Physics for a Specialized School

Project Title -Investigating the Factors Affecting the Efficiency of Solar Cells

Grade Level -11th Grade

Project Objective

To develop students' research skills and deepen their understanding of photovoltaic technology by investigating factors that influence the efficiency of solar cells.

Materials Needed

- Solar cells
- Multimeters
- Light sources (e.g., lamps)
- Variable resistors
- Thermometers
- Data loggers
- Laptops with data analysis software
- Project guidelines and worksheets

Project Outline

1. Introduction (1 week)

- Introduction to photovoltaic technology and the importance of solar energy.

- Overview of the scientific method and research project guidelines.

- Formation of student groups and assignment of preliminary research topics.

2. Research Question Formulation (1 week)

- Students brainstorm and formulate specific research questions related to solar cell efficiency (e.g., How does temperature affect the efficiency of solar cells?).

- Teacher approval and feedback on research questions.

3. Experimental Design (2 weeks)

- Students design experiments to investigate their research questions, including identifying variables, controls, and methods of data collection.

- Teacher review and feedback on experimental designs.

4. Conducting Experiments (3 weeks)

- Students conduct their experiments, collecting and recording data systematically.

- Teachers provide support and ensure safety protocols are followed.

5. Data Analysis (2 weeks)

- Students analyze their data using appropriate statistical and graphical methods.

- Interpretation of results and drawing conclusions based on data.

6. Presentation of Findings (2 weeks)

- Students prepare presentations of their research projects, including background information, methodology, results, and conclusions.

- Presentation to peers, teachers, and possibly a wider school audience.

7. Reflection and Feedback (1 week)

- Students reflect on their research process, challenges faced, and lessons learned.

- Teachers provide feedback on project quality and student performance.

Conclusion

The application of elements of research education in teaching physics has significant potential to enhance students' critical thinking, problem-solving, and research skills. By engaging students in authentic scientific inquiries, educators can foster a deeper understanding of physical principles and cultivate a scientific mindset. This research aims to provide empirical evidence of the benefits of research education in physics, contributing to the development of innovative teaching practices that prepare students for the demands of the 21st century.

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STEM EDUCATION AS A MEANS OF DEVELOPING STUDENTS' CREATIVE THINKING IN THE PROCESS OF LEARNING PHYSICS

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In the 21st century, the importance of creative thinking in education cannot be overstated. As the world increasingly relies on innovation and complex problem-solving, equipping students with the ability to think creatively is paramount. Physics, as a fundamental branch of science, provides a unique opportunity to cultivate these skills. STEM (Science, Technology, Engineering, and Mathematics) education, with its interdisciplinary and hands-on approach, is particularly effective in fostering creative thinking. This article explores the role of STEM education in developing students' creative thinking skills in the context of learning physics.

Relevance of the Topic

The relevance of this study is underscored by the growing emphasis on STEM education globally. Governments and educational institutions are prioritizing STEM initiatives to prepare students for future careers in an increasingly technical and innovative world. Creative thinking is a critical component of STEM education, enabling students to generate novel solutions, approach problems from multiple perspectives, and adapt to new challenges. In physics education, which traditionally focuses on understanding natural phenomena and laws, incorporating STEM elements can make learning more dynamic, relevant, and effective in developing creative thinkers.

Theoretical Provisions of the Research

Creative Thinking in Education

Creative thinking involves the ability to generate new ideas, make connections between seemingly unrelated concepts, and solve problems in innovative ways. It is characterized by originality, flexibility, and fluency of thought. In the context of education, creative thinking is crucial for students to navigate complex problems and devise unique solutions.

STEM Education

STEM education integrates science, technology, engineering, and mathematics into a cohesive learning paradigm based on real-world applications. It emphasizes hands-on, project-based learning, and encourages students to apply interdisciplinary knowledge to solve problems. By engaging students in practical and collaborative activities, STEM education nurtures critical thinking, creativity, and innovation.

Physics Education and STEM

Physics, as a core component of STEM, offers numerous opportunities for creative exploration. From understanding fundamental principles to experimenting with real-world applications, physics education can benefit greatly from a STEM approach. By incorporating technology, engineering principles, and mathematical modeling, physics lessons can become more engaging and effective in fostering creative thinking.

Experimental Methods in Pedagogical Research

To investigate the impact of STEM education on the development of creative thinking in physics, a mixed-methods approach will be employed, combining quantitative and qualitative data collection methods.

Research Design

The study will use a quasi-experimental design with a control group and an experimental group. Both groups will consist of students from 10th

and 11th grades in a specialized school, matched based on their prior academic performance in physics.

Participants

The participants will include 60 students, divided equally between the control and experimental groups. The experimental group will participate in physics lessons that incorporate STEM elements, while the control group will continue with traditional instruction.

Instruments

1. Torrance Tests of Creative Thinking (TTCT): A standardized test to measure students' creative thinking skills before and after the intervention.
2. Physics Achievement Test (PAT): To assess improvements in physics understanding and application.
3. Student Engagement Questionnaire (SEQ): To evaluate student engagement and attitudes towards physics.

Procedure

1. Pre-Test: Administer the TTCT and PAT to both groups.
2. Intervention: Over a period of 12 weeks, the experimental group will participate in weekly STEM-based physics lessons. These lessons will include activities such as physics projects, engineering challenges, and the use of technology for simulations and modeling.
3. Post-Test: Re-administer the TTCT and PAT to both groups.
4. Qualitative Data Collection: Conduct interviews and focus group discussions with students and teachers from the experimental group to gather insights into their experiences and perceptions.

Data Analysis

Quantitative data will be analyzed using statistical methods to compare the pre- and post-test scores of the control and experimental groups.

Qualitative data will be analyzed thematically to identify common themes and insights related to the effectiveness of STEM education in developing creative thinking.

Example of a Physics Lesson Plan Using STEM Elements

Lesson Objective

To develop students' creative thinking skills and deepen their understanding of electromagnetism through a STEM-based project.

Grade Level -11th Grade

Lesson Topic

Electromagnetism and Electromagnetic Induction

Materials Needed

- Interactive whiteboard
- Copper wire, magnets, and iron nails
- Multimeters
- Arduino kits and sensors
- Laptops with programming software
- Worksheets and project guidelines

Lesson Outline

1. Introduction (10 minutes)

- Briefly review the concepts of electromagnetism and electromagnetic induction.

- Explain the project: Students will design and build a simple electromagnetic generator and use Arduino kits to measure and analyze the generated current.

2. Project Activity (45 minutes)

- Divide students into small groups and provide materials for building the generator.

- Students design and construct their generators, experimenting with different configurations of coils and magnets.

- Using multimeters and Arduino kits, students measure the current generated and use programming software to analyze the data.

- Teachers circulate the room, providing guidance and ensuring that students understand the concepts.

3. Presentation and Discussion (20 minutes)

- Each group presents their project, explaining their design choices, challenges faced, and findings.

- Discuss the various approaches taken by different groups and the creative solutions they developed.

- Encourage students to reflect on how the project helped them understand electromagnetism and develop their creative thinking skills.

4. Conclusion (5 minutes)

- Summarize the key learning points of the lesson.

- Highlight the importance of creativity and interdisciplinary thinking in solving complex problems.

- Assign a homework task that involves researching real-world applications of electromagnetism and proposing an innovative project idea based on their findings.

Conclusion

STEM education offers a powerful means of developing students' creative thinking skills, particularly in the context of learning physics. By integrating science, technology, engineering, and mathematics into cohesive and engaging lessons, educators can foster a deeper understanding of physical principles while promoting innovative and critical thinking. This research aims to provide empirical evidence of the benefits of STEM

education in physics, contributing to the development of teaching practices that prepare students for the challenges of the future.

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DEVELOPMENT OF VALUE ORIENTATIONS OF STUDENTS IN THE PROCESS OF LEARNING PHYSICS

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Introduction

In the modern educational landscape, the development of value orientations in students is a critical objective. Value orientations, encompassing beliefs, attitudes, and behaviors, play a significant role in shaping individuals' decisions and actions. Physics, as a fundamental science, offers a unique platform to instill these values by fostering a deeper understanding of the natural world and the principles governing it. The

integration of game-based activities in physics education can enhance engagement, making the learning process more interactive and effective. This article explores the development of value orientations in students during physics lessons through the incorporation of game elements.

Relevance of the Topic

The relevance of this study is driven by the need for educational strategies that not only impart knowledge but also cultivate essential values such as curiosity, critical thinking, and a scientific worldview. Physics education, with its focus on inquiry and exploration, provides an ideal context for developing these values. However, traditional teaching methods often fail to fully engage students, limiting the impact on their value orientations. Game-based learning, with its interactive and motivational aspects, can address this gap, promoting a more holistic educational experience.

Theoretical Provisions of the Research

Value orientations refer to the principles and standards that guide behavior and decision-making. In the educational context, these include values like integrity, curiosity, responsibility, and respect for evidence. Developing these values is crucial for students to become responsible and ethical members of society.

Physics Education and Value Development

Physics education inherently involves critical thinking, problem-solving, and understanding complex concepts, all of which contribute to the development of value orientations. By engaging with physical phenomena and the laws that govern them, students learn to appreciate the importance of evidence-based reasoning and the pursuit of knowledge.

Game-Based Learning

Game-based learning incorporates elements such as competition, collaboration, rules, and immediate feedback, which can significantly enhance student motivation and engagement. This approach aligns with constructivist theories, which emphasize active and experiential learning. By incorporating game elements into physics lessons, educators can create an environment that promotes both cognitive and affective learning outcomes.

Experimental Methods in Pedagogical Research

To investigate the impact of game-based activities on the development of value orientations in physics, the Mann-Whitney U test will be used. This non-parametric test is suitable for comparing differences between two independent groups, making it ideal for educational research where assumptions of normality may not hold.

Research Design

The study will employ a quasi-experimental design with a control group and an experimental group. Both groups will consist of students from 10th and 11th grades in a specialized school, matched based on their prior academic performance in physics.

Participants

The participants will include 60 students, divided equally between the control and experimental groups. The experimental group will participate in physics lessons that incorporate game-based activities, while the control group will continue with traditional instruction.

Instruments

1. Value Orientation Survey (VOS): A standardized survey to measure students' value orientations before and after the intervention.

2. Physics Achievement Test (PAT): To assess improvements in physics understanding and application.

3. Student Engagement Questionnaire (SEQ): To evaluate student engagement and attitudes towards physics.

Procedure

1. Pre-Test: Administer the VOS and PAT to both groups.

2. Intervention: Over a period of 12 weeks, the experimental group will participate in weekly game-based physics lessons. These lessons will include activities such as physics puzzles, simulations, and competitive problem-solving tasks.

3. Post-Test: Re-administer the VOS and PAT to both groups.

4. Qualitative Data Collection: Conduct interviews and focus group discussions with students and teachers from the experimental group to gather insights into their experiences and perceptions.

Data Analysis

Quantitative data will be analyzed using the Mann-Whitney U test to compare the pre- and post-test scores of the control and experimental groups. Qualitative data will be analyzed thematically to identify common themes and insights related to the effectiveness of game-based learning in developing value orientations.

Example of a Physics Lesson Plan Using Game Elements

Lesson Objective

To develop students' value orientations and deepen their understanding of Newton's laws of motion through game-based activities.

Grade Level 11th Grade

Lesson Topic

Newton's Laws of Motion

Materials Needed

- Interactive whiteboard
- Game cards with physics problems related to Newton's laws
- Tokens for game scoring
- Simulated physics lab software
- Worksheets

Lesson Outline

1. Introduction (10 minutes)

- Briefly review Newton's laws of motion.
- Explain the rules of the game: Students will work in groups to solve physics problems presented on game cards. Correct solutions earn tokens, and the group with the most tokens at the end wins a small prize.

2. Game Activity (30 minutes)

- Distribute game cards to each group. Each card presents a scenario that requires applying Newton's laws to solve a problem.
- Students work together to solve the problems, using critical thinking and collaborative strategies.
- Teachers circulate the room, providing guidance and ensuring that students understand the concepts.

3. Simulation Exercise (15 minutes)

- Use simulated physics lab software to visualize and experiment with scenarios related to Newton's laws.
- Students work in pairs to manipulate variables and observe the outcomes, reinforcing their understanding of the concepts.

4. Discussion and Reflection (10 minutes)

- After the game and simulation, bring the class together to discuss the strategies they used.

- Ask questions such as: "How did applying Newton's laws help you solve the problems?" and "What values did you find important during the activities?"

- Encourage students to reflect on how the game helped them think critically and appreciate the scientific principles.

5. Conclusion (5 minutes)

- Summarize the key learning points of the lesson.
- Highlight the importance of value orientations such as curiosity, responsibility, and respect for evidence in scientific inquiry.

- Assign a homework task that involves similar problems, encouraging students to apply the strategies they used in the game.

Conclusion

The integration of game elements into physics lessons holds significant promise for developing students' value orientations. By transforming traditional instruction into an engaging and interactive experience, educators can foster a deeper understanding of physical principles and cultivate essential values. This research aims to provide empirical evidence of the benefits of game-based learning in physics education, contributing to the development of innovative teaching practices that prepare students for the challenges of the future.

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DEVELOPMENT OF CRITICAL THINKING OF STUDENTS IN MATHEMATICS LESSONS USING ELEMENTS OF GAME ACTIVITY

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In contemporary education, critical thinking is recognized as an essential skill for students to navigate the complexities of the modern world. Mathematics, being a discipline that inherently promotes logical reasoning and problem-solving, provides an ideal platform for cultivating critical thinking. However, traditional teaching methods often fail to engage students deeply, leading to a lack of interest and insufficient development of critical analytical skills. The integration of game elements into mathematics lessons offers a promising approach to address this challenge. This article explores the development of critical thinking in students during mathematics lessons through the incorporation of game-based activities.

Relevance of the Topic

The relevance of this study is underscored by the increasing demand for educational methods that go beyond rote learning and encourage higher-order thinking skills. The integration of game elements in education is supported by constructivist theories, which posit that learning is most

effective when students are actively engaged in a meaningful context. Games provide such a context, offering interactive and enjoyable experiences that can motivate students and foster deeper understanding. In mathematics education, this approach can transform abstract concepts into tangible experiences, making learning more relatable and effective.

Theoretical Provisions of the Research

Critical thinking involves the ability to analyze, evaluate, and synthesize information to make reasoned judgments and solve problems effectively. It encompasses skills such as logical reasoning, reflective thinking, and the ability to challenge assumptions. In mathematics, critical thinking enables students to approach problems systematically, recognize patterns, and develop innovative solutions.

Game-Based Learning

Game-based learning leverages the motivational aspects of games to enhance educational experiences. It incorporates elements such as competition, collaboration, rules, and feedback, which can significantly increase student engagement and motivation. Research indicates that game-based learning can improve retention, foster a positive attitude towards learning, and develop a range of cognitive skills, including critical thinking.

Constructivist Approach

The constructivist approach to education emphasizes active learning, where students build new knowledge based on their experiences and prior knowledge. In a game-based learning environment, students engage in activities that require them to apply concepts in practical, often simulated, scenarios, thereby constructing a deeper understanding of the subject matter.

Experimental Methods in Pedagogical Research

To investigate the impact of game-based activities on the development of critical thinking in mathematics, a mixed-methods approach will be used, combining quantitative and qualitative data collection methods.

Research Design

The study will employ a quasi-experimental design with a control group and an experimental group. Both groups will consist of students from a specialized school, matched based on their prior academic performance in mathematics.

The participants will include 60 students from grades 8 and 9, divided equally between the control and experimental groups. The experimental group will participate in mathematics lessons that incorporate game-based activities, while the control group will continue with traditional instruction.

Instruments

1. Critical Thinking Assessment Test (CTAT): A standardized test to measure students' critical thinking skills before and after the intervention.
2. Mathematics Achievement Test (MAT): To assess improvements in mathematical proficiency.
3. Student Engagement Questionnaire (SEQ): To evaluate student engagement and attitudes towards mathematics.

Procedure

1. Pre-Test: Administer the CTAT and MAT to both groups.
2. Intervention: Over a period of 12 weeks, the experimental group will participate in weekly game-based mathematics lessons. These lessons will include activities such as mathematical puzzles, strategy games, and competitive problem-solving tasks.
3. Post-Test: Re-administer the CTAT and MAT to both groups.

4. Qualitative Data Collection: Conduct interviews and focus group discussions with students and teachers from the experimental group to gather insights into their experiences and perceptions.

Data Analysis

Quantitative data will be analyzed using statistical methods to compare the pre- and post-test scores of the control and experimental groups. Qualitative data will be analyzed thematically to identify common themes and insights related to the effectiveness of game-based learning in developing critical thinking.

Example of a Mathematics Lesson Plan Using Game Elements

Lesson Objective

To develop students' critical thinking skills through solving complex mathematical problems using game-based activities.

Grade Level 9

Lesson Topic

Systems of Linear Equations

Materials Needed

- Interactive whiteboard
- Game cards with system of equations problems
- Tokens for game scoring
- Worksheets

Lesson Outline

1. Introduction (10 minutes)

- Briefly review the concept of systems of linear equations.
- Explain the rules of the game: Students will work in pairs to solve systems of equations presented on game cards. Correct solutions earn tokens, and the pair with the most tokens at the end wins a small prize.

2. Game Activity (30 minutes)

- Distribute game cards to each pair. Each card presents a system of linear equations that needs to be solved.

- Students work together to solve the problems, using critical thinking and collaborative strategies.

- Teachers circulate the room, providing guidance and ensuring that students understand the concepts.

3. Discussion and Reflection (10 minutes)

- After the game, bring the class together to discuss the strategies they used.

- Ask questions such as: "What was the most challenging part of solving these systems?" and "How did you decide on the method to use for each problem?"

- Encourage students to reflect on how the game helped them think critically about the problems.

4. Conclusion (5 minutes)

- Summarize the key learning points of the lesson.

- Highlight the importance of critical thinking in solving mathematical problems.

- Assign a homework task that involves similar systems of equations, encouraging students to apply the strategies they used in the game.

Conclusion

The integration of game elements into mathematics lessons holds significant promise for developing students' critical thinking skills. By transforming traditional instruction into an engaging and interactive experience, educators can foster a deeper understanding of mathematical concepts and enhance students' problem-solving abilities. This research aims

to provide empirical evidence of the benefits of game-based learning in mathematics education, contributing to the development of innovative teaching practices that prepare students for the challenges of the future.

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Formal Sciences | Формальні науки

- Математика (Mathematics)
- Логіка (Logic)
- Інформатика (Computer Science)
- Статистика (Statistics)

STOCHASTIC GRADIENT DESCENT AND ITS APPLICATION IN MACHINE LEARNING

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In recent years, machine learning (ML) has become a cornerstone of technological advancements across various domains, including natural language processing (NLP), computer vision, financial analysis, healthcare, and many others. As the volume of data and complexity of tasks continue to grow, the need for efficient algorithms to train large-scale machine learning models becomes increasingly critical. Stochastic Gradient Descent (SGD) is one such algorithm that has proven to be fundamental in optimizing machine learning models. This article delves into the principles of SGD, its mathematical foundations, and its applications in machine learning [1, 2, 3].

Gradient descent is an optimization algorithm used to minimize the loss function of a model. The primary objective is to adjust the model parameters in such a way that the loss function, which measures the difference between the predicted outputs and actual outputs, is minimized. The basic idea of gradient descent involves the following steps:

1. Compute the gradient of the loss function with respect to each parameter.
2. Update the parameters in the direction opposite to the gradient.

The standard gradient descent update rule for a parameter θ is given by:

$$\theta_{t+1} = \theta_t - \eta \nabla_{\theta} L(\theta_t)$$

where:

- θ_t represents the parameter value at iteration t ,
- η is the learning rate,
- $\nabla_{\theta}L(\theta_t)$ is the gradient of the loss function with respect to θ at iteration t .

While gradient descent is effective, it becomes computationally expensive for large datasets as it requires calculating the gradient over the entire dataset at each iteration.

Stochastic Gradient Descent (SGD) is a variant of gradient descent that addresses the computational inefficiency of standard gradient descent. Instead of computing the gradient using the entire dataset, SGD updates the model parameters using a single randomly selected data point or a small batch of data points at each iteration.

The update rule for SGD is given by:

$$\theta_{t+1} = \theta_t - \eta \nabla_{\theta} L(\theta_t; x_i, y_i)$$

where:

- (x_i, y_i) is a randomly selected data point from the dataset.

For a mini-batch of m data points, the update rule becomes:

$$\theta_{t+1} = \theta_t - \eta \frac{1}{m} \sum_{j=1}^m \nabla_{\theta} L(\theta_t; x_{i_j}, y_{i_j})$$

where:

- $\{(x_{i_j}, y_{i_j})\}_{j=1}^m$ represents the mini-batch.

The loss function $L(\theta)$ measures how well the model with parameters θ predicts the target values. For a dataset with N samples, the loss function is given by:

$$L(\theta) = \frac{1}{N} \sum_{i=1}^N \ell(h_{\theta}(x_i), y_i)$$

where:

- $\ell(h_\theta(x_i), y_i)$ is the loss for a single data point,
- $h_\theta(x_i)$ is the model's prediction for input x_i .

The gradient of the loss function with respect to the parameters θ is given by:

$$\nabla_\theta L(\theta) = \frac{1}{N} \sum_{i=1}^N \nabla_\theta \ell(h_\theta(x_i), y_i)$$

In SGD, the gradient is approximated using a single sample or a mini-batch, which leads to faster updates and often better generalization.

While SGD introduces noise in the gradient estimates due to random sampling, it has been shown to converge to a local minimum under certain conditions. The noisy updates can also help SGD escape local minima, potentially leading to better solutions.

While basic SGD is a powerful optimization technique, several variants and enhancements have been developed to improve its performance and convergence properties.

Instead of updating parameters with a single data point, mini-batch SGD uses a small batch of data points. This approach balances the noise introduced by single-sample updates and the computational cost of full-batch updates.

Momentum is an enhancement that accelerates SGD in the relevant direction and dampens oscillations. The update rule with momentum is given by:

$$\begin{aligned} v_{t+1} &= \beta v_t + (1 - \beta) \nabla_\theta L(\theta_t; x_i, y_i) \\ \theta_{t+1} &= \theta_t - \eta v_{t+1} \end{aligned}$$

where:

- v_t is the velocity (accumulated gradient),

- β is the momentum coefficient.

Adaptive methods adjust the learning rate based on past gradients.

Popular adaptive methods include:

AdaGrad

$$\theta_{t+1} = \theta_t - \frac{\eta}{\sqrt{G_{t,ii} + \epsilon}} \nabla_{\theta} L(\theta_t; x_i, y_i)$$

where G_t is the sum of the squares of past gradients.

RMSprop

$$E[g^2]_t = \beta E[g^2]_{t-1} + (1 - \beta)(\nabla_{\theta} L(\theta_t; x_i, y_i))^2$$

$$\theta_{t+1} = \theta_t - \frac{\eta}{\sqrt{E[g^2]_t + \epsilon}} \nabla_{\theta} L(\theta_t; x_i, y_i)$$

Adam combines the ideas of momentum and RMSprop. The update rules are:

$$m_t = \beta_1 m_{t-1} + (1 - \beta_1) \nabla_{\theta} L(\theta_t; x_i, y_i)$$

$$v_t = \beta_2 v_{t-1} + (1 - \beta_2) (\nabla_{\theta} L(\theta_t; x_i, y_i))^2$$

$$\hat{m}_t = \frac{m_t}{1 - \beta_1^t}, \quad \hat{v}_t = \frac{v_t}{1 - \beta_2^t}$$

$$\theta_{t+1} = \theta_t - \eta \frac{\hat{m}_t}{\sqrt{\hat{v}_t + \epsilon}}$$

SGD is widely used in training various machine learning models. Some of the key applications include:

Neural networks, especially deep neural networks (DNNs), require efficient optimization techniques due to their high dimensionality and large datasets. SGD and its variants are the de facto standard for training these models.

Logistic regression, a linear model for binary classification, benefits from the efficiency of SGD. When dealing with large datasets, SGD

significantly speeds up the training process compared to batch gradient descent.

For linear SVMs, SGD provides an efficient way to optimize the hinge loss. It is particularly useful for large-scale SVMs where the kernel trick is not feasible due to computational constraints.

In recommendation systems, matrix factorization techniques like Singular Value Decomposition (SVD) can be optimized using SGD. This approach scales well with the number of users and items, making it suitable for large recommendation systems.

NLP models, such as word embeddings (e.g., Word2Vec, GloVe) and transformers (e.g., BERT, GPT), leverage SGD for training on massive text corpora. The scalability of SGD allows these models to learn from billions of words efficiently.

The choice of learning rate η is crucial. If η is too high, the algorithm may diverge; if too low, it may converge slowly. Techniques such as learning rate schedules (e.g., step decay, exponential decay) and adaptive learning rates help address this issue.

The size of the mini-batch impacts the balance between the computational efficiency and the noise in gradient estimates. Small batch sizes introduce more noise but require less memory, while large batch sizes provide more stable updates but at a higher computational cost.

Proper initialization of model parameters is important to ensure good convergence properties. Techniques such as Xavier initialization and He initialization are commonly used for neural networks.

Regularization techniques, such as L2 regularization (weight decay) and dropout, help prevent overfitting by adding a penalty to the loss function or randomly dropping units during training.

Early stopping monitors the validation loss during training and stops the training process if the validation loss does not improve for a specified number of epochs. This prevents overfitting and saves computational resources.

Stochastic Gradient Descent (SGD) and its variants are indispensable tools for optimizing machine learning models, especially in the era of big data and deep learning. The simplicity and efficiency of SGD make it suitable for a wide range of applications, from linear models to complex neural networks. By leveraging techniques such as mini-batch updates, momentum, and adaptive learning rates, SGD can effectively train large-scale models and achieve state-of-the-art performance in various domains.

As machine learning continues to evolve, further advancements in optimization algorithms will be essential to handle even larger datasets and more complex models. Nonetheless, SGD remains a fundamental and versatile optimization method that underpins many of the breakthroughs in modern machine learning.

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GALECTIN-3 AS A MARKER OF CARDIOVASCULAR RISK IN PATIENTS WITH HEART FAILURE AND CONCOMITANT TYPE 2 DIABETES

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Introduction. According to the latest data from the European Society of Cardiology in 2022, more than 64 million people worldwide suffer from heart failure (HF). HF is a multifaceted and life-threatening syndrome characterized by high prevalence of morbidity and mortality, low functional capacity and quality of life, and high costs [1]. In addition, it is widely known that type 2 diabetes is very common in patients with HF. In connection with the facts listed above, early diagnosis to provide timely treatment plays a very important role in increasing the duration and quality of life.

For diagnostic and prognostic purposes of HF, natriuretic peptide (NUP) is currently widely used, a neurohormone secreted by the ventricles of the heart. However, there is an inverse relationship between the level of NUP and body mass index, which complicates the diagnosis of HF in obese patients. Therefore, recent active studies of the galectin-3 biomarker, which is a chimeric protein from the lectin family, to obtain additional information about HF is an urgent medical and social problem.

The goal of the work. To study the diagnostic significance of determining the plasma level of galectin-3 in patients with heart failure and concomitant type 2 diabetes

Materials and methods. Literature was searched and analyzed using the PubMed scientometric database and several domestic medical journals

Results and discussion. Galectin-3 has a variety of biological effects, ranging from cell adhesion and migration to cell growth, differentiation, activation and termination of apoptosis, and plays an important role in the inflammatory response and the development of fibrosis. At the same time, it should be noted that the opposite effects of this biomarker on cells depend on its localization: intracellularly - protection of cells from apoptosis, extracellularly - cell death [2]. As HF progresses, the degree of fibrosis also increases, so despite the fact that galectin-3 is a fibrinogenic protein necessary for normal healing, at the same time its persistent expression and secretion in cardiac tissue leads to adverse remodeling of the heart [3].

Two meta-analyses demonstrated that elevated galectin-3 expression levels are associated with mortality in acute and chronic HF [4, 5], while another systematic review showed that galectin-3 is ineffective in predicting cardiovascular mortality, especially under the influence of certain clinical factors, including glomerular filtration rate, left ventricular ejection fraction and N-terminal pro-B-type natriuretic peptide [6]. In the Valsartan HF study, for every 1 µg/L increase in galectin-3, an associated increased risk of mortality, primary morbidity, and HF hospitalization was observed over a 4-month follow-up [7].

In contrast to NUP, when interpreting the results of determining the level of galectin-3, it is important to consider the following features [8]:

- the level of galectin-3 is not affected by HF decompensation, as it reflects the presence or absence of the process underlying the disease;
- the distribution of the level of galectin-3 is shown only in patients with established CHF;

- the increased level of galectin-3 is usually very stable over time (the influence of inflammation and therapy on the concentration of galectin-3 has not been proven);

- a galectin-3 level above 17.8 ng/ml is associated with an increased risk of adverse outcome, while there is still no generally accepted prognostically significant threshold level for cerebral NUP or precursor brain natriuretic peptide.

The role of galectin-3 in type 2 diabetes mellitus (DM) is ambiguous: some studies suggest that galectin-3 deficiency is associated with insulin resistance, and galectin-3 exerts a protective effect in type 2 DM by acting as a receptor for end products progressive glycation. However, a recent study found that knocking out the galectin-3 gene in mice fed a high-fat diet significantly reduced the development of insulin resistance. In addition, this study also provides preliminary evidence that extracellular galectin-3 directly binds the insulin receptor and attenuates downstream pathways, suggesting that galectin-3 is a novel target in insulin resistance and type 2 diabetes [3].

Conclusions. The obtained results of galectin-3 measurements should be interpreted together with the clinical picture and other instrumental research methods (echocardiography, dopplerography) as an auxiliary marker in assessing the prognosis for patients with CHF. Since galectin-3 is causally involved in pathological myocardial fibrosis, it has been suggested that it contributes to the development of HF, and therefore may become a target for HF therapy. The role of galectin-3 in type 2 diabetes is ambiguous.

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ХАРАКТЕРИСТИКА ПЕРЕБІГУ ТА КОРЕКЦІЯ СТАНУ ПІДЛІТКІВ З НЕРОВОЮ АНОРЕКСІЄЮ У ВІЙСЬКОВИХ УМОВАХ

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Нервова анорексія (АН) – особлива нозологічна форма, яка знаходиться на стику різних медичних дисциплін, таких як педіатрія, гастроентерологія, ендокринологія, психіатрія, медична психологія. Відповідно до Міжнародної статистичної класифікації хвороб (МКХ-10) нервова анорексія розглядається в рубриці «Поведінкові синдроми, пов'язані з фізіологічними і фізичними факторами». АН визначається як розлад, що характеризується навмисною втратою ваги, яка спричинена та підтримується самим пацієнтом [1, 2].

Найчастіше такі розлади харчової поведінки виникають у перехідні періоди життя, коли підлітки змушені адаптуватися та змінюватися відповідно до нових обставин, переживати різкі зміни, стикатися з надмірним стресом. Проте нервова анорексія може розвинути в будь-якому віці у відповідь на важливі життєві події чи потрясіння [3, 4].

Нервова (або психогенна) анорексія є третім за поширеністю хронічним захворюванням підлітків. АН характеризується важким психофізичним станом хворого, основною ознакою якого є втрата значної маси тіла, яка відповідає віку та зросту особи. У пацієнтів спостерігається спотворене уявлення про свою фізичну форму та занепокоєння щодо втрати ваги, навіть якщо цього насправді не спостерігається [4, 5].

Виражений дефіцит маси зумовлює катаболічний напрям метаболізму, швидке виснаження пластичних і енергетичних ресурсів організму, що може призвести до дистрофії внутрішніх органів і розвитку поліорганної недостатності. Тому АН є дуже важливою медико-соціальною проблемою, яка останнім часом привертає значну увагу лікарів різних спеціальностей [2, 5].

Метою дослідження було вивчення факторів ризику розвитку нервової анорексії у підлітків, особливостей клінічного перебігу та корекції стану хворих в умовах воєнного стану в Україні.

Матеріали та методи. Під спостереженням перебували 10 дівчат віком від 13 до 17 років, які страждали на нервову анорексію. Пацієнти перебували на стаціонарному лікуванні в педіатричному та психіатричному відділеннях Дніпровської дитячої лікарні протягом 2022 року. Критеріями виключення були діти з хронічними захворюваннями нирок, серця та шлунково-кишкового тракту з можливим розвитком вторинної дистрофії.

Всі хворі обстежені клініко-психопатологічними методами з ретельним вивченням анамнезу, нервово-психічного та соматичного статусу. Оцінку фізичного розвитку пацієнтів проводили двома методами: за регіональними таблицями сигма-відхилень та за шкалами вікової регресії (Z-score) з використанням антропометричного калькулятора (WHO AnthroPlus) [6]. Було оцінено співвідношення зросту до віку, маси тіла до віку, індексу маси тіла (ІМТ) і трофічного індексу по відношенню до відповідної ваги для зросту (ІТ). Для діагностики психотравмуючих факторів використовували розроблений нами метод структурованого клінічного інтерв'ю (SCID) та анкети. Статистичну обробку проводили за допомогою

статистичного пакету Statistica 6.1. Дослідження було схвалено місцевим етичним комітетом лікарні. Інформована згода була отримана від кожного пацієнта та їхніх батьків під час інтерв'ю.

Результати і обговорення. Фізичний розвиток хворих на АН характеризувався вираженою диспропорційністю. Показники зросту 70% дітей були в межах $\pm 1\sigma$, що відповідало середньому зросту для їх віку.

Одна дівчина була вищою за середній зріст (+1,386), а 2 дівчинки мали зріст нижче середнього (-1,16 та -1,296). Вага всіх хворих була нижчою за середню за віком. 20% пацієнтів мали масу тіла в діапазоні -1-2 σ , 30% -2-3 σ , 50% дітей мали масу тіла нижче норми більш ніж на 3 σ .

У всіх хворих на підставі показників трофіки та індексу маси тіла діагностовано білково-енергетичну недостатність (БЕН) I-III ступенів. ПЕІ I ступеня спостерігався в 1 дівчинки (10%), II ступеня – у 5 (50%) і III ступеня – у 4 (40%) дівчат.

ІМТ становив $13,41 \pm 0,87$ з діапазоном 10,8-16,3 в середньому при нормальних показниках для цієї вікової категорії – 18,9-20,5. Дефіцит маси тіла в досліджуваній групі дітей становив від 13 до 43 %.

Соматичний статус хворих характеризувався функціональними розладами шлунково-кишкового тракту, серцево-судинної та нервової систем організму. Найбільш частими скаргами були запор (у 70% випадків), біль у животі (50%), нудота (40%). Аменорея спостерігалась у 50% дівчат. Найбільш вираженими були симптоми порушення нервово-психічного стану підлітків у вигляді безсоння, головного болю, дратівливості або схильності.

схильність до ізоляції, симптоми депресії. Ці скарги відзначили 60% пацієнтів.

Зниження маси тіла у хворих основної групи спостерігалось в різні терміни: у 7 – протягом року, а 3 дівчинки спостерігалися з приводу АН протягом двох років із загостренням у 2022 році.

Аналіз тригерних факторів розвитку АН у досліджуваних пацієнтів дав змогу відзначити поєднання як індивідуальних, так і сімейних факторів, а також соціальних факторів, пов'язаних із поточною ситуацією в країні. Поряд із заниженою самооцінкою, прагненням до ідеальної фігури та страхом набрати вагу 60% підлітків відзначили значний страх перед військовими діями, втратою житла, смертю близьких та страх самотності.

Комбінована терапія хворих включала дієтотерапію з розробкою індивідуального режиму харчування, медикаментозну терапію з метою корекції метаболічних порушень та відновлення ваги. Особливу увагу було приділено диригуванню психотерапією з використанням індивідуального психоаналізу та сімейної терапії. Усі лікувальні заходи супроводжувалися ретельним моніторингом соматичного статусу пацієнтів.

Спостерігалася позитивна динаміка збільшення маси тіла пацієнтів після комбінованої терапії. За період перебування в стаціонарі (в середньому до 2 тижнів) трофічний показник збільшився в середньому на 6,07%, ІМТ - на 1,16. Повторне обстеження фізичного розвитку дітей показало позитивні зміни в харчовому статусі хворих і дало підстави для зміни ступеня ПЕІ з III ступеня на II у 4 дівчаток.

Відмічено значний ефект 10-денного сеансу психотерапії у вигляді нормалізації психоневрологічного статусу, зниження рівня тривожності та стабілізації психоемоційного стану пацієнтів.

Висновки.

1. Психотравмуючі фактори в умовах війни сприяють розвитку нервової анорексії у підлітків.

2. Клінічний перебіг АН у підлітків характеризується швидким розвитком ПЕІ, функціональними розладами соматичних систем організму та погіршенням нервово-психічного стану.

3. Комбінована терапія АН повинна включати курсову психологічну реабілітацію, яка дозволяє не тільки стабілізувати психоемоційний стан підлітків, а й попередити загострення АН та перехід його в хронічну стадію.

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RESEARCH ON THE ARRAY OF MEMS MICROPHONES FOR SOUND SOURCE LOCALIZATION

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This article presents a comprehensive study on the array of MEMS microphones, emphasizing the mathematical rationale behind their construction and operation for sound source localization. The work details the theoretical underpinnings, including the derivation of key formulas and principles governing the array's performance. Furthermore, practical aspects such as connecting the array to a Raspberry Pi and modeling the system in MATLAB (Simulink) are discussed. This study aims to provide a thorough understanding of MEMS microphone arrays' functionality and practical implementation.

Introduction

Micro-Electro-Mechanical Systems (MEMS) microphones have revolutionized acoustic sensing due to their small size, low cost, and high performance. When arranged in arrays, these microphones can effectively determine the direction of sound sources, making them valuable in various applications such as voice recognition, surveillance, and acoustic mapping. This paper explores the mathematical foundation of MEMS microphone arrays, their practical implementation with a Raspberry Pi, and the simulation of the system in MATLAB (Simulink).

Mathematical Rationale for MEMS Microphone Arrays

Sound Wave Propagation and Time Difference of Arrival (TDOA)

The basis of sound source localization using microphone arrays is the Time Difference of Arrival (TDOA) method. Consider an array of N microphones placed at known positions. The sound wave from a source located at (x_s, y_s) propagates and reaches each microphone at different times due to their spatial separation.

The TDOA between two microphones i and j is given by:

$$\tau_{ij} = \frac{d_{ij}}{c} = \frac{|\mathbf{r}_i - \mathbf{r}_j|}{c}$$

where:

τ_{ij} is the time difference of arrival between microphones i and j ,

d_{ij} is the distance between the microphones,

c is the speed of sound in air (approximately 343 m/s at room temperature),

\mathbf{r}_i and \mathbf{r}_j are the position vectors of microphones i and j .

Localization Algorithm

To determine the sound source position (x_s, y_s) , we solve a system of equations derived from the TDOA measurements. For a two-dimensional space, the equations for N microphones can be expressed as:

$$(x_s - x_i)^2 + (y_s - y_i)^2 = c^2(\tau_i - \tau_1)^2 \quad \forall i = 2, 3, \dots, N$$

where (x_i, y_i) are the coordinates of the i -th microphone, and τ_i is the arrival time of the sound wave at the i -th microphone. By solving these equations, we can estimate the coordinates of the sound source.

Array Geometry

The geometry of the microphone array significantly affects the accuracy and resolution of sound source localization. A common configuration is the linear array, but more complex geometries like circular or planar arrays can provide better localization performance. The array's aperture (the maximum distance between any two microphones) determines the array's resolving power.

Connect each MEMS microphone module to the Raspberry Pi's GPIO pins. Ensure that each microphone has a distinct channel for data communication.

Install necessary libraries such as PyAudio or ALSA for audio processing.

Write Python scripts to initialize the microphones, capture audio data, and perform TDOA calculations.

Example Python code snippet for initializing the microphones and capturing audio data:

Example Python code snippet for initializing the microphones and capturing audio data:

```
import pyaudio
import numpy as np

# Initialize PyAudio
p = pyaudio.PyAudio()

# Configuration parameters
CHANNELS = 4
RATE = 44100
CHUNK = 1024

# Open stream
stream = p.open(format=pyaudio.paInt16,
                channels=CHANNELS,
                rate=RATE,
                input=True,
                frames_per_buffer=CHUNK)
```

```
print("Recording...")
```

```
while True:
```

```
    data = np.frombuffer(stream.read(CHUNK), dtype=np.int16)
```

```
    # Process data for TDOA and localization
```

Data Processing

Capture and digitize the audio signals from the microphones.

Apply digital signal processing (DSP) techniques to filter and extract relevant features from the audio signals.

Compute the TDOA using cross-correlation methods.

Simulating the MEMS Microphone Array in MATLAB (Simulink)

Create a Simulink model with blocks representing the MEMS microphones, sound source, and signal processing components.

Simulate the sound source and its propagation to the microphone array.

Implement TDOA estimation using cross-correlation blocks.

Solve the localization equations to estimate the sound source position.

Example MATLAB code snippet for cross-correlation:

```
N = 4;
% Sample rate
fs = 44100;
% Time vector
t = 0:1/fs:1-1/fs;

% Generate synthetic signals
signals = zeros(N, length(t));
for i = 1:N
    signals(i, :) = sin(2 * pi * 1000 * (t - i * 0.001));
end
```

```
% Compute cross-correlation
for i = 2:N
    [c, lags] = xcorr(signals(1, :), signals(i, :));
    [~, I] = max(abs(c));
    TDOA(i-1) = lags(I) / fs;
end

disp('TDOA:');
disp(TDOA);
```

Simulation and Analysis

Run the simulation to analyze the array's performance under different conditions.

Evaluate the accuracy of the sound source localization and the effects of noise and other environmental factors.

Conclusion

The study of MEMS microphone arrays for sound source localization involves both theoretical and practical considerations. This article has provided a mathematical foundation for understanding the array's operation, detailed the steps for interfacing with a Raspberry Pi, and described the simulation process in MATLAB (Simulink). Despite challenges such as environmental noise and computational complexity, MEMS microphone arrays offer significant potential for precise and reliable sound source localization in various applications.

By leveraging advanced digital signal processing techniques and robust hardware setups, MEMS microphone arrays can be effectively integrated into modern acoustic sensing systems, providing valuable capabilities for both consumer and industrial applications. Future research will focus on enhancing the array's performance through improved algorithms, better hardware integration, and real-world testing.

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ЕФЕКТИВНІ АЛГОРИТМИ ДЛЯ МОДЕЛЕЙ МАШИННОГО НАВЧАННЯ

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У сучасному світі машинне навчання (ML) стало наріжним каменем багатьох технологій, що використовуються в різних галузях, таких як обробка природної мови, комп'ютерний зір, фінансовий аналіз, охорона здоров'я та багато інших. Зі збільшенням обсягів даних і складністю задач, які потрібно вирішувати, виникає необхідність у розвитку ефективних алгоритмів для навчання великих моделей

машинного навчання. Ця стаття розглядає ключові напрямки досліджень у цій сфері, включаючи стохастичний градієнтний спуск, розподілене та паралельне обчислення, автоматизоване машинне навчання, методи регуляризації та зниження розмірності, а також оптимізацію підготовки даних [1].

Стохастичний градієнтний спуск (SGD) є основним методом оптимізації для навчання моделей машинного навчання. Його популярність обумовлена простотою реалізації та ефективністю для великих наборів даних. Проте, стандартний SGD має деякі обмеження, такі як висока варіативність оновлень ваг, що може призвести до повільної конвергенції [2]. Для вирішення цих проблем були розроблені різні варіанти SGD:

- Міні-батч SGD: Замість оновлення ваг після кожного прикладу, міні-батч SGD оновлює ваги після обробки невеликої підмножини даних (міні-батча). Це дозволяє зменшити варіативність оновлень та покращити ефективність навчання.

- Адаптивні методи: Методи, такі як Adam, RMSprop та AdaGrad, автоматично регулюють швидкість навчання на основі даних. Вони враховують історію градієнтів для кожного параметра, що дозволяє швидше досягати конвергенції та уникати проблем з вибором оптимальної швидкості навчання.

Зростання розмірів даних та моделей потребує використання розподілених та паралельних обчислень для ефективного навчання. Існує кілька підходів до цього:

- Дані Паралелізм: У даному підході дані розподіляються між кількома процесорами або машинами. Кожен процесор навчає свою

копію моделі на своєму підмножині даних, а потім оновлення об'єднуються. Це дозволяє значно зменшити час навчання.

- **Модельний Паралелізм:** В цьому випадку різні частини моделі розподіляються між процесорами або машинами. Це особливо корисно для великих нейронних мереж, де кожен шар або група шарів можуть бути оброблені окремо.

Для забезпечення ефективної роботи розподілених систем необхідно враховувати проблеми комунікації між процесорами та синхронізації оновлень. Існують різні методи синхронізації, такі як синхронний та асинхронний SGD, кожен з яких має свої переваги та недоліки [3].

AutoML є важливою областю досліджень, яка спрямована на автоматизацію процесу побудови моделей машинного навчання. Це включає автоматичний вибір архітектури нейронної мережі та оптимізацію гіперпараметрів. Основні підходи включають:

- **Neural Architecture Search (NAS):** NAS автоматично шукає найкращу архітектуру нейронної мережі для даного завдання. Це досягається шляхом обстеження великого простору можливих архітектур з використанням різних методів оптимізації, таких як еволюційні алгоритми або методи підсилення.

- **Гіперпараметрична Оптимізація:** Включає автоматичний вибір таких параметрів, як швидкість навчання, розмір міні-батчів, коефіцієнти регуляризації та інші параметри моделі. Серед методів, що використовуються, можна виділити випадковий пошук, байєсівську оптимізацію та гіперпараметричні сітки.

AutoML дозволяє значно зменшити час та ресурси, необхідні для розробки моделей, що є особливо важливим для роботи з великими

наборами даних. Це робить машинне навчання більш доступним для дослідників та інженерів, що не мають глибоких знань у цій галузі.

Для покращення узагальнювальної здатності моделей важливо використовувати методи регуляризації та зниження розмірності. Вони допомагають уникнути перенавчання та підвищити стабільність моделей [4].

- Dropout та DropConnect: Dropout випадково вимикає нейрони під час навчання, що допомагає зменшити перенавчання. DropConnect аналогічно випадково вимикає зв'язки між нейронами. Ці методи дозволяють моделі стати більш стійкими до змін у даних та покращують їх узагальнюючу здатність.

- Регуляризація ваг: L2 регуляризація додає штраф за велику величину ваг, що допомагає уникнути перенавчання. Це досягається шляхом додавання до функції втрат додаткового члена, який пропорційний сумі квадратів ваг.

Методи зниження розмірності також відіграють важливу роль у підвищенні ефективності навчання та узагальнювальної здатності моделей:

- Principal Component Analysis (PCA): Метод зниження розмірності, який знаходить нові змінні (компоненти), що є лінійними комбінаціями початкових змінних і зберігають найбільшу частку дисперсії даних.

- T-SNE та UMAP: Нелінійні методи зниження розмірності, що зберігають локальні структури даних і використовуються для візуалізації високовимірних даних.

Ефективна підготовка даних є ключовою для успішного навчання моделей. Це включає такі аспекти, як завантаження даних, обробка даних та їх збільшення.

- **Онлайнове Збільшення Даних:** Динамічно генерує нові зразки під час навчання, що покращує стійкість моделей. Наприклад, для зображень це може включати такі операції, як повороти, віддзеркалення, масштабування та зміна яскравості.

- **Оптимізація Конвеєрів Завантаження Даних:** Для великих обсягів даних важливо мати ефективні механізми завантаження та обробки, щоб уникнути затримок. Використання багатопотоковості та асинхронного завантаження може значно підвищити продуктивність.

Окрім зазначених вище методів, існують новітні технології та підходи, які стають все більш популярними у контексті навчання великих моделей машинного навчання.

- **Federated Learning:** Цей метод дозволяє навчати моделі на даних, розподілених по різних пристроях або серверах, без необхідності централізованого зберігання даних. Це підвищує конфіденційність та безпеку даних, а також дозволяє використовувати обчислювальні ресурси різних пристроїв.

- **Методи Інкрементного Навчання:** Вони дозволяють оновлювати моделі в режимі реального часу, коли нові дані стають доступними. Це особливо важливо для динамічних середовищ, де дані можуть змінюватися з часом.

- **Комп'ютерне Зорієнтування та Едж Обчислення:** Використання спеціалізованих апаратних засобів, таких як GPU, TPU та FPGA, для прискорення обчислень. Едж обчислення дозволяє виконувати

частину обчислень на пристроях, що знаходяться ближче до джерела даних, зменшуючи затримки та підвищуючи ефективність.

Для кращого розуміння, розглянемо кілька практичних прикладів застосування ефективних алгоритмів для навчання великих моделей машинного навчання.

- Обробка Природної Мови (NLP): Використання моделей типу BERT та GPT для задач обробки тексту, таких як аналіз тональності, машинний переклад та генерація тексту. Ці моделі потребують величезних обсягів даних та обчислювальних ресурсів, але ефективні методи оптимізації та паралельного обчислення дозволяють досягати високих результатів.

- Комп'ютерний Зір: Навчання великих конволюційних нейронних мереж (CNN) для задач розпізнавання об'єктів, сегментації зображень та автоматичного водіння. Використання методів, таких як Dropout та розподілені обчислення, дозволяє значно підвищити ефективність моделей.

- Фінансовий Аналіз: Використання машинного навчання для прогнозування цін на акції, оцінки кредитних ризиків та виявлення шахрайства. Великі набори даних та складність моделей вимагають використання розподілених систем та методів регуляризації для досягнення надійних результатів.

Розвиток ефективних алгоритмів для навчання великих моделей машинного навчання є критично важливим напрямком сучасних досліджень. Використання вдосконалених методів оптимізації, розподілених та паралельних обчислень, автоматизованого машинного навчання, методів регуляризації та оптимізації підготовки даних дозволяє значно покращити продуктивність та узагальнювальну

здатність моделей. Ці напрями досліджень відкривають нові можливості для застосування машинного навчання у різних галузях, роблячи його більш доступним та ефективним.

З подальшим розвитком технологій, таких як *federated learning*, інкрементне навчання та спеціалізоване апаратне забезпечення, можна очікувати, що ефективність та можливості машинного навчання будуть продовжувати зростати, відкриваючи нові горизонти для досліджень та практичних застосувань.

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