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STUDYING AI TECHNOLOGIES IN EXTRACURRICULAR ACTIVITIES WITH TEENAGERS

Abstract. Today, artificial intelligence (AI) has significantly transformed all spheres of society. One of the tasks of the education system is to prepare children for successful lives in a modern technological world, ensuring their professional realization and demand in the labor market. In this study, we describe the conduct of a class with students within the framework of extracurricular activities focused on artificial intelligence: terminology is introduced, an approximate lesson plan is provided, and methodological recommendations are given. During the class, children become familiar with the concepts of artificial intelligence and machine learning, the differences between them, the concept of computer vision, the stages of machine learning, the steps of object identification, data acquisition and classification, examples of image recognition projects, decision trees, the concept of neural networks and their training, and they also teach a machine with built-in artificial intelligence to "see" objects. Throughout the lesson, various games were proposed to help understand and assimilate complex concepts. The uniqueness of these classes lies in their duration and the variety of activities. They can be conducted in summer camps, during scientific studies/research during holidays. Work on project implementation takes place in small groups, which directly contributes to the development of soft skills. It also provides an opportunity to organize competitions between groups, present one's project to other groups, compare different solutions to a particular problem, and accordingly improve one's own project. Special attention should be paid to the use of artificial intelligence in robotic systems. This combination allows for the expansion of the study of traditional STEM subjects. The article presents the experience of conducting classes within the volunteer project "Ukrainian Hacker School" for children. Using the example of a class involving Zumi, the main approaches and features of AI learning for children aged 10-16 are revealed.

Keywords: education; artificial intelligence; machine learning; models; lesson plan.

1. INTRODUCTION

The surge of interest in applications of artificial intelligence (AI) in education is evidenced by the significant increase in publications indexed in scientific databases, particularly Scopus. A search using keywords such as "artificial intelligence," "education," and "teacher" revealed a substantial growth in 2019. While this can be partly attributed to the global shift to online platforms during the COVID-19 pandemic, it is also related to announcements from major corporations focusing on the development of AI technologies and the expansion of cloud services that provide seamless access to relevant programs.

The popularity of the search term "artificial intelligence" in Google Trends (see Fig.1) indicates that global interest peaked in December 2022, following OpenAI's announcement of open access to GEN-3 (and subsequently GEN-4).

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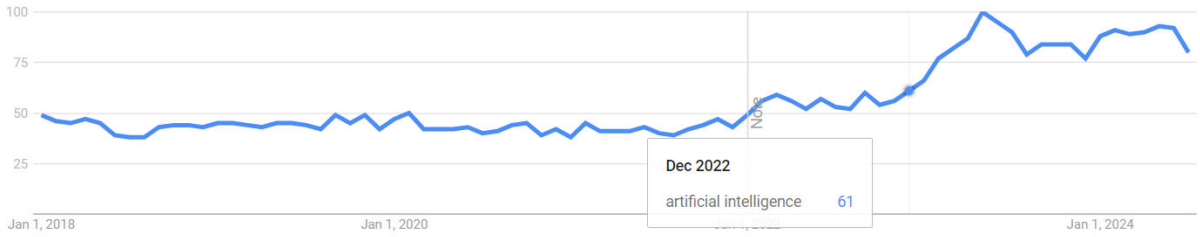

Fig. 1. Popularity of the Search Term "artificial intelligence" in Google Trends (relative value in percent)

Such trends prompt an examination of existing AI education programs and their impact on education. We analyzed online resources that can be utilized in the educational process at the initial stage, specifically for introducing the principles of AI operation and use. These resources serve as a means of developing skills in working with AI, understanding its advantages, limitations, and risks, as well as early career orientation [1]. Recommendations were made regarding the integration of AI programs into the educational process and the specific impact of these technologies on the role of the teacher, as well as their potential for broader implementation [2].

2. PROBLEM STATEMENT

In school education, the study of artificial intelligence (AI) remains underexplored and insufficiently developed. Despite the growing interest in STEM disciplines, the integration of AI into educational programs remains fragmented. Most cases focus on the use of generative networks, prompt engineering, and the accumulation of generated content. There is a need to develop effective teaching methodologies for introducing AI fundamentals to children, which not only explain theoretical aspects but also foster the development of practical technical skills.

It is also important to consider that teaching approaches should be adapted to the age-specific characteristics of students and incorporate various active learning methods. Since working in small groups, gamification, and project-based activities are key aspects of modern education, they should be effectively utilized in AI learning. At the same time, the effectiveness of such lessons in shaping both technical knowledge and students' soft skills remains an open question.

3. RESEARCH GOAL

The aim of this study is to analyze and summarize the experience of conducting AI-related extracurricular activities, particularly through the example of the volunteer project Ukrainian Hacker School. The research focuses on identifying optimal methodological approaches for teaching AI to children aged 10-16. Special attention is given to the use of gamification and teamwork to enhance material comprehension. The findings of this study may be valuable for educators implementing STEM education and seeking to integrate AI into the learning process.

4. STUDY OVERVIEW

To understand the impact of AI technology development on education and teacher training, a review of publications in scientometric databases such as Scopus and Elsevier was

conducted. The aim of this work was to examine the characteristics of AI training and education programs. This helped in identifying age groups, types of training programs, and educational directions across all age categories in the context of AI development.

As a result of the sampling, 67 documents were obtained containing the specified keywords: “artificial intelligence,” “education,” “teacher training,” “pre-service,” and “in-service teachers.” An analysis of keywords indexed by the system and cited by authors revealed, in addition to the main terms used in the selected documents, other relevant terms such as: personnel training, teaching, students, engineering education, and education computing. This also assisted in narrowing the search scope and selecting relevant indicators.

The analysis of publications revealed 27 systematic reviews. Among these reviews, notable attention is given to the study [3], in which the authors analyzed 30 studies related to teacher education. Since the concept of AI is quite broad and applied to various analytical methods and tasks, the authors identified subfields of artificial intelligence and their application areas. Specifically:

- Machine Learning (ML): This involves algorithms that use training data to identify patterns through iterative learning from the data.
- Deep Learning: This uses large datasets to model and predict educational outcomes.
- Natural Language Processing (NLP): This employs algorithms for language recognition to extract and analyze textual meaning.

The authors also identified the target audiences for AI education courses. They noted that most research (18 cases) in the field of education and AI is conducted at higher educational institutions during initial teacher training. In contrast, teacher training in professional development courses was less frequent (9 cases). This discrepancy can be explained by the educational goals of each type of training. Primary education aims at long-term objectives, including learning about trends and emerging directions, while professional development focuses on quickly updating information and training in new tools in the short term. Another important issue is the content of the courses. The authors concluded that there is insufficient attention to ethics and data privacy in all courses, as only a few of the reviewed studies mention ethical considerations.

In the study [4], an analysis of current research directions in the field of artificial intelligence in education (AIED) was conducted. The authors highlight a balance between evolutionary processes (improvements to existing structures) and revolutionary ones (broader and more audacious thinking about the role of AIED).

Similar considerations are presented by the authors of study [5], who analyzed works from the past 20 years to define the concept of "AI literacy." Pedagogical methods such as collaborative project work, software development, problem-based learning, robotics, and gamification have become commonplace in the teaching community. However, in recent years, teaching artificial intelligence has shifted from a technology-focused approach to an interdisciplinary one.

The authors of study [6] reviewed various AI education programs, detailing characteristics of programs for different target groups. For non-specialists, courses are designed as short modules utilizing online resources. Most provide a basic understanding of AI without focusing on specific subject areas. Education for children is project-oriented and has practical applications. Programs designed for student education and professional development meet specific professional requirements. Some programs define categories of skills and competencies acquired by course participants. Additionally, the authors analyzed publications dedicated to AI literacy, highlighting [7], where the authors emphasize that certain general competencies, such as "collaboration" or "solving complex problems," gain new significance with the emergence of AI. Furthermore, the question of a framework for AI ethics competencies remains unexplored.

In the study [8], a substantive analysis of programs was also conducted. The authors conclude that the most frequently studied subjects were discrete mathematics/algebra, often specified as “general” or “fundamentals.” "On the other hand, geometry and topology, applied mathematics, mathematical literacy, and interdisciplinary areas (e.g., STEM) were rarely included in these studies" [8]. Thus, it is observed that scholars focus more on addressing fundamental problems in mathematics courses, as this pertains to the foundational aspects of developing such systems. The programs reviewed, in addition to general concepts, included topics on machine learning and deep learning, as well as ethical issues (bias and the "black box" problem).

The creation of a framework for AI ethics competencies is addressed in article [9]. The authors identify a range of ethical issues pertinent to educational courses. Ethical concerns permeate many core interests of the community, including, but not limited to: the accuracy of learning outcomes for students interacting with educational systems; the choice of pedagogical methods used in assessment systems; predictions of learning outcomes made by these systems; issues of fairness, accountability, and transparency; and concerns related to the impact of AI and learning analytics on teachers' decision-making. The authors emphasize that attention is needed not only on data privacy issues (including informed consent, data confidentiality, and biased datasets) but also on the data analysis process itself (biased assumptions, transparency, and causal relationships).

Study [10] addresses the development of an AI curriculum for young children. The authors present a model curriculum titled “AI for Kids,” designed to promote digital literacy. This course is built using a project-based STEM methodology and focuses on environmental protection while incorporating local socio-cultural contexts. The objectives of the course include: understanding the fundamental principles of AI data processing; comprehending and applying the core principles and judgment processes of AI; and recognizing the concept of AI biases. These goals are achieved through activities such as listening to music and engaging in specific tasks, as well as through stories about "common life things such as traffic lights, vehicles, fruits, animals, and professions to enrich children's understanding of everyday life" [20].

Article [11] delves into the content of AI education courses. The authors explore the use of AI tools in STEM activities. Students are encouraged to use artificial intelligence for predictive modeling, such as how different concrete mixes might affect compressive strength under various conditions. The authors note that popular AI concepts like machine vision, natural language processing (NLP), machine learning (ML), deep learning (DL), and reinforcement learning (RL) enable teaching students to create artificial neural networks (ANN), recurrent neural networks (RNN), convolutional neural networks (CNN), or generative adversarial networks (GAN). However, foundational knowledge in programming languages and the ability to represent mathematical models as code are essential. Consequently, the target audience for such training is university students. Additionally, the authors propose a probabilistic approach based on Bayesian networks (BN) for investigating hypothetical questions using computational modeling, with user-friendly software that can be implemented in classroom settings for beginners within a relatively short time frame (one hour).

An interesting study [12] provides an overview of the content of teacher training programs in Latvia. The authors note that Latvian teacher preparation programs scarcely include concepts such as virtual reality, artificial intelligence, adaptive spaces, digital competencies, e-learning, and electronic education.

In article [13], the social contexts that can and should be addressed in courses on robotic automated systems are identified. Specifically:

- Human Physiology. The vulnerability of the human body should be considered when designing robotic systems, including elements of protection.

- Human Cognition. The study of social and behavioral sciences, as well as psychology, is crucial for interpreting human actions related to decision-making, navigation and orientation, human communication, and the interpretation of intentional behavior.
- Moral Considerations. Ethical issues are always relevant, as robot creators embed specific algorithms and behavioral patterns for various situations. Universal human values can be interpreted differently due to diverse socio-cultural differences.
- Social Norms and Consequences. Establishing trust, responsibility, and accountability will facilitate the integration of innovations into societal life. Understanding the consequences in dynamic collective decision-making systems (e.g., the use of drones in military conflicts and wars) will aid roboticists in implementing innovations.

The authors emphasize that access to such knowledge relies on teamwork and interdisciplinary collaboration. They also identify a range of emerging issues, such as design considerations related to creating socially-robotic colonies, liberating robots from social isolation, and equipping them with social intelligence.

It is noteworthy that the Association for Computing Machinery (ACM) [14] has recently released the "ACM Code of Ethics and Professional Conduct." This code consists of four sections:

- Section 1 contains fundamental ethical principles and definitions. Among these principles is the provision that the results of activities "should respect diversity, be used in socially responsible ways, meet societal needs, and be broadly accessible".
- Section 2 addresses issues related to professional responsibility and obligations.
- Section 3 describes the Principles of Professional Leadership, which apply to leadership roles both in the workplace and as a volunteer.
- Section 4 outlines principles related to the adherence to the Code.

In the article [15], the authors have developed argumentation frameworks for modeling the ethical acceptability of actions taken by agents (or decisions) in military programs and healthcare applications for computer science students. The authors provide examples of how these frameworks are applied to autonomous unmanned devices. They also describe moral decision-making scenarios, practical reasoning arguments, and critical issues (reliability and bias, intervention and control) from the perspective of applying these frameworks. However, in their models, they assume that “moral responsibility rests with the individuals involved in the creation or use of the agent (programmers, designers, purchasers, users, etc.).” Practical work in the presented course was organized as debates on the ethics of artificial intelligence (AIED).

In article [16], an example of studying ethical issues by computer science students through science fiction works is provided. The authors utilized discussion and debate methods as effective teaching strategies. The course is structured to introduce three ethical theories—utilitarianism, deontology, and virtue ethics—and consists of 14 topics. Each topic includes the theory, analysis, and discussion from the perspective of each theory, as well as “examination of fundamental ethical issues in IT, including surveillance, the relationship between news and social media, and autonomous vehicles.” The authors also provide examples of pedagogical materials. Topics covered include: Individuality of Knowledge (privacy invasion), Information Control (access control and information integration), and Performance (de-anonymization, hacking and Wikileaks, trust and distrust, data cleansing).

In summary, based on the analysis of the reviewed publications, it can be observed that the authors emphasize the significance of integrating artificial intelligence into education. They highlight the necessity of understanding not only the technical aspects of AI but also ethical and safety considerations. Some articles focus on the development of educational systems that incorporate AI, or on the use of AI-powered services to support teachers' activities. Other authors explore the construction of educational courses on AI for teachers and students. A much smaller portion of the literature addresses the teaching of AI to schoolchildren, with only one

study presenting a course program for children. However, methodological issues regarding the study of artificial intelligence from a programmer's perspective among students of different age groups remain unresolved. Therefore, we present a course developed to teach teenagers the fundamentals of artificial intelligence programming.

5. METHODOLOGY

In previous research, we identified three stages in developing competencies in students during computer science lessons: familiarization with AI capabilities, building custom machine learning programs using builders, and transitioning to programming. Analysis of the publications revealed that the first two stages are well-represented. However, the third stage-transitioning to creating artificial intelligence systems and machine learning models-is underrepresented in the literature, as these tasks are typically associated with university-level study and involve a significant number of complex concepts and algorithms.

Our objective was to determine the essential terminology, isolate and translate the simplest tasks into terms and analogies accessible to children aged 10-16, and facilitate their development of machine learning models. Based on our research, we established the minimum necessary terminology used in AI work, including foundational elements of AI (data sets, algorithms, predictions), classification of AI algorithms (computer vision, language models), and aspects of AI-based program operations, and identified the corresponding content (see Fig. 2).

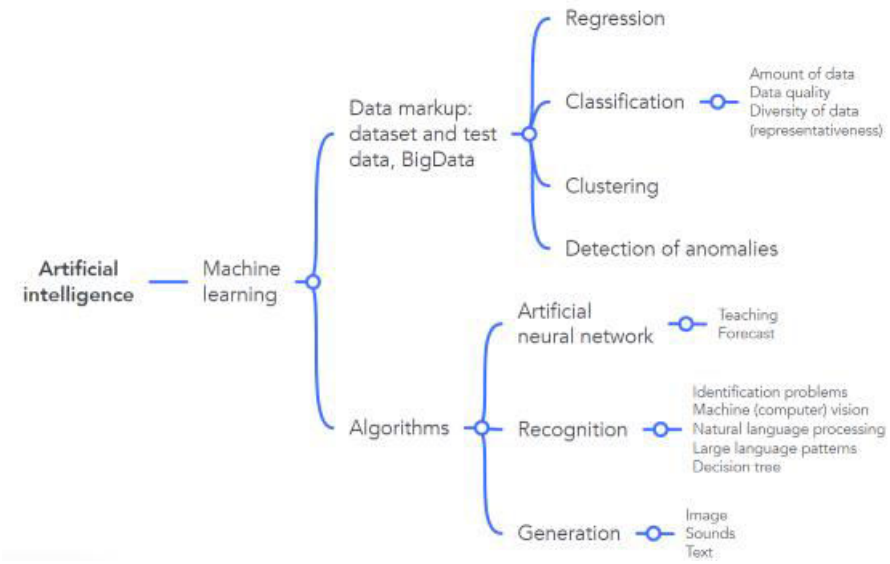

Fig. 2. Mind Map of the Lesson Plan with Key Term

We based our approach on two primary tasks that students face when working with AI tools: 1. Data Annotation: Understanding the process of preparing and annotating datasets for machine learning models. 2. Understanding Machine Learning: Comprehending the functionality of machine learning, particularly artificial neural networks, and how they operate.

Objectives of the Lesson:

- To introduce students to the concepts of artificial intelligence, neural networks, decision trees, and computer vision.
- To explain the principles underlying AI, including the functionality of neural networks and their predictive capabilities.

- To familiarize students with AI-based solutions and to develop skills in working with AI and robotic devices equipped with AI.

Skills Acquired:

- Distinguishing between artificial intelligence and machine learning.
- Classifying objects and understanding data acquisition methods (e.g., surveys, experiments).
- Creating and annotating datasets, including generating test data.
- Classifying data, assessing its quantity, quality, and diversity.
- Analyzing AI results in terms of accuracy and task alignment.

6. ASSUMPTIONS AND SIMPLIFICATIONS

In the presented program for teaching artificial intelligence programming, we have used simplified definitions of terms related to AI. The level of children's preparedness can vary significantly. According to the study [17] only 3.4% of scientific publications related to AI studies include definitions. Therefore, this topic is good for further research and can be further developed and interpreted.

7. RESULTS

We have developed a plan for conducting an extracurricular session for teenagers. This session can also be held as an interdisciplinary activity during lessons or divided into separate activities for STEM week.

The lesson spans 4.5 hours and is designed to be conducted in settings such as summer camps or during scientific study/research periods in school vacations. Depending on the age of the students and their skill levels, the program can be either condensed or extended, and it can be divided into several parts.

Additionally, the program features a variety of activities, including familiarization with terminology and concepts, discussions, practical work, and changes in location for active movement. Certain activities may involve group work, with students collaborating in pairs or small teams.

Lesson plan:

1. Introductory Remarks. A brief overview of the lesson's objectives and structure.
2. Game "What's in the Bag?". This game sets the stage for observing the process of identification, highlights the importance of prior experience, and demonstrates practical experience as a foundation for data acquisition for learning and understanding how the human brain (or one's own neural network) works.
3. Terminology. Definitions of key concepts and terms such as artificial intelligence, machine learning, and the differences between them.
4. Critical Analysis of AI Applications in Daily Life. The primary goal is to establish what various AI systems can and cannot do, explore the potential harmful consequences of misuse, consider avoidance strategies, and address ethical issues and transparency in decision-making.
5. Game "Tic-Tac-Toe" (https://www.aaronccwong.com). This online AI-based game illustrates concepts such as strategy, prediction, and machine learning algorithms [18].
6. Transition from Rules to Data. Creating a dataset through research, such as determining the most popular type of footwear - this activity [19] helps students understand

where to gather data, the concept of a dataset, and characteristics such as quantity, quality, and diversity (representativeness). Concepts like classification, data clustering, and anomaly detection are also introduced.

7. Introduction to Machine Learning Algorithms from a Programming Perspective. Analyzing different images of an object, such as a cat, to determine features used for identifying its presence or count. Identifying issues related to classification and anomalies in data.

8. Creating a Recognition Project Using Teachable Machine by Google. The main objective is to create a high-quality dataset for recognition, such as distinguishing between the left and right hand. Practically, students test the importance of dataset characteristics - quantity, quality, and diversity. At the end of this activity, students are guided to the concept of a neural network, noting that the "training" block of the game may not be immediately obvious.

9. From Data to Algorithms. Game "Guess the Object." This game demonstrates how known characteristics are used for classification, prediction, or decision-making. It introduces the concept of a "decision tree" in the context of neural networks.

10. Game "Neural Network of People". Reinforces the concept of neural network operation in the task of image recognition [20]. In this game, the "neurons" are the students themselves, who must decide which features of an object are relevant and distinguish essential features from non-essential ones.

11. Programming Zumi. These small robots with built-in artificial intelligence modules are designed for programming education. They come with their own software and working environment. Basic recognition tasks from the manufacturer's website [21] were selected for the lesson. Programming can be done using either the graphical interface or Python.

12. Conclusion. Summarize the lesson and reflect on the key concepts and skills acquired.

8. DISCUSSION

Activity: "What's in the Bag?"

Objective: The goal of this game is to demonstrate to students how personal experience (learning) influences object recognition. Understanding how our own natural intelligence works helps to better comprehend the principles of object recognition by artificial intelligence.

Equipment: An opaque bag made of dense fabric and a set of various small objects.

Description: Children take turns reaching into the bag, selecting one of the objects without looking, and try to identify it by touch. They describe the object's characteristics and make a hypothesis about what it might be. Other children can also make their own guesses based on the description provided. Afterward, the object is removed from the bag for everyone to see.

Such an exercise sets the stage for the lesson. It is not important who guesses correctly or incorrectly. The focus here is on the fact that there are items which children can easily identify or reasonably infer their function based on available characteristics (shape, material, size), because they have encountered such an item before and are familiar with it. Conversely, there are items that not all children can recognize, or that none of them can identify because they lack prior experience with such objects. If an item is not present in our experience (our "big data" in the brain), we start finding analogies with other familiar objects. Thus, we build predictions about what the item might be and name the closest similar object.

From our experience, items such as a medicine tube, a dowel, and electrical connectors turned out to be interesting for recognition. For instance, the tube might contain glue or paste, and depending on their previous experience, children suggested different possibilities. At the end, the children concluded that the data available was insufficient for accurate identification. In the case of electrical connectors, the children referred to them as "LEGO" because it

resembled that. They concluded that prior experience plays a significant role in how people recognize the world and engage in practical activities. Even a simple introduction to something new enriches our data pool and gives our brains a chance to generate more interesting, diverse, complex, and deeper ideas.

Terminology

In our definition, artificial intelligence (AI) is a system that performs actions based on a machine learning model but also includes additional components. For example, it may include modules for query censorship and protection against model breaches.

Machine learning (ML) is defined as a model that is based on algorithms, which is trained on data using various methods, such as deep learning or random forest.

Deep learning is characterized as a process involving the operation of algorithms.

Deep learning algorithms are built upon artificial neural networks.

Deep learning is conducted based on labeled data. For instance, algorithms for image or video surveillance identification utilize such labeled datasets.

We define datasets as structured and labeled collections of data. They constitute a curated collection for machine learning purposes, including data analysis, training, and evaluation. Datasets can also be processed using traditional data analysis tools.

Big data is defined as extremely large datasets, which are typically unstructured. Managing, processing, or analyzing such data is challenging with traditional tools and manual methods (see Fig. 3).

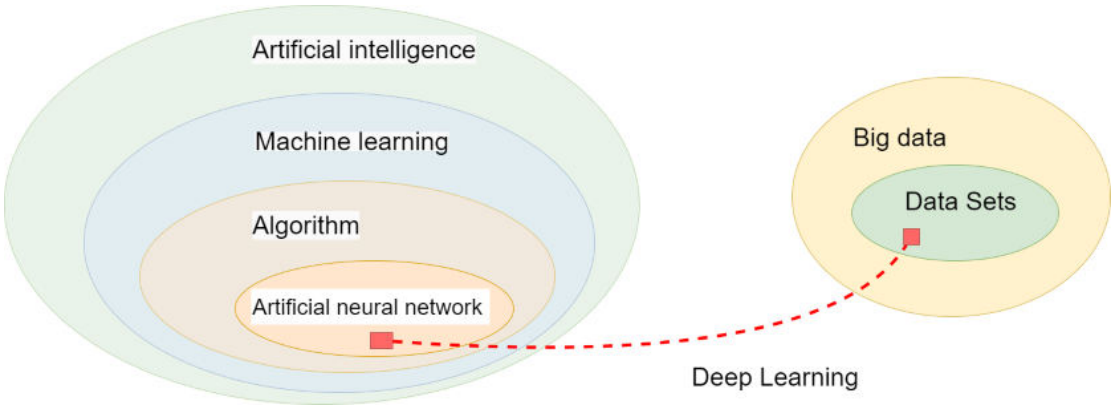

Fig. 3. Terminology Diagram

Critical Analysis of Examples of AI Use in Everyday Life

At the current stage of artificial intelligence technology development, in order to adapt existing complex concepts, we have defined artificial intelligence as a system that not only makes predictions but also makes decisions about appropriate actions and executes those actions. Examples include autonomous vehicles, military drones, and fire-fighting drones. Children often quickly recall examples of AI solutions such as Alexa, self-driving cars, smart homes, and ChatGPT. Less obvious are translation programs, search engines, social networks, company chatbots, bank security systems, and computer games. Rarely do they mention AI

applications such as drug creation, prosthetics, or scientific research in fields like medicine, climatology, and ecology. The goal of this task is to characterize the mentioned examples: whether the example simply makes a prediction or suggestion, or whether it makes a decision and performs an action. This distinction allows us to emphasize the difference between artificial intelligence as a general concept and complex system, and machine learning as a model that operates based on algorithms to make predictions or inferences, but does not perform actions.

Transition from Rules to Data: The Game "Which Footwear Is Most Popular?"

This game is interactive and always very popular with children. It helps them understand aspects of dataset formation, including quantity and quality, approaches to data classification, and introduces them to frequency diagrams.

In 2008, Franklin, C.A., and Mewborn, D.S. [19] described an activity that teaches children how to conduct statistical research. In this exercise, we focused on data collection, classification, and anomaly detection. During the game, children become familiar with characteristics of collected data such as quantity, quality, and representativeness.

Equipment: Footwear of the game participants.

We collect one piece of footwear from each participant, analyze its color, type, and material, and draw initial conclusions about which footwear is the most popular. We then pose the following questions: For example, which footwear would be most popular if we conducted the data collection near a sports school? / near the beach? / at the theater? Are there any types of footwear that were not represented at all? Do all categories contain approximately the same number of pieces of footwear? Are some categories overrepresented or underrepresented compared to others? Would we expect different results if we collected the data at the theater? What if we collected the data at a school in Hawaii? What if we gathered data in January instead of April? This exercise concludes the segment on understanding data and its characteristics.

Introduction to Machine Learning Algorithms from a Programming Perspective: Game "Where is the Cat?"

The goal of this activity is to introduce the concept of object classification, the challenges of object identification, and anomaly detection. To conduct this game, several photographs are required in which an object, such as a cat, is difficult to recognize (see Fig. 4). Initially, children identify the features of the object. They then need to justify why they believe the photograph depicts a cat based on the identified features, specifying which features support this assertion and what the minimum set of features is required to identify a cat. This exercise allows participants to critically evaluate data and view familiar objects from a different perspective. Data is considered as a collection of object characteristics. The concept of anomalies among the data is introduced in this exercise. For example, in Figure 4, there is a cat, but there are also pillows with images of cats, so such objects should not be classified as cats by the algorithm. Certain features of the object may not match the “average” characteristics of that object.

Depending on the age group and readiness for discussion, children can be encouraged to solve this problem through brainstorming or debate. For instance, each feature might be identified as key or not. Alternatively, the introduction of feature significance coefficients and the intersection with features of another object could be explored. Features represent a multidimensional space in which object property vectors are formed. The concept of a context window can also be introduced. This concept defines the amount of information (features) the algorithm retains to generate a response. Its size directly affects the quality of the result produced by the algorithm (greater detail but also with its own drawbacks and advantages).

Fig. 4. Examples of object images for identifying algorithmic identification problems

For successful object identification, various examples of the object's images are needed (representatives). There may be several possible solutions to the problem, and it is important to discuss their strengths and weaknesses, whether they complement each other, their balance, and to conclude that there is no single correct solution. The solution will depend on the specific dataset.

It is crucial to emphasize that datasets are not always perfect; identifying an object requires experience and knowledge, and datasets need to be updated regularly (see Fig.6).

This exercise serves as a foundation for further practical work with recognition based on *Google's Teachable Machine*.

Creating Your Own Recognition Project with Google's Teachable Machine. In this project, students train the algorithm to recognize left and right hands. Typically, they create numerous uniform images to define the hand. However, after running the recognition program, it often fails to correctly identify the hand if it is rotated 90 degrees, turned palm-side away, or if one or more fingers are clenched into a fist. The conclusion drawn is that the object's dataset needs to be modified, expanded, and improved.

From Data to Algorithms. Game "Guess the Object."

The goal of the game is to demonstrate how a decision tree works. This is a typical children's game where one person thinks of a word (which can be written on paper to avoid misunderstandings), and the others must ask questions about its characteristics. Answers can only be "yes" or "no." To record the properties, the named attributes can be written on a board in the form of a tree.

An interesting observation is that modern children often take a long time to guess ordinary objects that do not require electricity, such as a barrel, balcony, fork, etc.

Programming Zumi

We used the manufacturer's basic methodology [21]. Alternatively, any other artificial intelligence tool can be utilized based on preference [1].

Extension of the Lesson

With the widespread adoption of AI technologies, the ethical implications of artificial intelligence have become increasingly pertinent. During the lesson, we did not address the ethical aspects of AI and human values as a separate topic. However, we did touch upon the ethical use of AI in various contexts. To extend the lesson, the following issues can be discussed.

Ethics and Regulation of Artificial Intelligence:

- Data and human safety in the use of artificial intelligence.
- Copyright issues in generated images.
- Bias and fairness, and censorship in artificial intelligence.
- Privacy – violations of digital rights and privacy.
- Responsibility – the trolley problem.
- Transparency in decision-making – autopilot systems.
- Human oversight of artificial intelligence.
- Governance – societal values and goals.

We plan to address these topics in more detail in our subsequent work.

9. CONCLUSIONS AND IMPLICATIONS FOR FURTHER EDUCATIONAL RESEARCH

The analysis of publications indicates a significant demand for the study and teaching of artificial intelligence technologies. Among the literature, there is a substantial number of works revealing the practical applications of AI tools. Additionally, there is a considerable amount of publications describing the process of teaching AI technologies to students and enhancing the qualifications of educators. However, the development of educational programs for children on AI algorithms and AI literacy remains insufficiently addressed.

The conducted study confirmed the importance of integrating artificial intelligence (AI) into the educational process for children aged 10-16. The analysis of lessons within the volunteer project Ukrainian Hacker School demonstrated that the use of gamification, small-group work, and project-based activities enhances material comprehension and fosters the development of both technical and soft skills among students.

Educational programs differ in their learning objectives. Our program emphasizes the study of AI algorithms and introduces the fundamentals of programming, creating neural networks, understanding their operation, and the predictive nature of models. The program also places a strong emphasis on data handling: from creating datasets through analyzing and processing results to critically evaluating and describing them with relevant characteristics important for training neural networks.

The application of practical tasks and real-world cases allows students not only to familiarize themselves with AI fundamentals theoretically but also to learn how to apply the acquired knowledge in practice. The use of robotic systems significantly increases children's engagement in learning and expands the possibilities of STEM education.

The developed program scales well for both short-term sessions and extended courses. It is suitable for teenagers to spark their interest in technologies and model building. Thus, the findings of this study may be beneficial for educators and organizers of extracurricular activities who seek to integrate modern technologies into the educational process. Future research could focus on developing methodological materials, adapting learning programs to the age-specific

characteristics and proficiency levels of students, and assessing the impact of such lessons on the development of their technical skills.

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REFERENCES (TRANSLATED AND TRANSLITERATED)

[1] N.O. Kushnir, N.V. Valko “Methodical aspects of studying artificial intelligence by future teachers”. In: DigiTransfEd@ ICTERI. pp. 155–170. 2023. [Online]. Available: https://ceur-ws.org/Vol-3553/paper25.pdf (in English)

[2] O. V. Spivakovsky, S. A. Omelchuk, V. V. Kobets, N. V. Valko, and D. S. Malchykova, “Institutional policies on artificial intelligence in university learning, teaching and research,” *Information Technologies and Learning Tools*, vol. 97, no. 5, pp. 181–202, Oct. 2023, doi: https://doi.org/10.33407/itlt.v97i5.5395. (in English)

[3] S.Z. Salas-Pilco, K. Xiao, X. Hu “Artificial intelligence and learning analytics in teacher education: A systematic review.” *Education Sciences* 12(8), 569 (2022)

[4] I. Roll, R. Wylie “Evolution and revolution in artificial intelligence in education.” *International journal of artificial intelligence in education* 26, 582–599 (2016)

[5] K. Ng, Min Goo Lee, R. Jun, X. Hu, J. Stephen Downie, and S. Kai, “A review of AI teaching and learning from 2000 to 2020,” *Education and Information Technologies*, vol. 28, Dec. 2022, doi: https://doi.org/10.1007/s10639-022-11491-w. (in English)

[6] M. C. Laupichler, A. Aster, J. Schirch, and T. Raupach, “Artificial Intelligence Literacy in Higher and Adult education: a Scoping Literature Review,” *Computers and Education: Artificial Intelligence*, vol. 3, p. 100101, Sep. 2022, doi: https://doi.org/10.1016/j.caeai.2022.100101. (in English)

[7] L. Markauskaite *et al.*, “Rethinking the entwinement between artificial intelligence and human learning: What capabilities do learners need for a world with AI?,” *Computers and Education: Artificial Intelligence*, vol. 3, no. 3, p. 100056, 2022, doi: https://doi.org/10.1016/j.caeai.2022.100056. (in English)

[8] G.-J. Hwang and Y.-F. Tu, “Roles and Research Trends of Artificial Intelligence in Mathematics Education: A Bibliometric Mapping Analysis and Systematic Review,” *Mathematics*, vol. 9, no. 6, p. 584, Mar. 2021, doi: https://doi.org/10.3390/math9060584. (in English)

[9] W. Holmes *et al.*, “Ethics of AI in Education: Towards a Community-Wide Framework,” *International Journal of Artificial Intelligence in Education*, vol. 32, no. 1, pp. 504–526, Apr. 2021, doi: https://doi.org/10.1007/s40593-021-00239-1. (in English)

[10] W.Yang “Artificial intelligence education for young children: Why, what, and how in curriculum design and implementation.” *Computers and Education: Artificial Intelligence 3*, 100061 (2022)

[11] M.-L. How and W. L. D. Hung, “Educing AI-Thinking in Science, Technology, Engineering, Arts, and Mathematics (STEAM) Education,” *Education Sciences*, vol. 9, no. 3, p. 184, Jul. 2019, doi: https://doi.org/10.3390/educsci9030184. (in English)

[12] K. Uzule, “Teacher training and education programs in Latvia: are e-competences included?,” *Business, Management and Education* 18(2), 294–306 (2020)

[13] C. J. Andrews, “Preparing to Design Robots for Social Contexts,” in *IEEE Technology and Society Magazine*, vol. 41, no. 1, pp. 15-17, March 2022, doi: 10.1109/MTS.2022.3147530. (in English)

[14] D. Gotterbarn, B. Brinkman, C. Flick, M.S. Kirkpatrick, K. Miller, K. Vazansky, M.J.Wolf “Acm code of ethics and professional conduct“. Association for Computing Machinery. 2018

[15] N. L. Green and L. J. Crotts, “Argument Schemes for AI Ethics Education.,” pp. 41–50, Jan. 2020. (in English)

[16] E. Burton, J. Goldsmith, and N. Mattei, “How to teach computer ethics through science fiction,” *Communications of the ACM*, vol. 61, no. 8, pp. 54–64, Jul. 2018, doi: https://doi.org/10.1145/3154485. (in English)

[17] F. K. Fadlelmula and S. M. Qadhi, “A systematic review of research on artificial intelligence in higher education: Practice, gaps, and future directions in the GCC,” *Journal of University Teaching and Learning Practice*, vol. 21, no. 06, Apr. 2024, doi: https://doi.org/10.53761/pswgbw82. (in English)

[18] N. B. Black and S. Brooks-Young, “Hands on AI Projects for the Classroom: A Guide for Elementary Teachers”, Jun. 2024. [Online]. Available: https://learn.robolink.com/lesson/signdetection/ (in English)
[19] C. A. Franklin and D. S. Mewborn, “Contemporary Curriculum Issues: Statistics in the Elementary Grades: Exploring Distributions of Data,” *Teaching Children Mathematics*, vol. 15, no. 1, pp. 10–16, Aug. 2008, doi: https://doi.org/10.5951/tcm.15.1.0010. (in English)
[20] S.Parmar “Artificial intelligence class 9. creating a human neural network. Class 10.” Jun 2024. [Online]. Available: https://www.tutorialaicsip.com/ai/creating-a-human-neural-network-ai-class-9-10 (in English)
[21] Zumi, "Lesson works with Zumi," Jun. 2024. [Online]. Available: https://learn.robolink.com/lesson/signdetection/. (in English)

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НАВЧАННЯ ТЕХНОЛОГІЙ ШІ В ПОЗАКЛАСНІЙ РОБОТІ З ПІДЛІТКАМИ

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Анотація: Сьогодні штучний інтелект (ШІ) суттєво змінив усі сфери життя суспільства. Одним із завдань системи освіти є підготовка дітей до успішного життя в сучасному технологічному світі, забезпечення їх професійної реалізації та затребуваності на ринку праці. У даному дослідженні описано проведення заняття з учнями із залученням ШІ в позакласній роботі: ознайомлено з термінологією, подано орієнтовний план уроку, надано методичні рекомендації. Під час заняття діти знайомляться з поняттями штучного інтелекту та машинного навчання, відмінностями між ними, поняттям комп’ютерного зору, етапами машинного навчання, етапами ідентифікації об’єктів, збору та класифікації даних, прикладами проєктів розпізнавання зображень, дерева рішень, концепцією нейронних мереж та їх навчання, а також навчають машину з вбудованим штучним інтелектом «бачити» об’єкти. Протягом уроку були запропоновані різноманітні ігри, які допомагають зрозуміти та засвоїти складні поняття. Унікальність цих занять полягає в їх тривалості та різноманітності заходів. Вони можуть проводитись у літніх таборах, під час наукових занять/досліджень під час канікул. Робота над реалізацією проєкту відбувається в малих групах, що безпосередньо впливає на формування м’яких навичок. Також це дає можливість організовувати змагання між групами, презентувати власний проєкт іншим групам, порівняти різні шляхи розв’язання певної проблеми та відповідно покращити власний проєкт. Особливу увагу слід приділити використанню штучного інтелекту в робототехнічних системах. Таке поєднання дозволяє розширити вивчення традиційних предметів STEM. У статті представлено досвід проведення занять у межах волонтерського проєкту “Ukrainian Hacker School” для дітей. На прикладі заняття за участю Zumi розкриваються основні підходи та особливості навчання ШІ дітей 10-16 років.

Ключові слова: освіта; штучний інтелект; машинне навчання; моделі; план уроку.

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